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Study of the effect of electromagnetic fields on indoor and outdoor radon concentrations

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Abstract: In the present work, the effect of electromagnetic fields produced by high voltage power lines (132kV) and indoor equipments on the indoor and outdoor average radon concentrations in Al-Kazaliya and Hay Al-Adil regions in Baghdad city were studied using CR-39 track detectors and a gauss-meter. Results of measurements of the present study, have shown that the highest value for the indoor average radon concentration (76.56 ± 8.44 Bq/m³) was recorded for sample A₁ (Hay Al-Adil) at a distance of (20 m) from the high voltage power lines, while the lowest value for the indoor average radon concentration (30.46 ± 8.44 Bq/m³) was recorded for sample A₃ (Hay Al-Adil) at a distance of (50 m) from the high voltage power lines. The indoor gaussmeter measurements were found to be ranged from (30.2 mG) to (38.5 mG). The highest value for outdoor average radon concentration and the highest gaussmeter measurements were found for sample (1), with values (92.63 ± 11.2 Bq/m³) and (87.24 ± 2.85 mG), directly under the high voltage power lines respectively, while the lowest outdoor average radon concentration and the lowest gaussmeter measurements were found in sample (4), with values (34.19 ± 6.33 Bq/m³) and (1.16 ± 0.14 Bq/m³), at a distance of (120 m) from the high voltage power lines respectively. The results of the present work have shown that there might be an influence of the electromagnetic field on radon concentrations in areas which were close to high voltage power lines and houses which have used many electric equipment for a long period of time.

Keywords : Power lines, Radon, Gaussmeter, CR-39. Electromagnetic.

1-Introduction;

A group at the International Agency for Research on Cancer worked and classified that exposure to low-frequency magnetic fields for long time will causes cancer [1]. In (2005), a large-scale case-control study from Britain, showed an association between proximity of residence at birth near high voltage power lines and the risk of childhood leukemia [2]. The association extended beyond distances where the power line-induced (ELF-MF) exceed background levels, which suggested that the association was not explained by the magnetic field, but perhaps by some other risk factor. Several studies have looked for potential confounders which could explain the observed association between (ELF-MF), and childhood leukemia [3,4]. Radon progeny like other airborne particles (tobacco smoke, chemical pollutants, spores, bacteria and viruses) might be affect our health, which can be inhaled [5,6]. Many researchers have found that the deposition of these particles increasing under the high voltage power lines [7]. For that they have suggested that the electric field that result from these lines can breakdown the air electrically, that give positive and negative ions and charge particles when they pass through ions, which finally increased the affect on health by increasing exposure [8]. Radon (an alpha emitter) is an odorless, naturally occurring radioactive gas that comes from the soil. Radon and its radioactive decay products (progeny) are found in easily measurable concentrations in all outdoors air and in higher



concentrations indoors. Studies of tens of thousands of miners exposed to high concentrations of radon and its decay products show that they cause lung cancer, however, these studies found no significant increase in other forms of cancer due to exposure to radon and its decay products[9]. Contribution of radon and its progeny to the total effective dose has been reported to be more than (50%) [10]. The risk of lung cancer from exposure to radon and radon decay products depends on their concentrations in air and the length of time a person is exposed to the radon source[11]. Radon as a cause of leukemia has also been discussed by Richardson et al [12]. It has been reported that indoor radon exposure is associated with the risk of leukemia and other cancers such as melanoma and cancers of the kidney and prostate [13]. Exposure to radon has become a global concern due to its health hazards inside dwellings[14-16]. CR-39 detector is considered one of the best detectors to record the tracks of alpha particles and nuclear fission fragments, because of the advantage of its high sensitivity and efficiency [17, 18]. The aim of this work is to study

a probable behavior of radon in fields like electromagnetic produced by high voltage power lines(132kV), in addition to the effects of the electromagnetic fields from indoor electrical equipment.

2-Experimental Method:

The CR-39 track detectors, (128) pieces, with dimensions (1x1 cm²) and thickness of (250 μm) have been distributed in (22) houses, (16 indoors and 6 outdoors) for the period of one month for the purpose of natural exposure. After the exposure time, (30day), the (CR-39) track detectors were etched in (6.25N) (NaOH) solution at temperature of (60 °C) for (5 h), and the tracks density were recorded using an optical microscope with magnification (400X). The density of the tracks (ρ) of the samples were calculated according to the following relation [17]:

$$\rho = \frac{N_{ave}}{A} \text{-----} \quad (1)$$

Where:

N_{ave} : is the average number of total pits(track). A : is the area of field view.

An example of a photograph for the observed tracks of one of the studied samples is shown in Figure (1). Radon gas concentration in the samples were obtained by the comparison between track densities registered on the detectors of the sample and that of the standard samples which are shown in Figure(2), using the relation [3]:

$$C_x = C_s(\rho_x / \rho_s) \text{-----} \quad (2)$$

$$C_x = \rho_x / \text{slope} \text{-----} \quad (3)$$

Where:

C_x : is the radon gas concentration in the unknown sample. C_s : is the radon gas concentration in the standard sample. ρ_x : is the track density of the unknown sample (track/mm²). ρ_s : is the track density of the standard sample (track/mm²).

A calibration curve [20] for outdoor measurements, see Fig(2), and calibration constant (0.161 track.m³/ Bq. day.mm²) for indoor measurements [21], have been employed in the present work for the determination of the radon concentrations. On the other hand, it has been measured the electromagnetic fields intensity under high voltage lines (132 kV), which were passed through the area of Al- Kazaliya region (K-symbol), and Hay Al-Adil (A- symbol) to Al-Maree station in Baghdad city using a milligauss meter which was designed by Shreef [22], and it is shown in the Figure (3) and Table(1) represent these results. For the studied houses, a computer program was designed (in Matlab language), to calculate the electromagnetic field intensity for every studied device, which contains the intensity, type of the device, distance at (30 cm), and the time for using the device, (60% for more frequently used), (30% for moderate frequently used) and (10% for less frequently used), as shown in Table (2) and Table (3) for high voltage lines (132 kV). Table(1) illustrates the values of the induced electromagnetic field emissions which were previously obtained for the different electrical devices inside the houses near the high voltage power lines[22]. Table(2) displays the results of radon concentrations which were obtained for the same places for the years (2006) and (2008)[20], and also for the current study(2016). Also included in Table (2), the measured intensity values of the electromagnetic field emissions in the present study (2016).

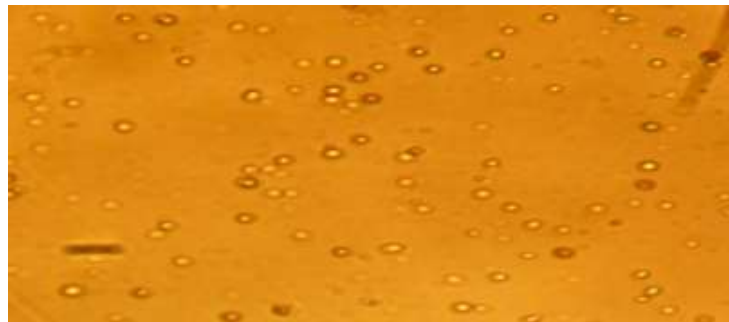


Figure (1): Photograph of the observed tracks for a sample obtained in present work.

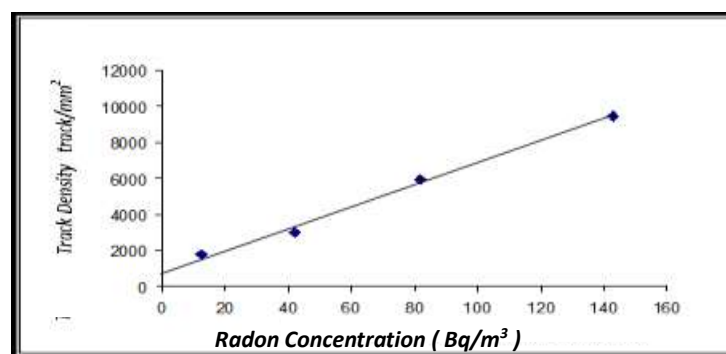


Figure (2): Calibration curve between track density and outdoor radon concentration employed in the present work[20].



Figure (3): Photograph of milligauss-meter used in the present work[22].

Table (1): Electromagnetic emission (EME) values at different distances[22].

	EME (milli-gauss)			
Electric device name	15 cm	30 cm	60 cm	120 cm
Can opener	٦٥.	١٦.	٢٧	٥
Hair dryer	٣٥.	٢	١	٠
Vacuum cleaner	٣٥.	٧.	١.	٠
Electric saw	٢٥.	٤.	٤	٠
Food mixer	١٠.	٢٥	٠	٠
Food processor	١٢٥	٢.	٢	٠

Heater (fan)	10.	20	1.	.
Printer	10.	3.	0	1
Shaving machine	120.	20	.	.
Air conditioner	3	2	.	.
Battery charger	30	1.	2	.
Electronic clock	1.	.	.	.
Clothes dryer	2	2	.	.
Fluorescent lamp	40	1.	0	.
Dishwasher	3.	1.	2	.
Fan (desktop)	0	1	.	.
Clothes iron	1	.	.	.
Refrigerator	2	1	.	.
Television	10	1.	.	.
Computer monitor	2.	6	3	.
Computer(desktop)	3	2	.	.
Computer (laptop)	0	.	.	.
Electric oven	1.	0	.	.

Table (2): Indoor average radon concentrations and average electromagnetic field emission (intensity)(EME) for different distances from high voltage power lines

Indoor					
Sample no.	d (m)	Average radon concentration (Bq/m ³) * for different studied years			Gauss-meter measurements (mG) * 2016[p.w]
		2006[22]	2008[22]	2016[p.w]	
K ₁	15	69.99±11.5	73.3±11.9	74.86±2.2	33.5
K ₂	15		72.9±7.2	73.19±6.8	33.5
K ₃	30	67.34±3.4	69±15.34	73.46±2.7	36.2
K ₄	30	55.8±6.37	53.7±6.3	52.11±8.42	36.2
K ₅	00	41.76±11.08	56.26±16.1	58.49±12.10	38.5
K ₆	120	35.37±7.21	39.63±9.73	40.87±6.1	30.5
A ₁	20	-----	74.16±5.3	76.56±8.44	38.5
A ₂	40	-----	65.6±4.9	62.88±8.33	38.5
A ₃	50	-----	25.9±8.9	30.46±5.83	30.2
A ₄	60	-----	43.47±4.9	46.96±7.12	34.8

* The average of (10) measurements.

[p.w]: Present work.

Table (3): Outdoor average radon concentrations and average electromagnetic field emission (intensity) (EME) for different distances from high voltage power lines.

Outdoor					
Sample no.	d (m)	Average radon concentration (Bq/m ³) * for different studied years			Gauasmeter measurments (mG)* 2016[p.w]
		2006[22]	2008[22]	2016[p.w]	
1	.	80.12±15.9	84.39±13.7	92.63±11.2	87.24±2.85
2	30	34.9±5.3	77.9±8.01	48.33±8.16	5.32±0.69
3	00	33.67±10.8	46.5±17.9	37.66±6.24	2.45±0.32
4	120	31.96±11.5	30.68±5.54	34.19±6.33	1.16±0.14

* The average of (10) measurements.

[p.w]: Present work.

3- Results and discussion:

From Table(2), it can be noticed that ,apart from (K₄), and (A₂) samples and for a fixed distance from the high voltage power lines, values of the indoor average radon concentrations were found to be increased with the time (measuring year). The highest value for the indoor average radon concentration ($76.56 \pm 8.44 \text{ Bq/ m}^3$), was recorded for sample (A₁), (Hay Al-Adil), at a distance of (20 m) from the high voltage power lines, (present study in 2016), while the lowest indoor average radon concentrations ($25.9 \pm 8.9 \text{ Bq/ m}^3$), was recorded for (A₃) sample, (Hay Al-Adil), at a distance of (50m) from the high voltage power lines in (2008) by Raheem [20]. However ,from the present study in (2016), the lowest indoor average radon concentration ($30.46 \pm 5.83 \text{ Bq/ m}^3$), was also recorded for sample (A₃), (Hay Al-Adil), at a distance of (50 m) from the high power lines. For all samples studied in the present work, the gaussmeter measurements were found to be ranged from (30.2 mG) to (38.5 mG). From Table (3), and for the present study in 2016, it can be noticed that, the outdoor average radon concentrations and the gaussmeter measurements were found to be decreased as the sample distance from the high voltage power lines was increased .The highest outdoor average radon concentration and the highest gaussmeter measurements were found for sample (1), with values ($92.63 \pm 11.2 \text{ Bq/ m}^3$) and ($87.24 \pm 2.85 \text{ Bq/ m}^3$) respectively, directly under the high voltage power lines. While the lowest outdoor average radon concentrations and the lowest gaussmeter measurements were found for sample (4), with values ($34.19 \pm 6.33 \text{ Bq/ m}^3$) and ($1.16 \pm 0.14 \text{ mG}$) respectively at distance (120 m) from the high voltage power lines. From Tables (2&3), it can be noticed that a significant differences were found in radon gas concentrations outside the houses near to the high voltage power lines, also the increasing of the electrical power supplied nowadays from the source might be accounted for these differences, which were in agreement with the other previous studies [20]. Also we have found that an increase in radon gas concentrations in some houses which might be due to the excessive use of electrical devices, although these houses have been selected on the basis of similarity of designs and building materials. These differences might have resulted due to the differences in the usage duration of these electrical devices, nature and the resulting field. From the above present results it can be noticed that the presence of the residential houses near to high voltage power lines might led to an increase in radon gas concentration inside and outside these houses, In addition, the fields produced from high usage of electrical devices which might also produced high electromagnetic fields as it was shown in Tables (1,2,3). This could give a high risk and side effects to the human health. To reduced these effects, we suggest that and through this study to activate some proper precautions to avoid the radon gas concentrations by using a certain substances which have low diffusion factors to radon gas which can lead to a high gas absorption capability ,or, by increasing ventilation inside these houses, as well as residential building areas should be situated more than about (50) meter from the electrical high voltage power lines, if possible. Alternatively, we can use underground cables to minimize the electromagnetic fields, because in this case it will be grounded and the electromagnetic fields will decrease more rapidly because the cables will have smaller distance between them. Because the underground lines are not frequently used and they are often situated at very short distances from high electrical usage areas, which could cause high electromagnetic fields, however, it will have only little effects on, for example ,for the ground floor, basement apartments, shops, gardens, pavements etc. Since higher power consumption means the existing high voltage power lines will emit greater electromagnetic fields, the radiation emitted by cables nowadays has more aggravating waveform, so that the extensive use of electronic non-linear load devices such as fluorescent lamps, AC adapters, dimmer electronic switches, inverter air conditioners, plasma TVs, photovoltaic systems etc., will result in deformation of the plain sinusoidal signal of (50-60)Hz mains with high frequency harmonics. This phenomenon is called "Dirty Electricity" because it causes overheating of the neutral conductor and premature aging of equipment. Some scientists believe that the new waveform of the power grid is particularly burdensome for humans [23]. A previous Research at the University of Bristol [24], have shown that the presence of high levels of low-frequency electromagnetic fields near the high voltage cables, have increases up to 18 times the accumulation of radon particles. As it is well documented , elevated radon levels are also associated with lung cancer [25].

4-Conclusions :

From the present study, and in general for a fixed distance from the high voltage power lines ,values of the indoor average radon concentrations were found to be increased with time (measuring years). Also the average outdoor radon concentrations , and the gaussmeter measurements were found to be decreased as the sample distance from the high power lines was increased . Finally , it can be concluded from this study ,the presence of the residential houses near to high voltage power lines might led to an increase in radon gas concentrations inside and outside these houses.

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