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Features of atmospheric Carbon Monoxide at two different coastal environments

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ABSTRACT
Trace gases in the atmosphere influence the radiation budget of our planet and their abundance often determines the air quality of a region. Though carbon monoxide (CO) is not a potent green house trace gas, it affects human health. Using a non-dispersive IR analyzer, CO in ambient air is being measured at a tropical clean coastal site, Thiruvananthapuram (8.5° N, 77.6° E) from 2003. The location of the instrument is in a pristine coastal environment with ample vegetation. A similar CO analyzer is functional in a coastal industrial city, Kochi (10.08° N, 76.3° E) from 1997. The diurnal and seasonal CO patterns at these two coastal stations are compared with reference to their environments. Besides, the differences in weekday and weekend CO abundance were examined for both the sites. Since Kochi has data for the last eight years, the long-term trends and temporal variations in CO are also examined.

INTRODUCTION

Trace gases regulate the Earth's atmosphere mainly in two ways: greenhouse warming and air quality. They absorb the incoming solar radiation and trap the outgoing long-wave IR radiation contributing to greenhouse warming. While the major greenhouse gases like CO_2, CH_4, water vapour (H_2O), O_3 determine the radiation budget and climate on our planet, a few other minor greenhouse gases like CO, oxides of N_2 and S, surface O_3 affect the air quality of a region. Climate change is of concern to humanity in terms of the havoc it wrings upon our globe and the insurmountable mitigation called for to restore normalcy. Also, climate change is a long-term effect and its latency is in the response of the atmosphere to increasing aggregate levels of greenhouse gases. Of equal concern is the air quality determined by the minor green house gases that directly affect the biosphere. CO, oxides of N_2 and S, surface O_3 etc have large anthropogenic source and their concentrations get altered by human activities, which in turn, affect the ambient air quality.

Carbon monoxide in the ambient air ranks as a criteria pollutant, affecting directly the warm-blooded animals, particularly human beings. CO has both natural and man-made sources. The main natural source of ambient CO includes photochemical conversion of CH_4 and hydrocarbons, although vegetation and ocean surfaces form a weak source (IPCC Report, 2001). Assuming that the natural sources are in equilibrium, only the man-made CO load is discussed in this paper. The transport industry (surface, ocean and air) accounts for a major share (70%) of anthropogenic CO generation. Steel, cement, coal and natural gas industries too produce high CO next to the transport sector (EHC 213 1999; Mayer 1999).

Even with the increase in transport and industries in the world over the last three decades, studies have shown that CO has decreased. Hydroxyl radicals (OH) are produced photo-chemically in the atmosphere by the interaction of insolation with water vapour. OH sinks CO preferentially to CH_4, masking the actual increase in CO, besides leading to CH_4 increase and green house warming by it. Studies have shown this reason valid for CO stabilization and decrease for the last three decades over the northern hemisphere (Yurganov 2000).

With a view to understanding the base level CO at a coastal clean site, CO was monitored continuously at Thiruvananthapuram from 2003. The site is in the outskirts of the city, with ample vegetation and away from traffic. Long-term CO data for the period 1997 to 2005 was also obtained from a similar instrument deployed at a coastal industrial site, Kochi, in a factory premises. To study the features of CO in ambient air at the above two coastal sites that differ environmentally, the diurnal, seasonal and CO level differences during weekdays and holidays were examined. Besides, the long-term trend at Kochi was also studied.

METHOD OF MEASUREMENT

At Thiruvananthapuram, for monitoring CO, an analyzer using non-dispersive infrared photometer technique (Monitor Europe Model 9830B) was used. The analyzer measures CO by absorption at the IR at 4.6 ìm, and can measure CO up to 200 ppm in 4 ranges. CO from 10 ppb can be measured and the accuracy of measurement is 1% of measured value in the lowest range. A data interval of 5 min. was selected considering analyzer memory and the data length. The instrument displays Time in IST, instantaneous CO and its average value. The event log describes 20 events of instrument operation such as power failure, restoration etc. Also, an instrument status menu displays to the components behaviour such as the heater, scrubber gas, CO_2, valves operation, electronic status, etc. Analog and digital outputs are available for data monitoring. The data is stored in the memory module and transferred to a computer using a communication software package. The data is analyzed further using appropriate software. This instrument was calibrated once at the Physical Research Laboratory, Ahmedabad with standard gas and also with similar CO analyzers. A comparison of similar CO measuring instruments was done at New Delhi and the measurement by this instrument agrees well with similar ones.

For Kochi, long term CO data (1997–2005) from an IR instrument working continuously at an industrial environment (FACT, Udyogamandal, Kochi) was obtained. This long-term data, hourly averages, is made use of to arrive at an average annual picture and the trend in CO over Kochi.

DATA AND RESULTS

Data for Thiruvananthapuram and Kochi are presented in four different categories. The pattern of CO distribution over a day is evident from diurnal patterns at both the sites. The CO levels in different seasons appear in an annual pattern, the average CO distribution during weekdays and weekends and the long-term trend at Kochi are presented below.

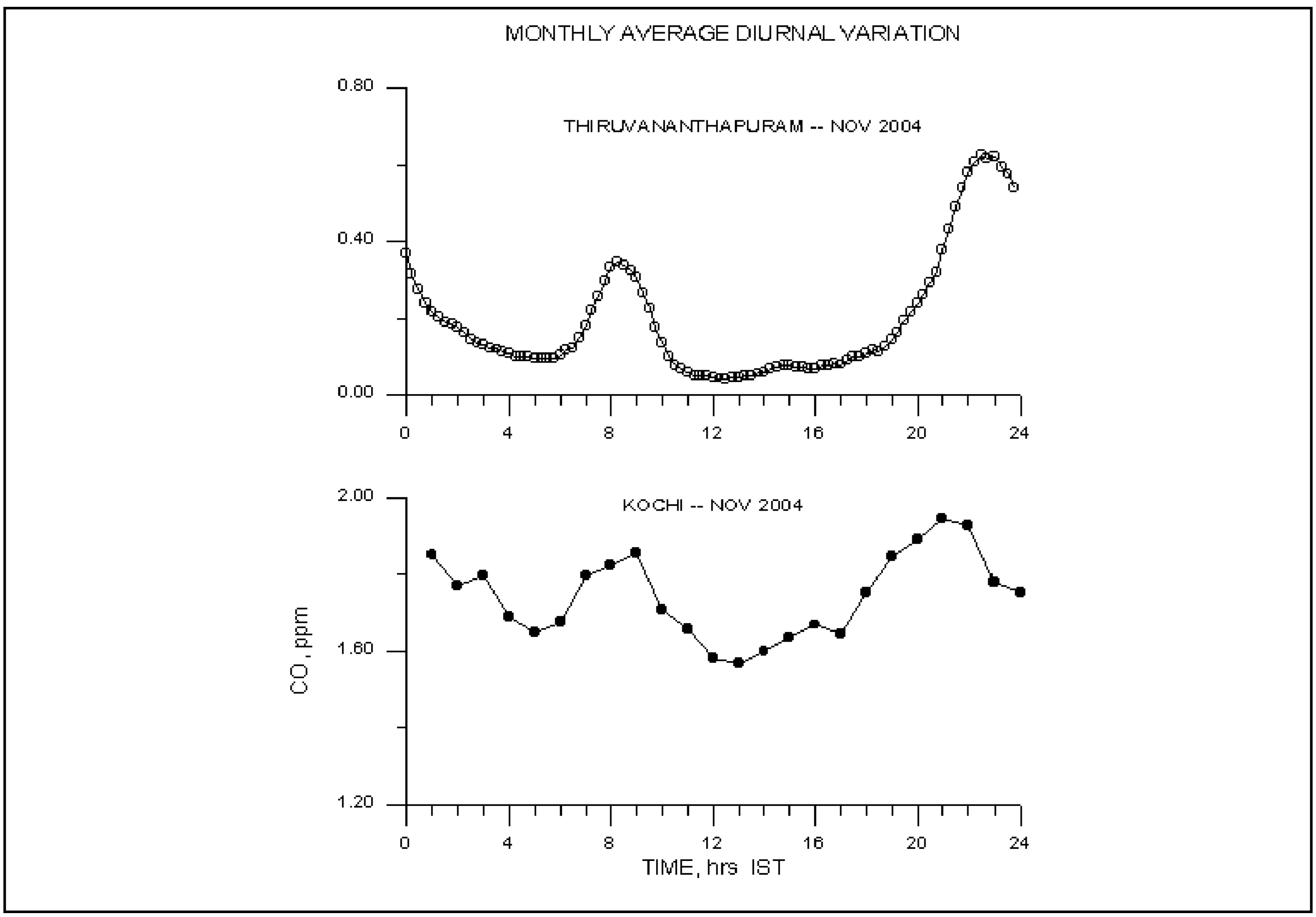

Figure 1. Monthly average diurnal variation of CO at Thiruvananthapuram and Kochi

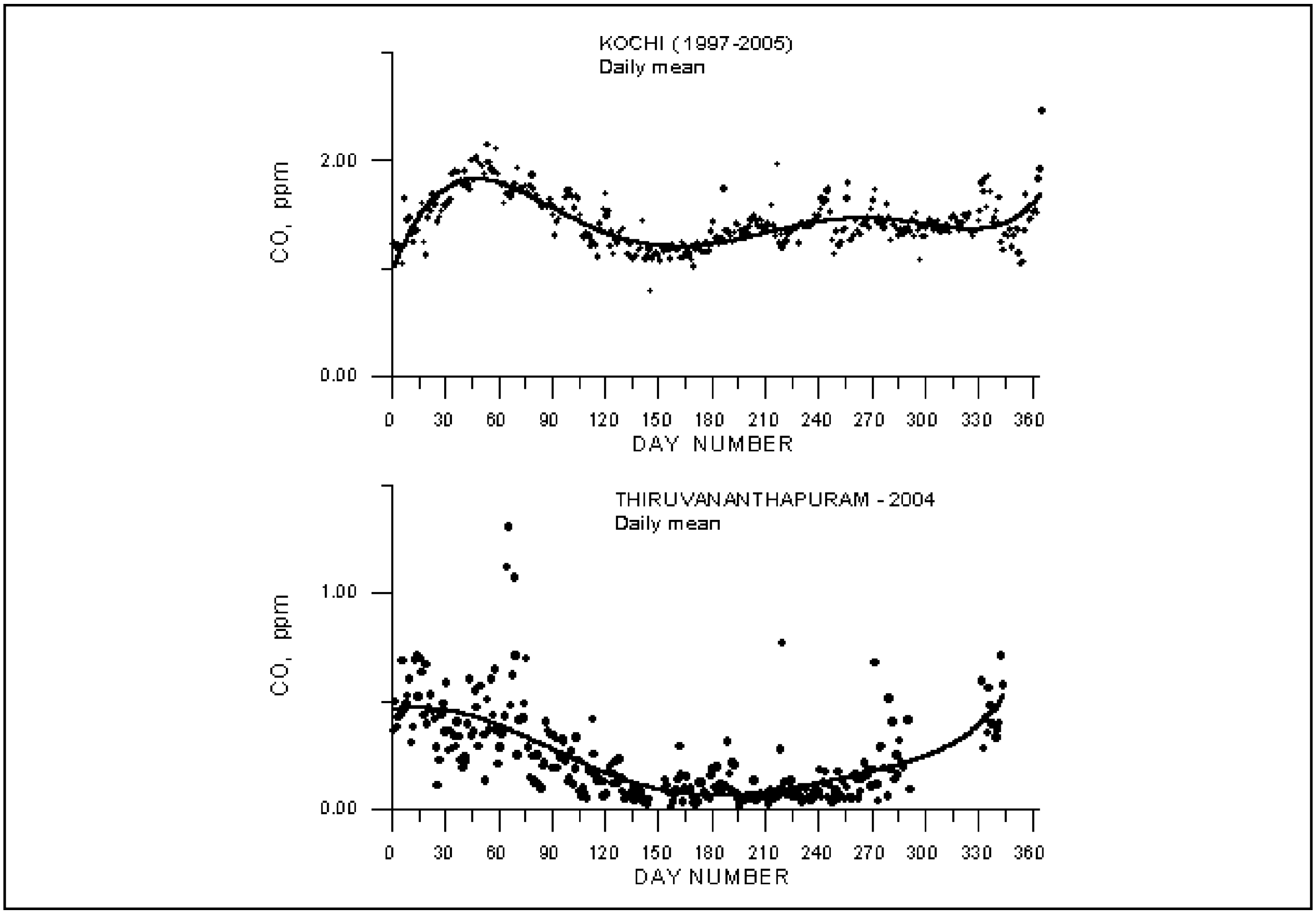

Figure 2. Variation of daily mean CO as a function of day number for Thiruvananthapuram and Kochi

Diurnal Pattern

The ambient CO shows a typical diurnal variation as shown in Fig.1. The CO shows two peaks, one in the morning around 0800 hrs IST and another around 2200 hrs. These two peaks are attributed to sea and land breezes. The diurnal characteristic of the boundary layer also plays an important role in the diurnal variation of CO. The noon or in general the daytime values are very small. The diurnal variations at Thiruvananthapuram and Kochi more or less show a similar behaviour. Kochi has a greater traffic flow than Thiruvananthapuram. This is reflected in the ambient CO values being four time that at Kochi than at Thiruvananthapuram. In all the seasons, CO in ambient air is high at Kochi. Minor differences in the behaviour of CO diurnal patterns between Thiruvananthapuram and Kochi could be attributed to the data interval (5 minutes at Thiruvananthapuram, 1 hour at Kochi).

Seasonal Pattern

Seasonal variation in CO at a site is dependant on the vertical and horizontal transport processes that are governed to a great extent by the behaviour of the boundary layer over that site and large scale wind systems. In general, during summer months the height of the boundary layer is high and hence the circulation is more rapid. This makes the CO to be carried upwards and therefore, a low ambient CO results. In winter, the circulation is weak and the upward mobility of CO is also less, which results in a high ambient CO. Therefore, during a year, a winter high and a summer low characterize the ambient CO. At Kochi and Thiruvananthapuram, the South West monsoon is very dominant. CO has very low solubility in water and therefore, the low in CO cannot be attributed to the dissolution of CO in rain**.** But this low can be attributed to a large extent to the large-scale monsoon winds that causes a thorough mixing of air over the region. Earlier studies on CO in tropical region have also indicated a low CO during wet seasons (Pochanart et al., 1999). A high CO during winter or cold season is apparent. But Kochi shows an exceptionally low value during January that needs to be understood. In Fig.2, the annual variation in CO is shown.

Weekday Weekend Effect

As mentioned above, traffic exhausts form a major anthropogenic source of ambient CO. In order to bring out the effect of traffic on ambient CO levels, from the data available for Kochi and Thiruvananthapuram, the averaged CO diurnal patterns for weekdays and weekends in 2004 were computed. It is generally considered that traffic is high during weekdays compared to weekends. Therefore, a difference in the ambient CO level is expected between weekdays and weekends. The diurnal CO averaged for weekdays and weekends for a winter month (January) and a summer month (May) for these two locations are presented in Fig.3. At Thiruvananthapuram, the CO averages during weekdays are more than over weekends and holds good for most of the months in 2004, except the summer month May. At Kochi in January, the weekday average CO was close to the weekend average. The difference between weekdays and weekends is not apparent. However, in a summer month (May), the CO during weekends was distinctly higher than those over weekdays, similar to that at Thiruvananthapuram. This could be due to a reduction in traffic during the summer month, as many of the educational institutions remain closed, causing a. reduction in traffic exhaust. This could be a reason for weekdays to show low CO compared to weekends during May.

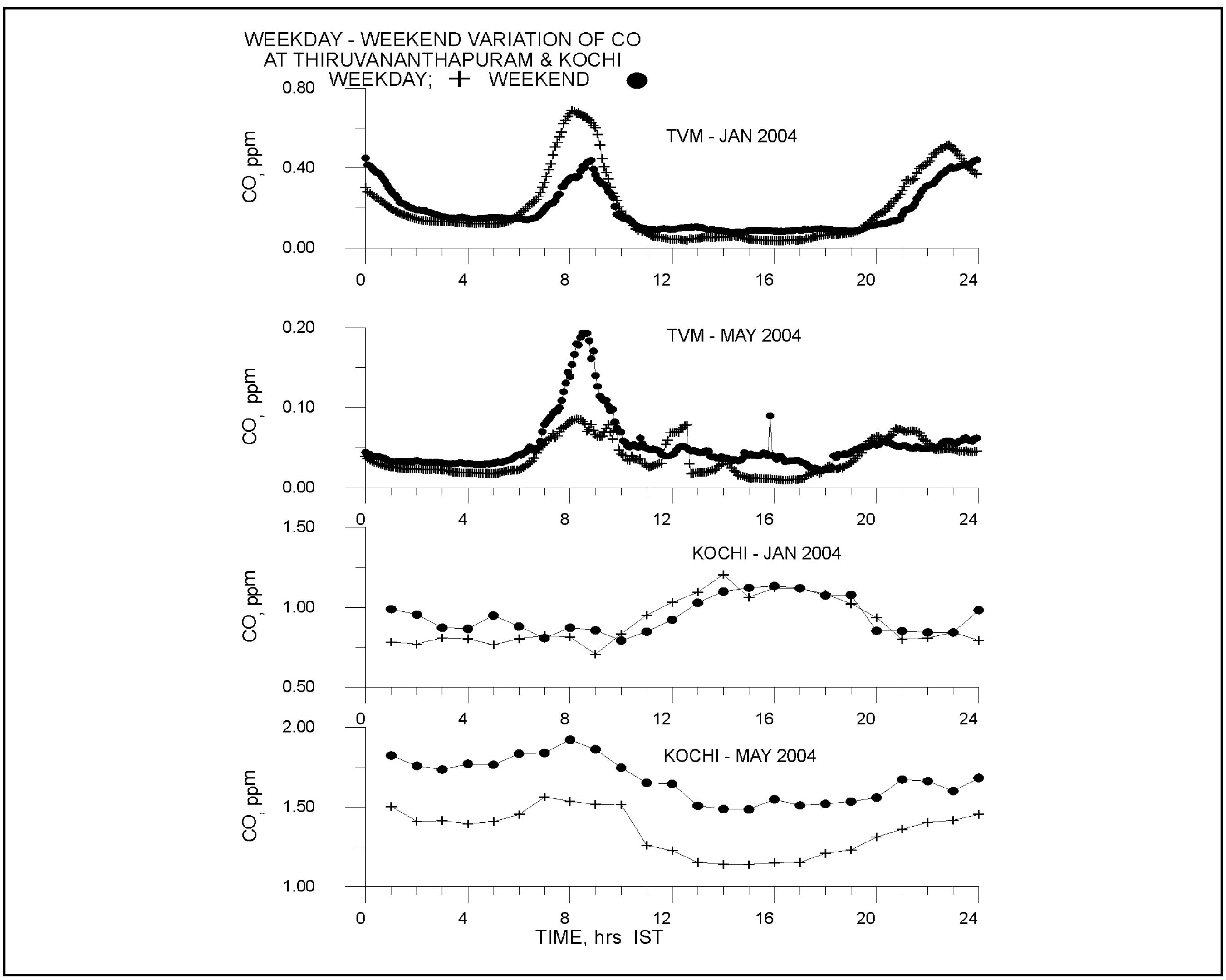

Figure 3. Diurnal variation of CO during weekdays and weekends at Thiruvananthapuram and Kochi

Long term trend in CO at Kochi

Kochi has CO data from 1997 to 2005 period. Daily mean CO is plotted in Fig. 4a with daynumber 1 from June 1, 1997. Figure 4b is the smoothed data of the daily mean CO with a sixth degree polynomial fitted to it. The nature of the data behaviour is evident from this distribution. Figure 4c gives the power spectral analysis of the CO data at Kochi. Two dominat periods of 425 days and 530 days are seen in the data. CO measurements started at Thiruvananthapuram station only from 2003 and sufficient data length does not exist for a long-term trend analysis.

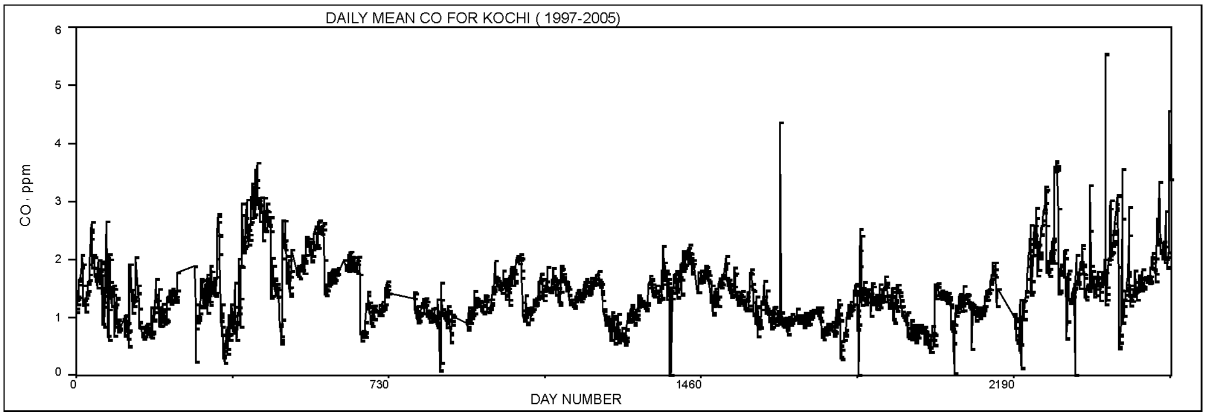

Figure 4a. Daily average CO at Kochi against day number for the period 1997-2005

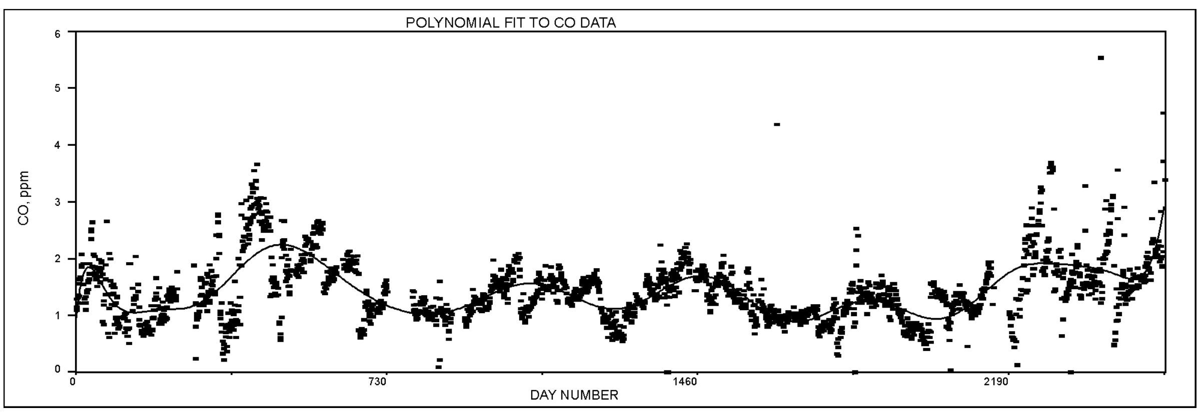

Figure 4b. A polynomial fit to the data in Figure 4a shows the dominant periods

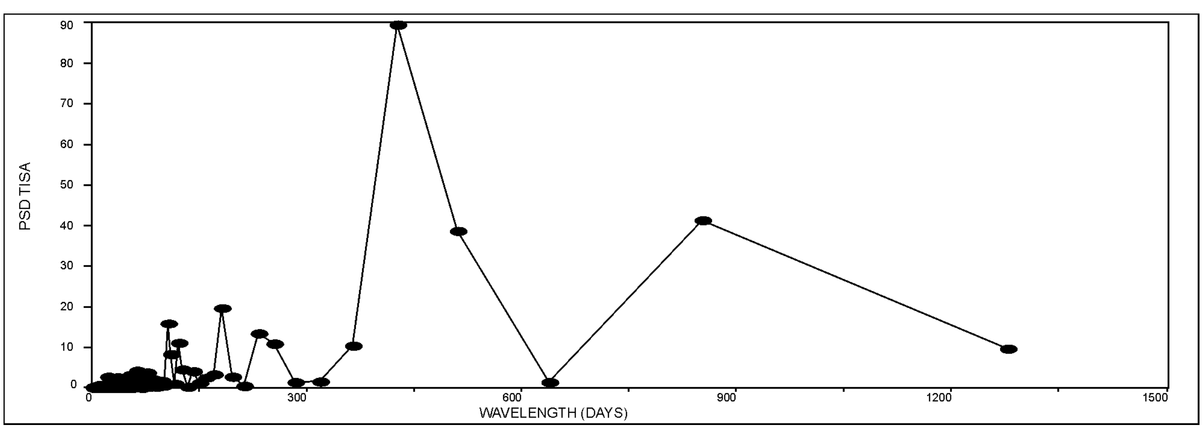

Figure 4c. A FFT analysis showing the wavelength against the power spectrum.

SUMMARY

Diurnal patterns at the two coastal sites Thiruvananthapuram and Kochi show similar behaviour with two peaks one in the morning (0800 hrs) and another in the late evening (2000 hrs).

Kochi, a city with more traffic flow and industries compared to Thiruvananthapuram shows a higher average CO.

The annual variation of CO at Thiruvananthapuram shows a winter high and a summer monsoon low.

The weekday and weekend variations at Kochi and Thiruvananthapuram show the effect of traffic in modulating the ambient CO

Long term behaviour of CO at Kochi show that the data has a predominant oscillation with a period of 425 and 530 days.

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