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TECHNICAL NOTE

SOME FEATURES OF AITKEN NUCLEI IN NAIROBI

J. K. NG'ANG'A and G. K. NGUGI
Department of Meteorology, University of Nairobi, Kenya

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Abstract—Measurements of Aitken nuclei in Nairobi were made using the small particle detector from November 1981 to July 1982 in the industrial area and four stations at varying distances from the centre of the industrial area. The industrial area had a concentration that was on average a factor of two higher than of the residential estates. The concentration was found to decrease with increasing distance from the industrial area.

Concentration values depict a monthly variation with dry months recording a higher concentration than the wet months. The Aitken nuclei were found to be a good indicator of industrial pollution in the city, as a good correlation was found between the Aitken concentrations and total suspended particulate concentration values in the industrial area over the same period. The monthly variation of the Aitken nuclei were found to follow closely the annual wind and stability patterns.

1. INTRODUCTION

The world of small particles has been associated with the formation of cloud droplets from early times. These particles become condensation nuclei (CN) at supersaturations created in the counter chambers. In the atmosphere, only a small number of them may participate in the formation of cloud droplets (Junge, 1963; Kocmond and Mock, 1972).

The condensation nuclei are classified according to size, the smallest having radii $< 0.1\ \mu m$, referred to as the Aitken nuclei. The Aitken nuclei are sensitive to the proximity of combustion sources and form spontaneously during the photochemical smog episodes. They have short lives of the order of minutes, because of their rapid growth by coagulation (Selezneva, 1966). In the work presented here, only the Aitken nuclei were investigated.

Nairobi is located 1°S and 40°E and at a mean altitude of 1.7 km above the mean sea level. This is a rapidly growing urban area with a great deal of commercial and residential activities. The commercial sector is concentrated within the city, while most of the industries are located to the SE in the main industrial area. The population has almost doubled in the last 10 y, while the number of industries with potential impact on air pollution has increased by 50% during the same period (Kenya Bureau of Statistics, 1981).

Nairobi experiences two distinct rainfall seasons. The long rain season centred around April and the short rain season centred around November. During the long rain season, periods of heavy rains and showers are frequent. In between the two rainy seasons, we have the warm dry season that covers the period of late December to the beginning of March when sunny and warm conditions prevail, and the cool and dry season. This season covers the period June–October, a time of stable atmospheric conditions. The prevailing winds in Nairobi are NE (Ng'ang'a, 1980).

2. METHODOLOGY

Five stations were chosen for the study, the industrial area and four residential areas (Fig. 1). The industrial area (station 1) contains most of the potential air polluting industries found in Nairobi. Stations 2 and 3 were chosen for their close proximity to the industrial area, while stations 4 and 5 served as background locations which were far from the industrial area and also free from the influence of any major pollution sources.

As the particles in the sub-μm range are so small, they cannot be filtered out of the air separately and weighted. Their concentration was therefore measured by counting them as droplets after condensing moisture on them using the small particle detector, type CN, made by Gardner Associates.

With the help of a hand pump, the air sample was sucked through to the instrument and after allowing time for condensation to take place, a reading was obtained from the scale provided. From the scale reading, the manufacturers' calibration curve was used to obtain the number of Aitken condensation nuclei per cubic centimetre.

Measurements were taken from November 1981 to July 1982 at 1-h intervals twice a month in the stations. There were 11 measuring stations in the industrial area, average values of which determined the average industrial areas concentration, while single measuring stations were used to represent the concentration in the residential areas. Measurements made over a 5-min period centred around the hour were averaged and assigned to that hour.

3. RESULTS AND DISCUSSION

Figure 2 shows the average Aitken nuclei concentrations values for the five stations. The concentrations in the industrial area are on average a factor of two higher than those in the residential areas. The concentrations show a decrease with increasing distance from the industrial area, clear evidence that the industrial area is a major prolific source of Aitken nuclei. Station 2 has a higher concentration than station 3, which is closer to the industrial area, because the former is downwind of the industrial area and therefore is exposed to air pollution more frequently.

The number of Aitken nuclei in the air is strongly influenced by human activities which increase the natural number many times through release of combustion products from fires and combustion engines. Large industrial centres have been found to have a high record of condensation nuclei (Junge, 1951; Selezneva, 1966; Shives and Robinson, 1979; Peyrous and Lapeyre, 1982), and Nairobi appears to be no exception.

Figures 3 and 4 give the variation of the mean monthly

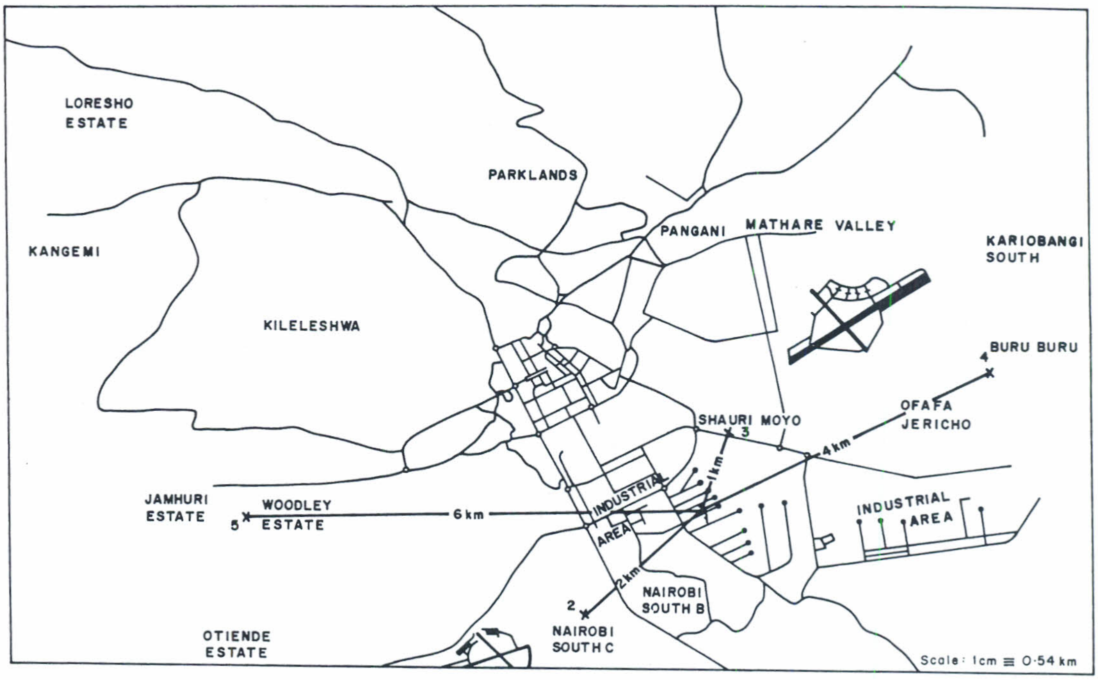

Fig. 1. Map of Nairobi showing Aitken nuclei measuring stations and their distances from the centre of the industrial area.

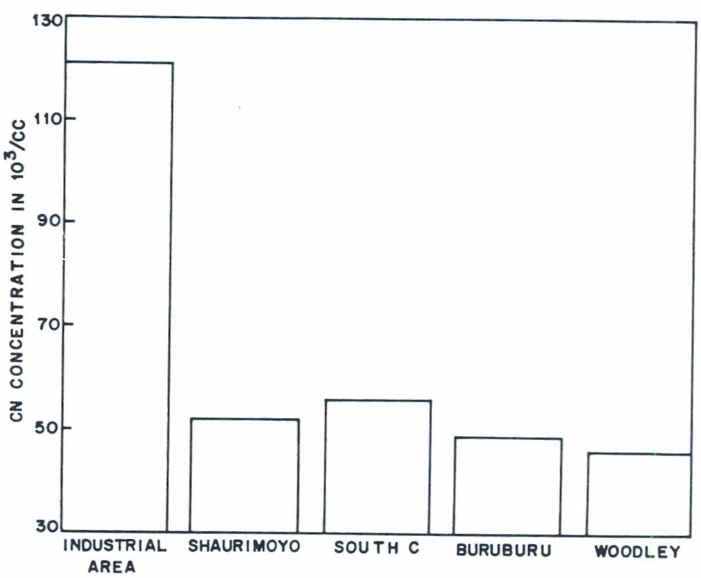

Fig. 2. Average Aitken nuclei concentrations in the five stations.

concentrations in the industrial and residential areas, respectively. The results show the Aitken nuclei concentrations to vary from month to month with low concentrations during the wet months, which implies a washout. The monthly variation follows the annual wind and stability patterns. Ng'ang'a (1980) has shown the wind-speed to be an important parameter in evaluating the short-term impact of air pollution in Nairobi. As a result, the occurrence of light winds and stable conditions in the June–July period can be identified as a contributing factor to high Aitken nuclei concentrations being recorded in these months. The period January–March, which is characterized by a high frequency of strong winds and therefore is favourable for good dispersion and dilution, shows lower concentrations than the June–July period. Industrial activity is almost constant over the year.

Condensation nuclei have been found to be a good indicator of pollution (Junge, 1963; Renoux and Mouder, 1978). On plotting monthly mean concentrations of Aitken nuclei and concentrations of total suspended particulates (TSP) that had been measured over the industrial area (Fig. 5), a good correlation, particularly as far as maxima and minima were concerned, was observed. This fact has important

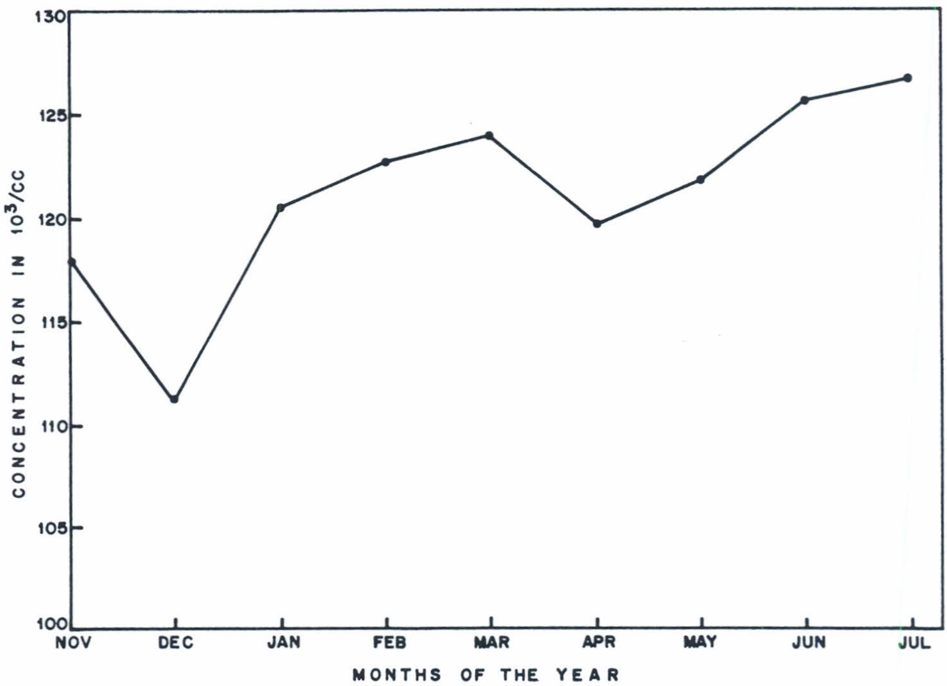

Fig. 3. Mean monthly Aitken nuclei concentrations in the industrial area.

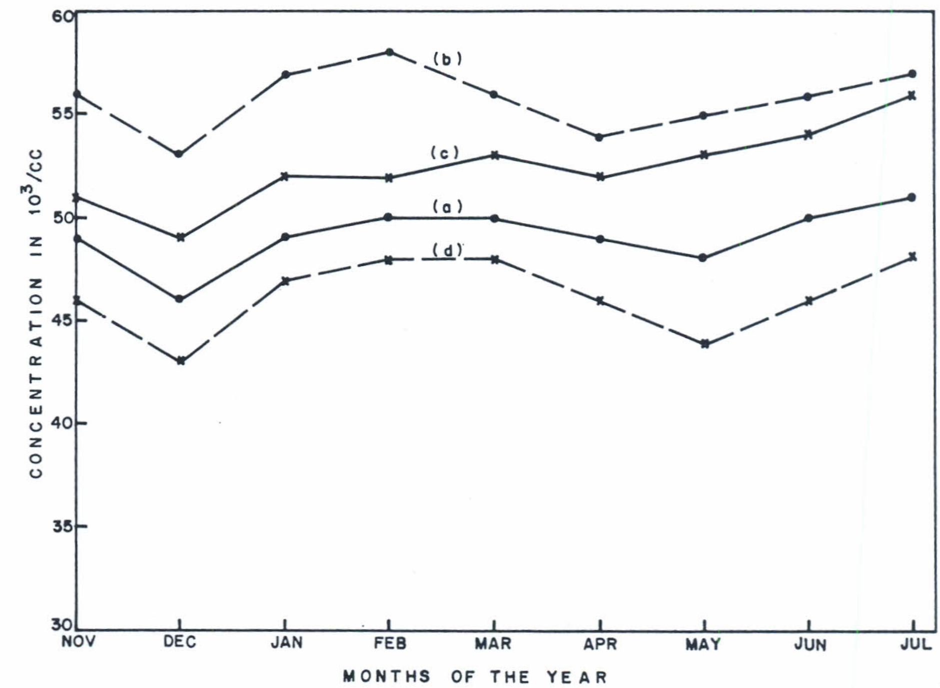

Fig. 4. Mean monthly Aitken nuclei concentrations in the four residential areas: (a) Buruburu, (b) Nairobi South C, (c) Shaurimoyo, (d) Woodley.

implications concerning the level of particulate pollution in the city of Nairobi, because it means that measurements of Aitken nuclei can serve as a good indicator of the level of TSP.

The modification of local precipitation through urbanization has aroused a great deal of reasearch interest among urban climatologists. One of the factors that has been investigated is the effect of increased concentration of condensation nuclei due to industrialization (Pilie and Kocmond, 1967; Hobbs *et al.*, 1970). Some previous research seems to indicate that high levels of these particles may lead to

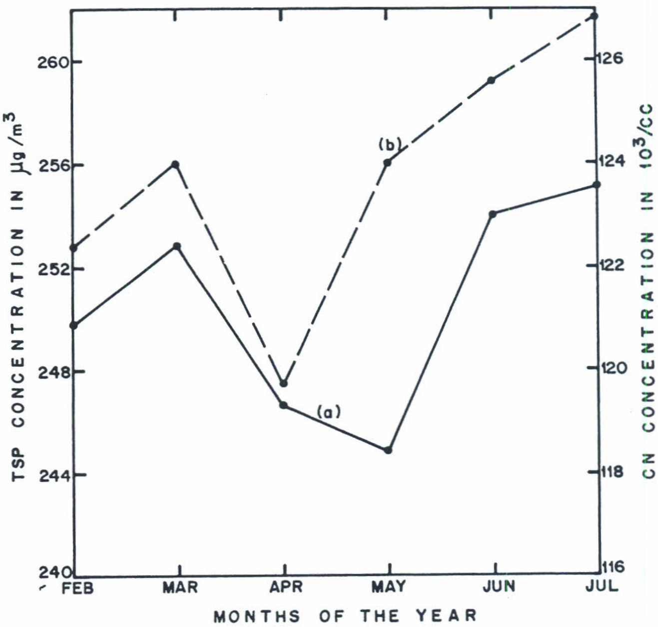

Fig. 5. Mean monthly concentrations of (a) TSP, (b) Aitken nuclei in the industrial area.

increased precipitation in an urban area (Ogden, 1969; Schaefer, 1969). How the high levels of condensation nuclei affect the precipitation in Nairobi is presently under investigation.

4. CONCLUSIONS

The concentrations of Aitken nuclei decrease with increasing distance from the industrial area of the city, indicating that the industrial area is a major source of suspended small particles. The Aitken nuclei concentration levels were found to be good indicators of the levels of TSP in Nairobi's urban area. The profiles of monthly variations show that there is a significant amount of washout, by rain, of both the small and large suspended particulates. Other meteorological parameters also affect the monthly variation of the Aitken nuclei concentration.

As no previous air sampling has been carried out in Nairobi due to a lack of monitoring instruments, it is not possible to relate the concentrations of the Aitken nuclei with pollutants other than TSP at this stage. This work was designed to be a pilot study to assess the concentration levels of particulate pollutants in the city. It should prove a useful foundation for more comprehensive and long term air pollution monitoring projects in Nairobi and other urban areas in the country.

REFERENCES

Hobbs P. V., Radke L. F. and Shumway S. E. (1970) Cloud condensation nuclei from industrial sources and their apparent influence on precipitation in Washington State. *J. atmos. Sci.* **27,** 81–89.

Junge C. E. (1951) *Nuclei of Atmospheric Condensation. Compendium of Meteorology* (edited by Malone T. F.), pp. 182–191. Bostons.

Junge C. E. (1963) *Air Chemistry and Radioactivity*, pp. 136–141. Academic Press, London.

Kenya Bureau of Statistics (1981) Statistical Abstracts, p. 12.

Kocmond W. C. and Mock E. J. (1972) The vertical distribution of cloud and Aitken nuclei downward of urban pollution. *J. appl. Met.* **11,** 141–148.

Ng'ang'a J. K. (1980) Some aspects of frequency and stability wind roses in a tropical region. *J. Air Wat. Pollut.* **13,** 27–34.

Ogden T. L. (1969) The effects on rainfall of a large steel works. *J. appl. Met.* **8,** 585–591.

Peyrous R. and Lapeyre R. M. (1982) Gaseous products created by electrical discharges in the atmosphere and condensation nuclei resulting from gaseous phase reactions. *Atmospheric Environment* **10,** 959–968.

Pilie R. J. and Kocmond W. C. (1967) Project fog drops. Cornell Aeornautical Laboratory, pp. 11–22.

Renoux A. and Mouder A. (1978) Study of light pollution in marine atmosphere. *Proc. 13th International Colloquium on Atmospheric Pollution*, Paris 1978.

Schaefer V. J. (1969) The inadvertent modification of the atmosphere by air pollution. *Bull Am. met. Soc.* **50,** 199–206.

Selezneva E. S. (1966) The main features of condensation nuclei distribution in the free atmosphere over the European territory of the U.S.S.R. *Tellus* **18,** 525–531.

Shives F. G. and Robinson E. (1979) Condensation nuclei concentrations at two specific northwest coastal sites. *Atmospheric Environment* **13,** 1091–1098.