NONIONIZING RADIATION EXPOSURE IN URBAN AREAS OF THE UNITED STATES

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1. INTRODUCTION

As part of a program to determine the need for environmental radio-frequency exposure standards, the U.S. Environmental Protection Agency began measuring radio-frequency radiation levels in urban areas of the United States in October 1975. Preliminary measurements indicate that transmissions in the broadcast bands are the principal sources of environmental radio-frequency radiation (1). Measurements were made in urban areas because sources are concentrated in and around regions of high population density (2,3). This paper describes the measurement system, typical environmental radio-frequency data, and one method of estimating population exposure.

2. MEASUREMENT SYSTEM

The measurement system consists of seven antennas, listed in Table 1, a scanning spectrum analyzer, and a minicomputer. The equipment is installed in a van equipped with gasoline powered electrical generators. Antennas are mounted sequentially on a pneumatically operated, telescoping mast and elevated 6.4 meters above ground level. After a predetermined number of scans through the desired frequency range, the data are corrected for antenna response and both the average root-mean-square values of the electric field strength and the power density obtained by integration of the squared field strength values are computed. The calculated values are displayed on the computer's cathode ray tube, copied onto thermally sensitive paper, and stored in the computer's memory. The measurement system, antenna calibration, and the analysis of system error are described in detail in reference (4). Examples of typical spectra can be found in references (4,5,6).

3. RESULTS

Measurements of environmental radio-frequency field strengths have been made at 72 sites located in Atlanta, Boston, Miami, or Philadelphia. The percent of sites having values equal to or less than a given total power density in the frequency range from 54- to 900-MHz are plotted against the logarithm of the power density on probability paper in Figure 1. Distributions for the land mobile bands, the low VHF-TV band, and the FM band are also shown. The power density values from the 0-2 MHz band are not included in this analysis and will be the subject of a later report.

The FM band contributes the most to environmental radio-frequency exposure between 54- and 900-MHz. Within this range of frequencies each of the three TV bands contributes about equally. The land mobile bands make an almost negligible contribution to the total power density and less active bands would make even smaller contributions. The maximum power

FREQUENCY (MHz)	USE	ANTENNA
0-2	VLF Communications and AM Standard Broadcast	Active Vertical Monopole
54-88	Low VHF Television Broadcast	Two Horizontal Orthogonal Dipoles
88-108	FM Broadcast	Three Orthogonal Dipoles
150-162	VHF Land Mobile	Vertical Coaxial Dipole
174-216	High VHF Television Broadcast	Two Horizontal Orthogonal Dipoles
450-470	UHF Land Mobile	Vertical Coaxial Dipole
470-806	UHF Television Broadcast	Horizontal Polarized Directional Log Periodic

TABLE 1 Antennas Used For Environmental Radio-Frequency Measurements

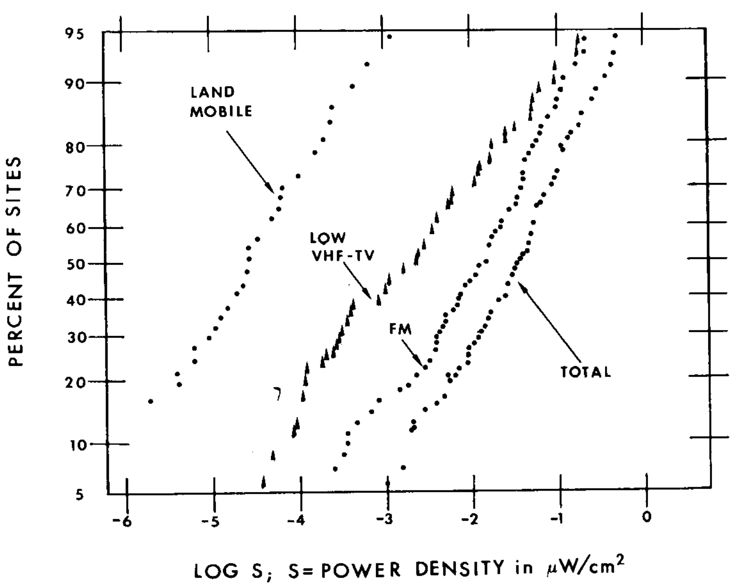

FIGURE 1 Distribution of Integral Power Density For The 54-900 MHz Band (total) And For Selected Bands In This Range

density at any site summed over all bands was 2.5 μW/cm². Four sites or about 6 percent fell in the range of 1 to 2.5 μW/cm² so that some of the population is potentially exposed to values in excess of 1 μW/cm².

3.1 Population Exposure

An estimator of population exposure must combine information on the distribution of radio-frequency levels with the distribution of population to provide numbers of people exposed at various levels. The population data base which was used here has been described elsewhere (6), but briefly, it consists of the population count for each of 250,000 census enumeration districts (CEDs) in the U.S. along with the geographic coordinates of the approximate population centroid for the CED. The population of an area is considered to be concentrated at a set of discrete points. The total power density from all sources at each of these discrete points is determined and the population exposed at the various levels is summed.

The model for determining the radio-frequency fields is based on data collected with the measurement system described above. The measured data from each source were observed to generally fall on a parabola when plotted as log (power density) versus log (distance). Furthermore, the shape of this parabola was approximately the same for all sources, regardless of source parameters, differing from source to source primarily by an additive constant. Therefore, an empirical expression for the field strength, E, in dB above 1 μV/m, as a function of log D (D = distance in miles), was chosen:

$$E = -10 (\log D)^2 - 20 \log D + C$$

where C is a source specific constant. To determine the field strength at any point (e.g., at a CED centroid) the three measurement sites nearest the point of interest are determined, and from the measured data at these three points, a value of the constant C for each source is determined. Substitution of the distance from the source to the point into the expression for E yields the required field strength estimate for that source. The individual source contributions can be appropriately summed to get the total exposure.

This approach was applied to each CED centroid in the four metropolitan areas where measurements had been made. The population for each CED was assigned the exposure determined for its centroid location. This information was sorted according to exposure ranges, and the results are presented in Figure 2 which shows the fraction of the population in the four metropolitan areas (total population = 8.3 million) exposed to various levels. The median power density is 0.014 μW/cm². Less than one percent of the population is exposed to values greater than 1 μW/cm².

This model for population exposure does not account for complications such as daily movements of the population within an area, exposures at heights greater than 6 meters where exposures can be higher due to non-uniform antenna radiation patterns, for any attenuation effects of typical buildings, or for times when sources are not transmitting. The results are simply the population residing in areas where an unobstructed measurement 6 meters above ground would result in the indicated values.

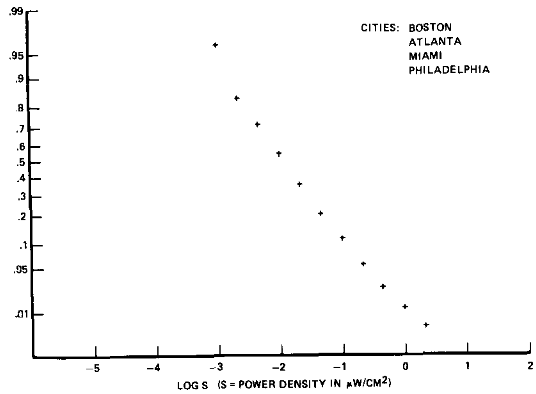

FIGURE 2 Fraction Of Population Exposed At Various Power Densities

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