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OUTDOOR RADIOFREQUENCY RADIATION LEVELS IN THE WEST BANK—PALESTINE

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This work presents the results of exposure levels to radio frequency (RF) emission from different sources in the environment of the West Bank—Palestine. These RF emitters include FM and TV broadcasting stations and mobile phone base stations. Power densities were measured at 65 locations distributed over the West Bank area. These locations include mainly centres of the major cities. Also a 24 h activity level was investigated for a mobile phone base station to determine the maximum activity level for this kind of RF emitters. All measurements were conducted at a height of 1.7 m above ground level using hand held Narda SRM 3000 spectrum analyzer with isotropic antenna capable of collecting RF signals in the frequency band from 75 MHz to 3 GHz. The average value of power density resulted from FM radio broadcasting in all investigated locations was 0.148 μW cm^{-2}, from TV broadcasting was 0.007 μW cm^{-2} and from mobile phone base station was 0.089 μW cm^{-2}. The maximum total exposure evaluated at any location was 3.86 μW cm^{-2}. The corresponding exposure quotient calculated for this site was 0.02. This value is well below unity indicating compliance with the International Commission on non-ionising Radiation protection guidelines. Contributions from all relevant RF sources to the total exposure were evaluated and found to be ∼62 % from FM radio, 3 % for TV broadcasting and 35 % from mobile phone base stations. The average total exposure from all investigated RF sources was 0.37 μW cm^{-2}.

INTRODUCTION

People are increasingly exposed to electromagnetic energy in their environment. The primary natural source of this exposure is the Sun. Radiofrequency radiation (RF) is an important part of the electromagnetic spectrum. Man-made sources, however, are the main source of RF exposure in highly populated areas. The use of RF radiation in wireless communications has increased greatly in recent years and there is continuing change in the frequencies used and variety of applications. Man is exposed to the RF energy radiated by transmitting antennas of FM radio broadcasting in the range of 88–108 MHz, TV broadcasting in the VHF and UHF range and mobile phone base stations[1]. Radio and TV terrestrial transmitters provide an omni-directional coverage area in order to serve the whole population around the site. Usually, a restricted zone around transmitting antennae is provided to limit the exposure of the general public to relatively high levels of electromagnetic fields. Mobile telephony base stations transmit power levels from a few Watts to 100 Watts or more. Their antennae emit radiofrequency beams that are typically very narrow in the vertical direction, but quite broad in the horizontal direction. Because of the narrow vertical spread of the beam, the RF power intensity at the ground directly below antenna is low. The field intensity increases slightly as one moves away from the base station and then decreases at greater distances from the antenna[2]. In principle, the emitted power from FM radio and TV transmitters do not vary over time. In contrast, the radiated power of base stations does vary with time as traffic channels of the base station emit when traffic requires and can transmit at full capacity at peak traffic[3].

Exposure of the general public to RF is usually assessed in the context of the International Commission on non-ionizing Radiation protection (ICNIRP) guidelines. These guidelines are based on acute health effects such as elevation of tissue temperatures resulting from absorption of energy during exposure to RF electromagnetic fields. If the experimental values of power density are less than safety limits recommended by ICNIRP, then it is assumed that there is no health risk[1, 4].

Study of electromagnetic fields and their levels in the Palestinian environment is relatively a new area of research. Initial studies have been reported by the Center for Radiation Science & Technology at Al-Quds University as a response to the public concern about possible health effects of this kind of non-ionising radiation. This concern has increased mainly after the spread of mobile telephony base stations over the country, and has became the main area of concern from environmental electromagnetic fields. The public interest has also highlighted the importance of having accessible and easy-to-understand information on the levels of electromagnetic

exposure in their environment. The main goal of this work is to evaluate the exposure levels from different sources of radiofrequency exposure in highly populated areas in the major cities of the West Bank and to clarify the relative contribution of different sources to the total exposure.

MATERIALS AND METHODS

The area of the West Bank is extended over ~5640 km^2 with a population of about 2.3 millions. Prior to surveying measurements, a collection of data has been performed to compile a detailed database of all RF sources in the West Bank area. This involves a collection of all relevant information on the electromagnetic fields sources which includes location, site characteristics and transmitter technical parameters. All these information are provided by the Ministry of Telecommunications and in case of mobile stations by the Palestine Cellular Communications Ltd. This database includes information about 500 mobile base stations, 37 TV broadcasting stations and 27 FM radio stations. These data include source address/coordinates, transmitter output power, frequencies and antenna's gain and pattern. No AM radio stations are operated by the Palestinian Authority.

Measurements of RF exposure levels from different sources were conducted in 65 locations over the area of the West Bank, most of them in highly populated areas in the centres of the major cities. These measurements are referred to as environmental RF exposure levels and data are presented in power density. The location of each measurement was recorded by a GPS system. RF signals were collected using a Narda SRM-3000 selective radiation meter (Narda Safety Test Solutions). This instrument is a portable spectrum analyzer that covers the range 75 MHz–3 GHz with high sensitivity, equipped with an isotropic antenna. The instrument is designed to give immediate on-site results. The spectrum analysis mode provides an overview of all frequency components with their field strengths. The spectrum is clearly displayed and determines maximum values measured directly on site. In all cases, RF radiation levels were averaged over ~6-min interval. Significant signals in the measured frequency range include FM radio and TV broadcasting as well as mobile phone base stations. All measurements were performed in far-field conditions daily in real-life conditions with the antenna positioned at a height of 1.7 m above ground level. In the case of mobile phone base stations measurements, only downlink frequencies of the GSM-900 were considered.

In multiple frequency environment, all of the individual signals will contribute to the personal exposure, since their effects are additive, so the total exposure can be expressed in terms of exposure quotient based on the measured power density S of each detected signal and the ICNIRP reference level corresponding to the frequency of the signal, thus[5]:

$$\text{Exposure quotient} = \frac{S}{S_{\text{ref}}} \tag{1}$$

where S is the measured power density corresponding to the frequency of the signal and $S_{\text{ref:}}$ is the power density reference level advised in the ICNIRP guidelines corresponding to the frequency of the signal.

Total exposure quotient then is given by:

$$\text{Total exposure quotient} = \sum_{i=1}^{Nt} \frac{Si}{S_{\text{ref}_i}} \tag{2}$$

where, Nt is the total number of signals producing the exposure, S_i is the power density measured corresponding to the frequency of the signal and S_{refi} is the power density reference level advised in the ICNIRP guidelines corresponding to the frequency of the signal. It is also a usual practice to estimate how many times the exposure level is below the safe limit. Times below limit (TBL) can be derived easily from the following equation:

$$\text{TBL} = \frac{1}{\sum_{i=1}^{Nt} \frac{Si}{S_{\text{ref}_i}}} \tag{3}$$

Total exposure quotient not exceeding unity indicates compliance with the ICNIRP guidelines.

RESULTS AND DISCUSSION

A number of measurements were selected in each major city and the resulting power densities were divided into groups corresponding to individual signals (FM radio, TV and mobile phone base stations). The average exposure from different sources was calculated for each city as well as the contribution to the total exposure of the population. Figure 1 illustrates a typical spectrum of RF exposure detected in the city of Bethlehem. The spectrum shows a detected GSM-1800 signals, resulting from the emission of Israeli mobile phone base stations which are either located outside the West Bank or in Israeli settlements around. Exposure to RF signals from GSM-1800 is not analyzed in this work as it is not significant and only detected in few places.

Exposure levels from different RF sources varied from one city to other depending on the selected location (distance from the transmitting antenna), time of measurement, output powers of

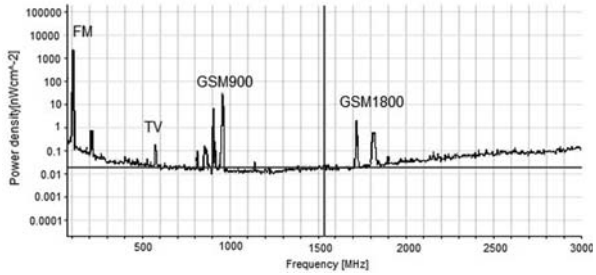

Figure 1. Typical RF exposure spectrum detected in the city of Bethlehem.

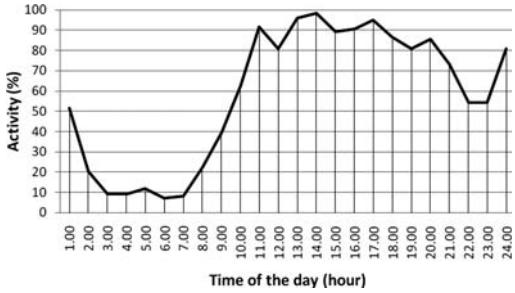

Figure 2. Twenty-four hours activity of a GSM-900 mobile phone base station measured in Bethlehem.

the RF transmitting antennas and other factors. In the case of mobile phone base station measurements, the 24 h activity of a base station was investigated and the maximum traffic was found from 11:00 to 14:00.This fact was considered in determining the time of measurement. Figure 2 shows the activity of a GSM-900 mobile phone base station measured for 24 h. Table 1 presents the measured RF exposure levels and the total exposure from different sources in the residential areas of the major cities in the West Bank. In most cases the dominant source of exposure is found to be the FM radio broadcasting. Relative contribution from individual RF sources to the total exposure was 62 % from FM, 35 % from mobile base stations and 3 % from TV broadcasting. Figure 3 shows the relative contributions from FM, GSM-900 and TV signals to the total exposure evaluated from all these sources. The amount by which individual sources contribute to the total exposure also varies from one city to other. In East Jerusalem, Tulkarem and Jericho, the situation is different. The dominant source of exposure in these areas is the mobile telephony base stations. FM radio services are provided in these areas by one or two radio stations. For comparison, in the city of Ramallah, about 6 FM radio stations provide this service. East of

Table 1. Environmental RF exposure levels resulted from different sources in the major cities of the West Bank.

City	FM (μW cm^{-2})	TV (μW cm^{-2})	GSM-900 (μW cm^{-2})	Total (μW cm^{-2})	TBL[a]
Bethlehem	0.05	0.002	0.03	0.082	3080
Hebron	0.15	0.005	0.14	0.295	925
Nablus	0.08	0.04	0.06	0.18	1442
Ramallah	1.52	0.02	0.63	2.17	110
Jenin	0.04	0.001	0.04	0.081	3414
Tulkarem	0.017	0.007	0.038	0.062	5064
Jericho	0.002	0.002	0.083	0.087	4939
East of Jerusalem	0.0008	0.0009	0.014	0.016	25832
Average	0.23	0.01	0.13	0.37	676

[a]Times below ICNIRPs limit.

Jerusalem, most of the measurements were conducted near the campus of Al-Quds University with a number of mobile phone base stations around, providing services for more than 20 000 people. The contribution of RF signals from mobile phone base stations to the total exposure was about 87 %. A similar situation was found in Jericho city which is a crossing border between Jordan, Israel and the Palestinian territories. The contribution of signals from mobile base stations was the highest (~95 %).

The maximum power density measured at any location was 2.66 μW cm^{-2} and resulted from FM radio signals in the city centre of Ramallah, which is the political and administrative centre of the West Bank. This value is ~1.3 % of the ICNIRP limit recommended for the general public. The total exposure evaluated for this site from all detected RF sources was 3.86 μW cm^{-2} with a calculated exposure quotient of about 0.02. This is the greatest exposure quotient based on the measured power density of each detected RF signal and the ICNIRP

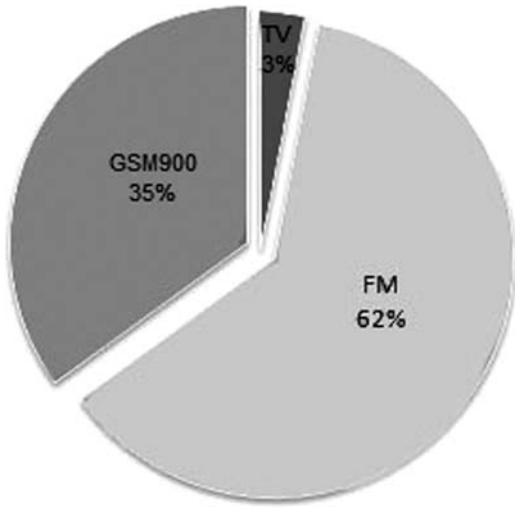

Figure 3. Contribution from different RF sources to the total exposure levels.

reference level corresponding to the frequency of the signal. Its value is well below unity, which indicates compliance with safety standards recommended for general public.

CONCLUSION

The main source of environmental exposure from RF radiation (in the frequency range from 75 MHz to 3 GHz) in the residential areas in the West Bank was found to be the FM radio broadcasting. This fact is of particular importance as the main public concern on possible health effects is the mobile telephony base stations, which was found to be the second contributor to public exposure. The maximum total exposure level measured at any location in this study is far below the recommended limits of ICNIRP for the general public. As the levels of RF signals from different sources, mainly mobile stations, are highly variable from site to site, further studies will be performed in individual cities and rural areas as well, with more focus on individual RF sources.

REFERENCES

1. Cooper, T., Mann, S., Khalid, M. and Blackwell, R. *Exposure to the general public to radio waves near microcell and picocell base stations.* J. Radiol Prot. **26**, 199–211 (2006).
2. World Health Organization: *Electromagnetic fields and public health. Mobile telephones and their base stations.* Fact sheet No. 193 (2000).
3. Viel, J. F., Tiv, M., Moissonnier, M., Cardis, E. and Hours, M. *Variability of radiofrequency exposure across days of the week: a population-based study.* Environ. Res. **111**, 510–513 (2011). http://www.ncbi.nlm.nih.gov/pubmed/21411077
4. International Commission on Non Ionizing Radiation Protection. *Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (1 Hz–300 GHz)*. Health Phys. **74**(4), 494–522 (1998).
5. Mann, S., Cooper, T., Allen, S., Blackwell, R. and Lowe, A. *Exposure to radio waves near mobile phone base stations.* NRPB-R321. NRPB (2000).