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NONIONIZING RADIATION IN THE NEW YORK METROPOLITAN AREA

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The U. S. Environmental Protection Agency (EPA) has the responsibility to protect the health and welfare of man and the environment from adverse effects due to exposure to both ionizing and nonionizing radiation. Ionizing radiation (including vacuum ultraviolet, x-rays, gamma rays, and various energetic particles such as betas, protons, neutrons, alphas) may have sufficient energy to cause ionization and significant chemical change in the cells of biological tissue for which the energy necessary to produce to a frequency of 2.4 x 10^{6} GHZ* (a wavelength of 1.2 x 10^{-5} cm). Nonionizing electromagnetic radiation, as its name implies, is incapable of producing ionization in biological tissue. Included in the frequency spectrum of nonionizing radiation are microwave and radiofrequency radiation. Although environmental levels of nonionizing radiation were negligible before the 1930's , virtually every American is now exposed. Sources have proliferated in number as well as power. Since 1945 electronics,navigation, and communications industries have flourished and today there are millions of sources operating. The number of radiofrequency and microwave sources alone is estimated to be increasing at 15 percent annually. In the ranges of primary interest, the radiofrequency (10 MHz to 300MHz) and microwave (300 MHz to 300 GHz) frequencies, sources include the following:

- radio and television broadcast stations
- radars
- satellite communications system earth terminals
- point to point microwave communications
- mobile communications systems
- microwave ovens
- industrial heating equipment

Quantum energies associated with microwave radiation at its extreme of 300 GHz are about 8000 times less than is needed to destroy cells by ionization; however, radiofrequency and microwave radiation are absorbed by tissue and do interact with biological systems. The electromagnetic energy is transformed into increased kinetic energy of the absorbing molecules, and results in tissue heating. The process of absorption and distribution in irradiated tissue depends on the radiation wavelength and its relationship to the physical shape, size and distribution of a nonuniform system of tissues, the electrical characteristics of tissue at specific frequencies, and the intensity of the radiation. A complex tissue structure such as the human body absorbs energy differently in specific parts,so that localized heating or non-uniform absorption may result.

Two kinds of effects on humans due to exposure to radiofrequency and microwave radiation are usually discussed: thermal effects from high-level exposures, and possible low-level or "nonthermal effects."

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* GHz, or gigahertz = 10^{9} cycles per second
MHz, or megahertz = 10^{6} cycles per second

Thermal effects resulting from irradiation with power densities above 10,000 microwatts/square centimeter, (abbreviated as uW/cm^2) and equivalent to ten milliwatts/cm^2 (mW/cm^2), involve tissue heating with the possibility of thermal damage. They may include increased body temperature and resulting heat stress, cataract formation, cardiovascular temperature and resulting heat stress, cataract formation, cardiovascular effects, testicular effects, and brainwave pattern changes.

Low-level effects are a subject of controversy. Effects of exposure to 1,000 uW/cm^2 (one mW/cm^2) or less have not been well-documented; in fact, all U. S. scientists do not even agree that they exist. Some Russian and Czech scientists believe that they occur, but not as a result of increased tissue temperature (hence "nonthermal" effects). Their views are based on animal research and statistical studies of workers' exposure histories and medical records. Considered to be mainly central nervous sytem effects, symptoms attributed to low-level exposure include headache, weariness, dizziness, irritability, emotional instability, partial loss of memory, loss of appetite, cardiovascular effects, electroencephalogram changes, blood chemistry changes, changes in respiration, and possible genetic effects.

The exposure limits in protective standards differ widely among various countries. In Eastern Europe standards are geared to protect against "non-thermal effects" of long-term exposure to low intensity radiation. On the other hand, in the U. S. and most Western European countries, standards were designed with high-level exposures and possible thermal effects in mind.

In the United States, existing guidelines or standards for exposure to nonionizing radiation are based on the premise that any direct effect on health is due to the heat that is generated when radiation is absorbed. In 1971, the Occupational Safety and Health Administration (OSHA) adopted the American National Standards Institute (ANSI) limit of 10 mW/cm^2 (milliwatts per square centimeter) for the frequency range of 10 MHz (megahertz) to 100 GHz (gigahertz) as a consensus standard for occupational exposure to electromagnetic radiation. The present limit, defined by ANSI, allows a power density of 10 mW/cm^2 for any 0.1 hour period or an energy density of 1 mW/cm^2 during any 0.1 hour period. The present standard gives no upper limit for total exposure. According to a December 31, 1975, decision, the OSHA standard is considered to be advisory rather than mandatory. In contrast, the USSR occupational standards allowed for the 300 MHz-300 GHz frequency range cannot exceed 10 uW/cm^2 for the duration of a working day although greater exposures are allowed for short periods of time,and the recommended general population exposure standard is 1 uW/cm^2 (HA74).

EPA has conducted surveys of metropolitan areas as part of a program to define environmental levels of radiofrequency radiation from a human exposure standpoint. Accurate electromagnetic radiation intensity measurements are made to define normal ambient radio-frequency levels before a decision can be made on the need to establish population exposure standards. The frequencies studied are shown in Table 1.

Metropolitan areas studied to date include New York, Boston, Philadelphia, Washington, Atlanta, Miami, Chicago, Las Vegas, San Diego, Houston, Portland, and Los Angeles. Further studies are continuing elsewhere.

In Region II, the New York Metropolitan area was monitored for radiofrequency and microwave radiation levels. Data for Region II were measured during the period from August 16 to September 1, 1976. The five boroughs of New York City, Long Island and West Orange, New Jersey were examined. The results of the measurements are shown in Table 2. The single maximum reading was for a New Jersey location underneath an FM antenna where the measured value was 4.6 uW/cm^2, a figure above the recommended Soviet standard for general population exposures. While this location is accessible to the public, it involves little population exposure. Few people would normally be near the location.

There are two types of data base which are pertinent to analyzing environmental levels of nonionizing electromagnetic radiation at frequencies below 300 GHz. The first of these consists of computer files of source locations and characteristics that permit the calculation of expected exposure levels if an appropriate model and sufficient source paramaters are available. The second type of data base consists of reports on studies of specific sources and the ambient environment. Until recently, only limited data have been available on the ambient environment.

By comparing population distribution and power density in each area of interest, population exposure can be determined. Such a comparison is only an approximation, since relatively few people remain in one place for a 24-hour period each day. However, the method offers a general estimate of total exposure. In an unpublished report (AT 76) Athey, et al reported "the median power density value is agout 0.006 uW/cm^2 with about 1% of the population estimated to be exposed at levels above 1 uW/cm^2." The median exposure estimated for the New York Metropolitan area is 0.002 uW/cm^2.

Levels recorded at individual building sites in the cities of New York, Chicago, and Miami are compared in Table 3. The locations were specifically chosen to obtain maximum power density measurements in each city. These locations are specified in the Table. All readings were taken indoors near windows facing transmitters. It can be seen that some portion of the general population is exposed to levels that exceed the Soviet standards.

Summary

In summary, several points should be noted:

* In small areas very close to transmitters there are levels of exposure above 1 uW/cm^2. In some cases these areas are accessible to the public.

* In New York City the median exposure was 0.00217 uW/cm^2, with less than 0.2 % of the population exposed to levels greater than 1 uW/cm^2.

* There are areas of tall buildings which have higher exposure levels caused by proximity to broadcasting antennae. Occupants of such areas are not likely to experience such levels of exposure for long periods of time since structural materials and window blinds can significantly reduce actual levels in the buildings.

* Data analysis indicates that the FM band contributes the largest fraction of radiofrequency environmental exposure between 54 and 900 MHz.

* Various television bands contribute about equal amounts of environmental exposure.

* Land mobile bands make the smallest exposure contribution to environmental radiofrequency radiation.

Further study is required before a total picture of the general population exposure can be drawn. Beyond areas adjacent to transmitter locations, radiofrequency exposure levels are well below present U. S. standards, which are based primarily on known thermal effects. Additional investigation of the low level effects of nonionizing radiations are being conducted in order to determine an appropriate general population exposure threshold if this is indeed indicated.

Table 1

Frequencies of Interest
for Microwave Exposure Study

Symbol	Principal Use	Frequency (MHz)
LVHF	VHF television signals (channels 2-6)	58-88
HVHF	VHF television signals (channels 7-13)	174-216
FM	the FM radio band	88-108
LLM	Land Mobile bands	150
HLM	Land Mobile bands	450
UHF	UHF television bands (channels 14-83)	470-890

Table 2 Exposure Levels at New York Metropolitan Area Measurement Sites

Description Location	Power Density by Band (uW/cm², except n=nW/cm², p=pW/cm²) 0-2	LVHF	HVHF	FM	UHF	LLM	HLM	TOTAL
Riverside Park	.042	.28n	.0011	.43n	.002n	*	*	.0018
Central High	.018	.027n	.083n	.25n	.006n	.071n	.018n	.00046
Essex Green Ctr.	.025	.11n	.27n	1.9	.030	.14n	.25n	1.9
Mt. Pleasant St.	*	*	*	4.6	.26n	*	*	4.6
Channel 68 Tower	*	*	*	*	.35	*	*	.35
Central Park,So.	*	.032	.016	.080	.039n	*	*	.13
Central Pk, N.	.085	.0090	.058	.018	.006n	.019n	.011n	.085
Ft. Tryon Park	.10	.24n	.10n	.31n	.039n	*	*	.00069
Randall's Is.	.068	.0031	.021	.0026	.0036	*	*	.030
Battery Park	.036	.77n	.36n	.0010	. *	.010n	.009n	.0021
Foley Square	.031	.0071	.0065	.0048	.033n	*	*	.018
E. River Pk.	.31	.010	.011	.012	.49n	.070n	.041n	.034
McCarrey Park	.32	.14	.19	.25	.092n	*	*	.58
Ft. Green Pk.	.0056	.0010	.0042	.0017	.36	.93n	.040n	.36
Prospect Park	.0092	.0012	.0011	.63n	.33n	*	*	.0033
Flatlands	.0086	.42n	.0017	.48n	.10n	.003n	.003n	.0027
Fort Hamilton	.020	.015n	.083n	.051n	.084n	*	*	.00023
Linden Blvd.	.0055	.0011	.0013	.55n	.37n	.010n	.001n	.0033
Shore Pkwy	.012	.27n	.0055	.61n	.0018	*	*	.0082
Yankee Stadium	.062	.0018	.0029	.0020	.082n	*	*	.0068
Fordham Univ.	.011	.13n	.26n	.027	.023n	.011n	*	.027
Fordham Radio	*	*	*	.12	*	*	*	.12
Van Cortland Pk.	.049	.80n	.0069	.83n	.69n	*	*	.0092
Cunningham Park	.033	.19n	.0020	.42n	.36n	.010n	.006n	.0030
Great Neck	.029	.41n	.42n	.57n	.23n	*	*	.0016
Flushing Meadow	.057	.0023	.071	.0068	.026	*	*	.11
Aqueduct	.014	.50n	.0033	.0010	.36n	.0086n	.0079n	.0052

Table 2 (Cont'd)

Description Location	0-2	LVHF	HVHF	FM	UHF	LLM	HLM	TOTAL
Forest Park	.012	.0016	.52n	.59n	.042n	*	*	.0028
Belmont Park	.0052	.055n	.0033	.35n	.37n	*	*	.0041
White Plains Rd.	.0095	.50n	.0014	.24n	.84n	.73p	.0020n	.0030
Throgs Neck	.16	.10n	.96n	.095n	.35n	*	*	.0015
Pelham Bay Park	.23	.26n	.0027	.48n	.0010	.64p	.0011n	.0044
Woodmere	.0093	.18n	.0015	.30n	.0013	.0018n	.016n	.0033
WIOK-FM	*	*	*	.22	*	*	*	.22
Grand Avenue Sch.	.028	.027n	.13n	.052	.76n	*	*	.053
Mitchel Park	.011	.17n	.63n	.14	.033	*	*	.17
Clove Lakes Park	.017	.87n	.0012	.0015	.0035n	*	*	.0036
Willowbrook Pk	.028	.26n	.38n	.48n	.16p	.57p	.0012	.0011
Tottenville	.0043	.012n	.015n	.041n	.23p	*	*	.000068
Great Kills Pk	.020	.27	.0023	.42n	.0029	*	*	.0059

Table 3

Maximum Power Densities
At Locations in Some Cities Surveyed

Location	Total Field Strength (uW/cm^2)
New York City	
World Trade Center	
(Observation Deck outdoors)	6.8
(Observation deck indoors)	1.2
Empire State Building (Inside, 102nd floor near window)	32.50
Pan Am Building (Inside, facing Empire State Building)	10.3
Miami	
Office Building at 2 Biscayne Blvd.	96.85*
Chicago	
Sears Tower (50th floor, inside, nearwindow)	65.73
Federal Building (39th floor)	6.47

* Measurement for 38th floor window facing FM station WIMI only, the strongest local source.

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