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# RADIOCARBON CONCENTRATION OF CALIFORNIA AEROSOLS

RAINER BERGER, DAVID McJUNKIN, and ROBERTA JOHNSON

Institute of Geophysics and Planetary Physics
Departments of Anthropology and Geography
University of California, Los Angeles

ABSTRACT. In this study the origin of the carbonaceous fraction of total suspended particles (TSP) in air was analyzed. While the summer data show increasing carbon concentrations in the Los Angeles air basin from west to east, in the winter high levels of carbon particles can be found over the coast. The smallest and most dangerous particle fraction is principally composed of fossil carbon.

## INTRODUCTION

Recently, Appel *et al* (1983) found that ca 20% of the total suspended particle load in air is carbonaceous and the major single class constituting TSP loads at three California locations. In fact, it was suggested that conifers would produce more smog-causing compounds in wet growth years, whereas during dry periods, less smog production could be expected (Sandberg, Basso & Okin 1978, 1979; Bufalini, 1979; Miller, Pitts & Winer, 1979). The California Air Resources Board has long been concerned with the origin of smog-producing emissions. Thus it became necessary to determine to what extent aerosols contain recent biospheric or fossil fuel carbon. Studies by Currie *et al* (1983) and Currie, Klouda and Cooper (1980) show the widespread nature of the problem. By assaying TSP samples for radiocarbon, it is possible to calculate the fossil and contemporary carbon contributions to the aerosol particles and thus determine their origin (Lodge, Bien & Suess, 1960). The TSP collection and isotopic assay methods were described earlier by Berger, Johnson and Holmes (1983). The biospheric data were normalized against the $^{14}C$ levels in the prevailing atmosphere (Berger *et al,* ms; Levin *et al,* 1985).

## DISCUSSION

There is no question that in all the air basins analyzed, except for Chico, fossil fuel sources play the predominant role. The concentration of carbon particles is often controlled by seasonal wind patterns (Figs 1, 2) as apparent from the comparison below (Table 1).

Inspection of these data shows that not only the east-of-the-coast communities such as downtown Los Angeles and Upland are affected, but also those on the coast itself (Pacific Palisades).

When the state-wide data are inspected they show average carbon concentrations ranging from ca 1–21 $\mu g/m^3$. In one case involving straw burning near Chico, the percentage of carbon in particulates reached 34% based on 42.9 $\mu g/m^3$ of total particulates containing 14.7 $\mu g/m^3 C$.

In addition, a massive high-volume air sampler was tested which was on loan from the Electric Power Research Institute (EPRI). The impaction plates of this sampler are coated with teflon. This type of sampler provides either necessary quantities in less time or large enough samples when the ambient particle concentration is low.

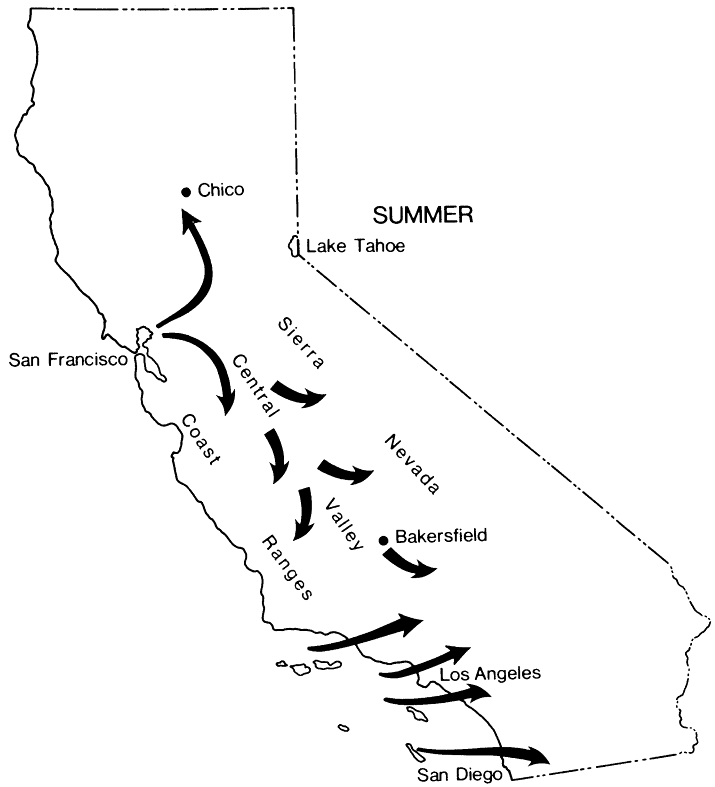


Fig 1. Typical summer wind patterns of California

TABLE 1
Isotopic composition of smog particles

| | Start | End | No. of days | Fossil carbon µg/m³ Pacific Palisades | Downtown Los Angeles | Upland |
|---|---|---|---|---|---|---|
| Summer 1982 | 6/8 | 6/21 | 10 | — | 9.4 | 9.0 |
| | 7/19 | 7/30 | 10 | 1.6 | 15.0 | 8.9 |
| | 8/9 | 8/20 | 10 | 0.2 | 6.5 | 17.6 |
| | | | Average | 0.6 | 10.3 | 11.8 |
| Winter 1982–1983 | 11/30 | 12/13 | 10 | 7.6 | 15.9 | 14.2 |
| | 1/25 | 2/07 | 9 | 3.7 | 4.3 | 1.9 |
| | 2/07 | 2/21 | 11 | 1.5 | 10.5 | 7.3 |
| | | | Average | 4.2 | 10.0 | 7.8 |
| % carbon in TSP | | | | | | |
| Summer 82 | | | | 3.0 | 15.3 | 12.8 |
| Winter 82–83 | | | | 6.7 | 17.0 | 14.0 |
| % fossil carbon in total carbon | | | | | | |
| Summer 82 | | | | 25.0 | 95.0 | 87.0 |
| Winter 82–83 | | | | 64.0 | 75.0 | 67.0 |

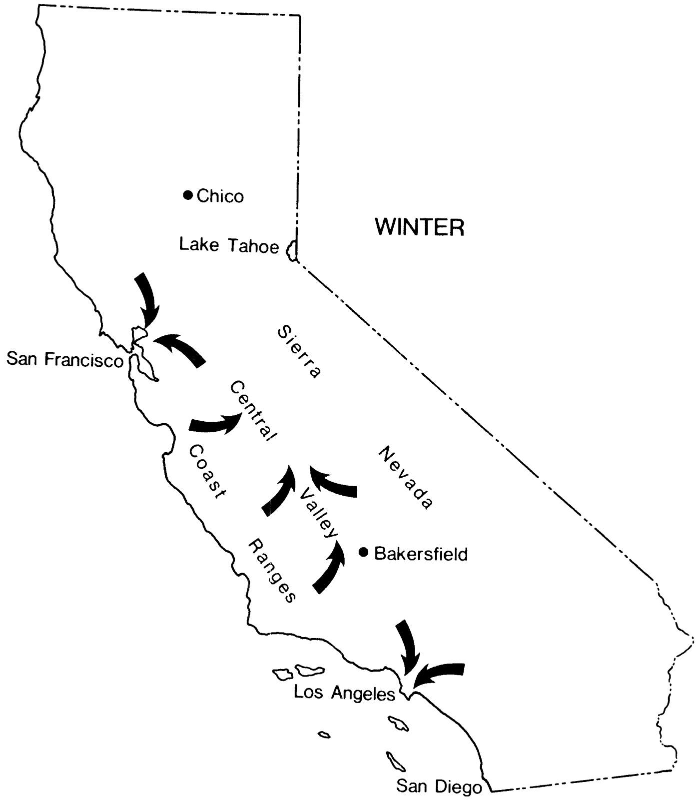


Fig 2. Typical winter wind patterns in California when the continental high pressure system is strong

Further, it allows size-segregated analyses with the results in Table 2.

Table 2 shows that much more information is obtainable by size-segregated samples than by ordinary air sampling techniques which combine all fractions into one single sample. Taking these data as indicative of the isotopic carbon content of particulates, the smallest-sized fraction is composed mainly of fossil carbon. This suggests that it is due mainly to motor vehicles and, in particular, to diesels. The smallest-sized particles are known

TABLE 2
Isotopic composition of smog particles

| | Size | Weight | | Biol C | | Fossil C | |
|---|---|---|---|---|---|---|---|
| | μ | g | % | g | % | g | % |
| Large impactor | 20–3.5 | 0.7408 | 30.6 | 0.4297 | 58 | 0.3111 | 42 |
| Small impactor | 3.5–1.7 | 0.6540 | 27.0 | 0.3401 | 52 | 0.3139 | 48 |
| Percipitator | up to 1.7 | 1.0300 | 42.4 | 0.2369 | 23 | 0.7931 | 77 |
| | | 2.4248 | 100.0 | 1.0067 | | 1.4181 | |

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TABLE 3
Isotopic composition of smog particles

| UCLA No. | Date Collected | | TSP μg/m³ air Total | TSP μg/m³ air C | % Carbon Content C | % Carbon Content Bio | Fossil |
|---|---|---|---|---|---|---|---|
| Pacific Palisades (Los Angeles Air Basin), 34° 2′ N, 118° 31′ W | | | | | | | |
| 2428A | 4/28–4/30 | 82 | 80.9 | 4.3 | 5.3 | 100 | — |
| 2428B&C | 5/4–5/13 | 82 | 86.5 | 2.8 | 3.2 | 99 | 1 |
| 2428E | 5/18–5/31 | 82 | 66.2 | §1.2 | §2.0 | — | — |
| 2428F | 6/8–6/21 | 82 | 57.2 | 1.2 | 2.1 | 100 | — |
| 2430A | 6/28–7/9 | 82 | 62.0 | §1.3 | §2.0 | — | — |
| 2431A | 7/19–7/30 | 82 | 82.6 | 2.3 | 2.8 | 32 | 68 |
| 2433B | 8/9–8/20 | 82 | 89.6 | 3.6 | 4.0 | 94 | 6 |
| 2433I | 9/20–10/18 | 82 | 142.1 | 4.9 | 3.4 | 72 | 28 |
| 2433E | 10/11–10/25 | 82 | 149.6 | 5.6 | 3.7 | 65 | 35 |
| 2439D | 11/1–11/12 | 82 | 97.3 | 6.6 | 6.8 | 28 | 72 |
| 2439B | 11/30–12/13 | 82 | 70.8 | 7.9 | 11.1 | 4 | 96 |
| 2440F | 1/25–2/7 | 83 | 121.8 | 5.4 | 4.4 | 32 | 68 |
| 2444C | 2/7–2/21 | 83 | 123.1 | 5.5 | 4.5 | 72 | 28 |
| 2445E | 4/4–4/15 | 83 | 85.1 | 3.6 | 4.1 | 70 | 30 |
| 2448A | 4/25–5/6 | 83 | 99.3 | 2.2 | 2.2 | 100 | — |
| 2448J | 5/16–5/27 | 83 | 72.0 | 4.3 | 6.0 | 41 | 59 |
| 2450F | 6/8–6/22 | 83 | 65.0 | 2.0 | 3.1 | 28 | 72 |
| 2453E | 6/27–7/8 | 83 | 73.0 | 2.7 | 3.7 | — | 100 |
| 2456A | 7/18–7/29 | 83 | 81.2 | 1.9 | 2.4 | 63 | 37 |
| 2458D | 8/29–9/9 | 83 | 100.8 | 2.7 | 2.7 | 62 | 38 |
| 2459F | 9/19–9/30 | 83 | 76.7 | 1.9 | 2.5 | 66 | 34 |
| 2452A | 10/11–10/25 | 83 | 118.3 | 3.0 | 3.1 | 39 | 41 |
| 2459C | 11/7–11/18 | 83 | 117.8 | 8.7 | 7.4 | 76 | 24 |
| Downtown Los Angeles (Los Angeles Air Basin), 34° 3′ N, 118° 15′ W | | | | | | | |
| 2428D | 4/27–4/29 | 82 | no data | | 10.1 | 57 | 43 |
| 2428G | 5/18–5/31 | 82 | 68.1 | 11.8 | 17.3 | 88 | 12 |
| 2428H | 6/7–6/18 | 82 | 74.5 | 9.4 | 12.6 | — | 100 |
| 2430B | 6/28–7/9 | 82 | 61.9 | 15.0 | 24.2 | — | 100 |
| 2431B | 7/19–7/30 | 82 | 82.0 | 7.5 | 9.1 | 14 | 86 |
| 2433J | 9/20–10/1 | 82 | 66.5 | 7.4 | 11.2 | 87 | 13 |
| 2440E | 11/29–12/10 | 82 | 94.1 | 20.1 | 21.4 | 21 | 79 |
| 2438E | 1/10–1/24 | 83 | 57.1 | 6.1 | 10.7 | 30 | 70 |
| 2444D | 2/7–2/21 | 83 | 74.7 | 14.0 | 18.8 | 25 | 75 |
| 2448K | 5/16–5/27 | 83 | 102.4 | 16.5 | 16.9 | 22 | 78 |
| 2450E | 6/8–6/22 | 83 | 94.0 | 10.0 | 10.6 | 24 | 76 |
| 2453F | 6/27–7/8 | 83 | 69.0 | 10.0 | 14.4 | 26 | 74 |
| 2456C | 7/18–7/29 | 83 | 78.5 | 12.5 | 15.9 | 25 | 75 |
| 2457C | 8/8–8/19 | 83 | 75.1 | 9.6 | 12.8 | 43 | 57 |
| 2458E | 8/29–9/9 | 83 | 75.7 | 15.5 | 20.5 | 29 | 71 |
| 2459E | 9/19–10/1 | 83 | 83.7 | 13.2 | 15.8 | 38 | 62 |
| 2452B | 10/11–10/25 | 83 | 97.0 | 15.6 | 16.2 | 24 | 76 |
| 2459B | 11/7–11/19 | 83 | 71.1 | 13.2 | 18.6 | 32 | 68 |
| El Monte (Los Angeles Air Basin), 34° 5′ N, 118° 2′ W | | | | | | | |
| 2427A&B | 3/25–4/9 | 82 | 82.4 | 10.9 | 13.4 | 84 | 16 |
| 2427C,D&E | 4/12–4/19 | 82 | 60.4 | 3.9 | 6.5 | 100 | — |
| 2427F | 4/19–4/22 | 82 | 84.3 | 13.5 | 19.7 | 45 | 55 |
| 2428I | 5/18–5/26 | 82 | 90.9 | 10.2 | 11.2 | 98 | 2 |
| 2428J | 6/7–6/18 | 82 | 83.6 | 9.7 | 11.6 | — | 100 |
| 2430C | 6/28–7/9 | 82 | 63.8 | 1.5 | 2.2 | — | 100 |
| 2431C | 7/19–7/30 | 82 | 85.8 | 11.5 | 13.5 | — | 100 |
| 2433C | 8/9–8/20 | 82 | 112.3 | 14.9 | 13.3 | — | 100 |
| 2464E | 3/28–4/26 | 84 | 56.9 | 8.5 | 15.0 | 38 | 62 |

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TABLE 3 (continued)

El Monte (Los Angeles Air Basin), 34° 5′ N, 118° 2′ W

| UCLA No. | Date Collected | | TSP μg/m³ air Total | TSP μg/m³ air C | % Carbon Content C | % Carbon Content Bio | Fossil |
|---|---|---|---|---|---|---|---|
| 2445A | 4/14–4/19 | 83 | 66.8 | 12.9 | 19.4 | 28 | 72 |
| 2445B | 4/14–4/19 | 83 | 64.3 | 6.5 | 14.5 | 20 | 70 |
| 2464A | 4/23–5/14 | 84 | 79.1 | 10.6 | 13.4 | 38 | 63 |
| 2451B | 9/27–10/14 | 83 | 70.2 | 10.7 | 15.2 | 40 | 60 |
| 2451C | 9/27–10/14 | 83 | 73.8 | 9.9 | 13.4 | 40 | 60 |
| 2451A | 10/18–10/28 | 83 | 84.1 | 14.8 | 17.6 | 27 | 73 |
| 2451D | 10/18–10/28 | 83 | 139.6 | 19.0 | 13.6 | 45 | 55 |
| 2449A | Brush of collector motor | | — | — | 100.0 | — | 100 |
| 2449B | Large impactor | | — | — | 5.1 | 58 | 42 |
| 2449C | Small impactor | | — | — | 6.9 | 52 | 48 |
| 2449D | Precipitator | | — | — | 13.3 | 23 | 77 |
| **Upland (Los Angeles Air Basin), 34° 6′ N, 117° 38′ W** | | | | | | | |
| 2428K | 5/18–5/31 | 82 | 90.7 | 11.9 | 13.1 | 17 | 83 |
| 2428L | 6/7–6/18 | 82 | 94.3 | 11.6 | 12.3 | 22 | 78 |
| 2430D | 6/28–7/9 | 82 | 60.9 | 3.4 | 5.6 | — | 100 |
| 2431D | 7/19–7/30 | 82 | 95.2 | 9.6 | 10.1 | 7 | 93 |
| 2433A | 8/9–8/20 | 82 | 120.5 | 19.3 | 16.0 | 9 | 91 |
| 2433H | 9/20–10/1 | 82 | 74.8 | 9.0 | 12.1 | 65 | 35 |
| 2433G | 10/11–10/22 | 82 | 101.7 | 9.2 | 9.0 | 95 | 5 |
| 2439A | 12/6–12/17 | 82 | 82.4 | 14.2 | 17.3 | — | 100 |
| 2438F | 1/10–1/21 | 83 | 61.2 | 6.9 | 11.2 | 72 | 28 |
| 2444A | 2/8–2/21 | 83 | 72.3 | 9.8 | 13.5 | 26 | 74 |
| 2448H | 5/16–5/27 | 83 | 106.5 | 16.9 | 15.9 | 17 | 83 |
| 2450G | 6/8–6/21 | 83 | 110.0 | 15.0 | 13.6 | 16 | 84 |
| 2459A | 11/7–11/18 | 83 | 73.7 | 12.0 | 16.3 | 45 | 55 |
| **Lake Tahoe (Lake Tahoe Air Basin), 39° 5′ N, 120° W** | | | | | | | |
| 2426A&B | 2/11–2/14 | 82 | 134.6 | 15.3 | 11.4 | 47 | 53 |
| 2426C&D | 2/29–3/4 | 82 | 81.9 | 6.2 | 7.6 | 47 | 53 |
| 2426E | 3/4–3/10 | 82 | 158.8 | 21.2 | 13.4 | 47 | 53 |
| 2426F | 3/10–3/16 | 82 | 43.3 | 8.0 | 20.7 | 47 | 53 |
| 2433D | 9/2–9/20 | 82 | 81.9 | 6.2 | 7.4 | 14 | 86 |
| 2456D | 7/11–7/24 | 83 | 33.2 | 4.0 | 12.0 | 29 | 71 |
| 2450B | 7/25–8/2 | 83 | 26.6 | 4.6 | 17.4 | 80 | 20 |
| 2450A | 8/2–8/8 | 83 | 39.0 | 6.7 | 17.2 | 25 | 75 |
| 2457A | 8/8–8/22 | 83 | 15.1 | 2.8 | 18.3 | 57 | 43 |
| 2457F | 8/15–8/22 | 83 | 22.1 | 4.9 | 22.3 | 36 | 64 |
| 2458F | 8/22–9/6 | 83 | 29.3 | 4.9 | 16.7 | 50 | 50 |
| 2459H | 9/5–9/11 | 83 | 16.4 | 6.8 | 41.3 | 64 | 36 |
| 2459I | 9/13–9/19 | 83 | 25.5 | 5.0 | 19.5 | 42 | 58 |
| 2452E | 9/19–10/3 | 83 | 9.6 | 1.7 | 17.8 | 55 | 45 |
| 2452C | 9/19–10/3 | 83 | 76.0 | 20.0 | 26.4 | 55 | 45 |
| **Chico (Central Valley Air Basin), 39° 46′ N, 121° 50′ W** | | | | | | | |
| 2433F | 9/21–10/7 | 82 | 28.0 | 5.0 | 17.7 | 79 | 21 |
| 2439G | 10/28–11/10 | 82 | 42.9 | 14.7 | 34.1 | 75 | 25 |
| **Bakersfield (Central Valley Air Basin), 35° 25′ N, 119° W** | | | | | | | |
| 2438B | 12/7–12/10 | 82 | 108.3 | 14.0 | 12.9 | 64 | 36 |
| 2438C | 12/20–12/23 | 82 | 89.2 | 19.0 | 21.4 | — | — |
| 2438A | 1/17–1/21 | 83 | 94.1 | 17.0 | 18.2 | 94 | 6 |
| 2438D | 1/24–1/28 | 83 | 147.0 | 10.1 | 6.9 | 30 | 70 |
| 2444F | 2/7–2/10 | 83 | 73.8 | 6.1 | 8.3 | 40 | 60 |

TABLE 3 (continued)

Bakersfield (Central Valley Air Basin), 35° 25′ N, 119° W

| | | | TSP $\mu g/m^3$ air | | % Carbon Content | | |
|---|---|---|---|---|---|---|---|
| UCLA No. | Date Collected | | Total | C | C | Bio | Fossil |
| 2444E | 2/10–2/14 | 83 | 66.9 | 13.9 | 21.6 | 19 | 81 |
| 2448E | 4/5–4/11 | 83 | 46.9 | 5.2 | 11.1 | 32 | 78 |
| 2453 | 5/12–5/20 | 83 | 60.0 | 5.0 | 8.3 | 38 | 62 |
| 2453B | 6/2–6/7 | 83 | 66.0 | 6.6 | 10.0 | 40 | 60 |
| 2453C | 6/27–7/1 | 83 | 75.0 | 7.5 | 10.1 | 42 | 58 |
| 2453D | 7/6–7/11 | 83 | 87.0 | 7.3 | 8.4 | 36 | 63 |
| 2458B | 8/24–9/2 | 83 | 75.7 | †6.3 | †8.3 | 52 | 48 |
| 2458A | 9/20–9/26 | 83 | 83.2 | 2.2 | 2.6 | 73 | 27 |
| El Cajon (San Diego Air Basin), 32° 48′ N, 116° 58′ W | | | | | | | |
| 2439C | 11/30–12/13 | 82 | 38.3 | 8.2 | 21.2 | 36 | 64 |
| 2438H | 12/29–1/12 | 82–83 | 40.5 | 7.8 | 19.2 | 39 | 61 |
| 2438G | 1/12–1/26 | 83 | 32.4 | 9.8 | 30.1 | 24 | 76 |
| 2445D | 3/30–4/26 | 83 | 27.0 | 2.8 | 10.6 | 23 | 77 |
| 2448I | 4/27–5/17 | 83 | 34.7 | 3.5 | 10.1 | 42 | 58 |
| 2448G | 5/18–6/8 | 83 | 37.1 | 4.9 | 13.4 | 28 | 72 |
| 2450D | 6/9–6/28 | 83 | 47.0 | 2.5 | 5.3 | 28 | 72 |
| 2456B | 6/29–7/19 | 83 | 44.0 | 3.8 | 8.7 | 27 | 73 |
| 2450C | 7/20–8/9 | 83 | 47.0 | 5.4 | 11.5 | 46 | 54 |
| 2457D | 8/10–8/30 | 83 | 32.5 | 3.2 | 9.7 | 50 | 50 |
| 2459G | 8/31–9/20 | 83 | 43.3 | 3.6 | 8.2 | 31 | 69 |
| 2452D | 9/21–10/18 | 83 | 27.3 | 3.5 | 13.0 | 38 | 62 |

to be the most harmful from a public health point of view since they readily enter the smallest lung capillaries.

With respect to the diurnal cycle, similarities seem to exist between ozone and TSP concentration levels. Both show maxima near noon (Hoggan, Davidson & Shikiya, nd; Fig 3). This may have important implications for ozone control if there is an active participation of the carbon portion of total suspended particles in air pollution reactions. Table 3 presents our state-wide analyses.

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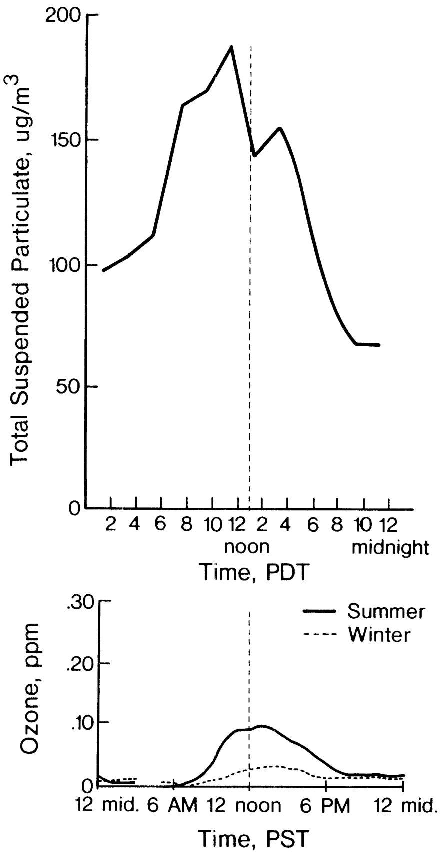


Fig 3. Diurnal variation of total suspended particles and ozone typical of the downtown Los Angeles area

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