NO_2 measurements on the Island of Hawaii[1]

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ABSTRACT

Recent measurements at Mauna Loa Observatory, Hawaii, appear to indicate a marked increase in the concentration of NO_2 over that measured 11 years ago.

Introduction

The Mauna Loa Observatory (MLO) is one of the world's original clean air monitoring stations (Price & Pales, 1959; Machta, 1972). Beginning in 1970, a program was initiated for the measurement of NO_2, SO_2 and particulate matter (currently part of the National Air Surveillance Network (NASN) of the Environmental Protection Agency (EPA)]. These measurements indicate NO_2 concentrations may have increased considerably over earlier measurements made on the Island of Hawaii (Junge, 1956 and 1957). The new Hawaii background NO_2 concentration is comparable to that reported at several mainland locations (EPA, 1971).

Experimental method

Samples are collected by bubbling ambient air through a system of tubes, each designed to react with a different constituent (e.g., NO_2, SO_2) of the atmosphere. The bubbler is operated for a predetermined time (24 hours, except MLO which is 48 hours), after which the sample is air-mailed to EPA for analysis. The analysis method for NO_2 has recently been published (Hauser & Shy, 1972). Particulate matter is collected by a "Hi-Vol" sampler.

Samples usually are taken twice a month. The NASN samples do not always coincide in time with samples taken in other parts of the island (i.e., at Volcano National Park and Hilo—see Fig. 1). All calculations, therefore, are based upon monthly averages.

Results

Junge (1956, 1957 and 1963) reported values of from 1.6 to 2.3 $\mu g/M^3$, with an error of up to 15% for NO_2 concentrations above the inversion level on the slopes of Mauna Kea. The average NO_2 concentration at MLO (also above the inversion layer) for fifty measurements over the past three years is 27.7 $\mu g/M^3$. Correspondence with EPA (Akland, private communication) indicates these measurements "are no better than $\pm 10\%$". However, recent evidence (Lenaggi et al., 1973) and correspondence with EPA (Thompson, private communication) has indicated that the previously reported NO_2 values may have to be reduced by a factor of 2 to 3. This is partly based upon a new EPA method of analysis (arsenite). The previous EPA method (Jacob-Hochheiser) also was used by the State of Hawaii, Department of Health. The average value for Hilo found by EPA was 31.9 $\mu g/M^3$ for 1972, and by the State of Hawaii 27.0 $\mu g/M^3$ for 1972. The sites are located in different parts of the city of Hilo. Recent correspondence with the State Department of Health indicates that the arsenite method gives results about a factor of 2 lower than previous measurements. This still gives values approximately five times those reported by Junge.

As no new absolute values are currently available from EPA, the numbers shown in this paper will be those reported by EPA as of

[1] The views expressed in this paper are those of the author and do not necessarily represent those of NOAA.

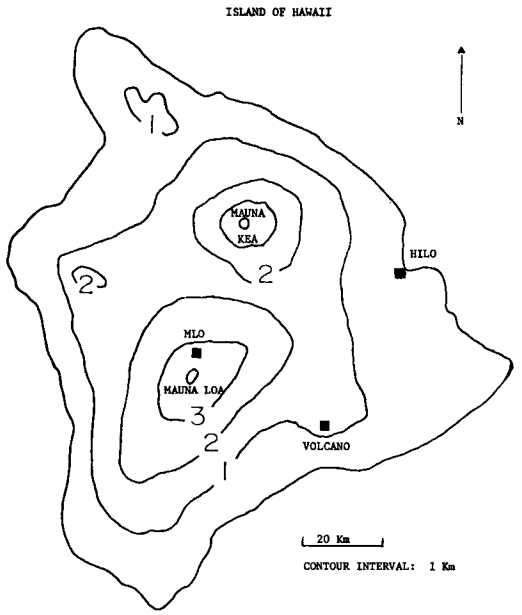

Fig. 1. Sampling stations on the Island of Hawaii.

April, 1973. It should be noted, however, that a change of the absolute values by a constant factor will not affect the correlation coefficients calculated below.

Fig. 2 shows the variation of NO_2 concentration with time for four locations within the State of Hawaii. The Honolulu sampling site is located in downtown Honolulu. The gaps in the graph represent missing or discarded data (e.g., the sample was received later than 14 days after it was obtained, insufficient solution was present for analysis, etc.—Akland, private communication). An apparent relationship between the Hawaii Island sites is easily noted.

Possibe sources of NO_2

The correlation coefficients (Gourevitch, 1965), calculated for different Hawaii Island sites (Table 1), indicate that they share a common NO_2 source. Examination of known wind patterns (Mendonca, 1969), coupled with the fact that the MLO values are occasionally higher than other sites (Fig. 2), suggests that the source of NO_2 may be the downslope air from above the island. This is air carried down the sides of the mountain as a result of the diurnal air flow, generated by the alternate daytime heating and nighttime cooling of the island. It has been shown to be characteristic of continental, rather than maritime air (Simpson, 1972).

SO_2 serves as an excellent tracer for local upslope winds, since Kilauea Volcano is a known SO_2 source (but not NO_2; Shepherd, 1919; Jagger, 1940). If high concentrations of NO_2 were coming from below MLO, they should be correlated with the SO_2. A correlation coefficient of 0.06 ($n = 22$) was found, indicating that the NO_2 does not originate below the station.

Particulate matter also is a good tracer since it occurs predominantly at levels below MLO (Pueschel & Mendonca, 1972; Mendonca & Pueschel, 1973). If the NO_2 were well correlated with the particulate matter, this would also indicate that the NO_2 source is below the observatory. A correlation coefficient of -0.11 ($n = 24$) was found, again indicating that source of NO_2 is not in the upslope air, and thus probably not of local island origin.

Because of the different transport rates and lifetimes of NO_2 and Pb (EPA, 1971; NAS, 1972) it is difficult to draw definite conclusions from the correlation coefficient of 0.20 ($n = 25$) found between NO_2 and Pb, which is also sampled at MLO (AEC, 1973). This is unfortunate, as Pb is an excellent indicator of anthropogenic activity.

If the NO_2 measured at MLO is of anthropogenic origin, it might come from Honolulu or from the Far East. A correlation coefficient of -0.28 was found between MLO and Honolulu for NO_2 (Table 1). This is in agreement with the facts that Honolulu is below the inversion level and to the northwest, while the trade winds generally blow from the northeast. Thus, Honolulu does not appear to be a likely source. The higher downslope concentrations, the intermittant peaks of high concentration and the increased industrialization of the Far East over the past 20 years, coupled with the fact that a westerly jet stream is known to reach these latitudes (a transport time of three days has been recorded for weather balloons to reach Hawaii from Japan—Bushniewski, private communication) would indicate that the possibility exists for the NO_2 detected to have been transported to Hawaii from the Far East. It must be stressed, however, that good evidence to either confirm or deny this supposition is lacking.

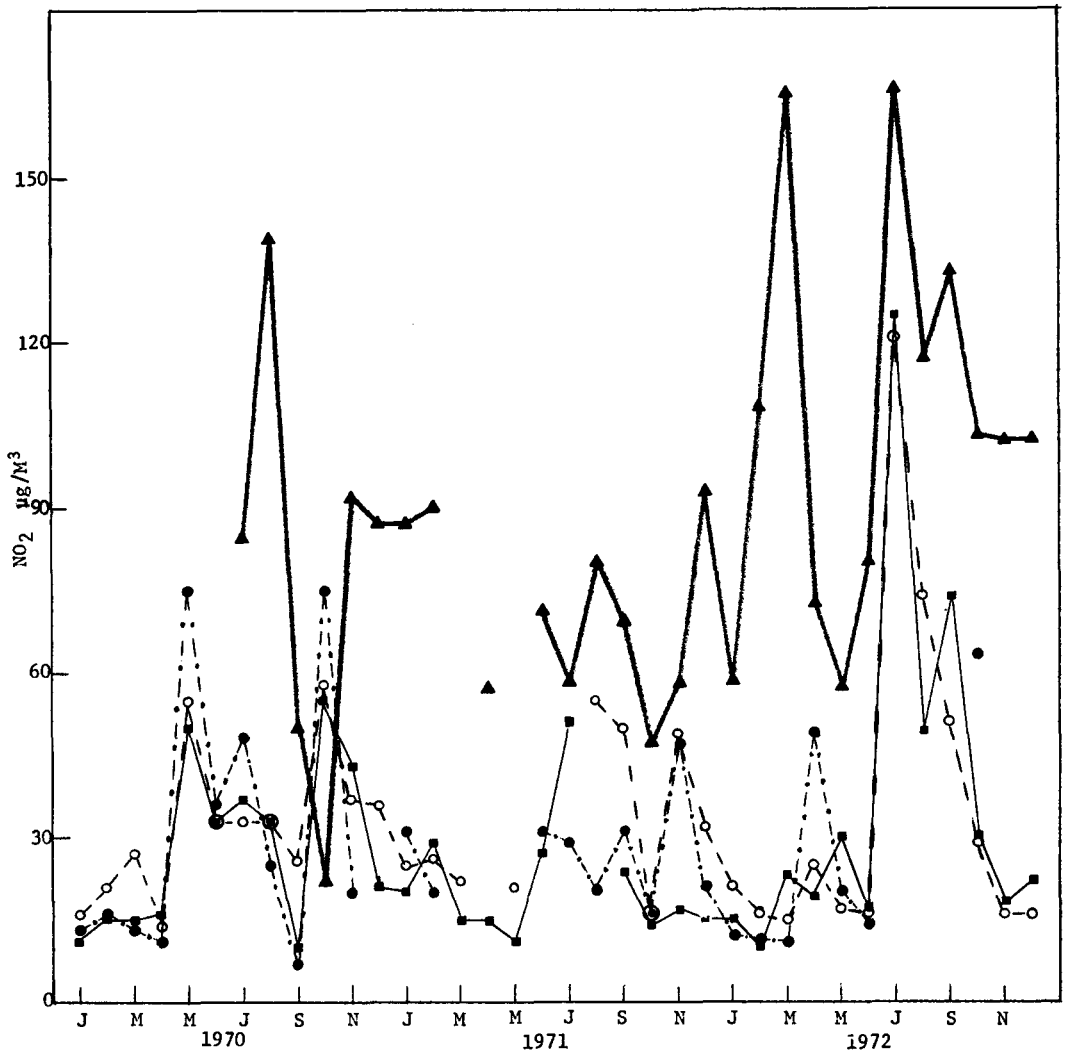

Fig. 2. Variation of NO_2 concentration with time at Honolulu (▲, ——), MLO (●, –·–·–), Hilo (○, – – –), and Volcano National Park (■, ——).

Conclusion

The NO_2 concentration apparently has risen markedly on the Island of Hawaii in recent years. The NO_2 does not appear to be of local origin, but representative of an enhanced background concentration in the upper air above the island. At this time, however, no definite statement can be made as to whether these measurements truly are representative of the global background or, perhaps, a consequence of jet-stream transport from the west.

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Table 1. *NO_2 correlation coefficients between various Hawaiian sites*

	Hilo (n)[a]	Volcano (n)	Honolulu (n)
MLO	.66 (25)	.80 (26)	–.28 (21)
HILO		.88 (32)	.17 (25)

[a] n = number of measurements.

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ИЗМЕРЕНИЯ NO_2 НА ОСТРОВЕ ГАВАЙИ

Недавние измерения в Обсерватории Мауна Лоа, Гавайи, указывают на заметное увеличение в концентрации NO_2 по сравнению с данными измерений, проведенных 11 лет назад.