Measurements of Radon Activity Concentrations in Tap Water in Some Dwellings of the Konya Province – Turkey

Mehmet Erdogan[1], Kaan Manisa[2], Fidan Tel[1]

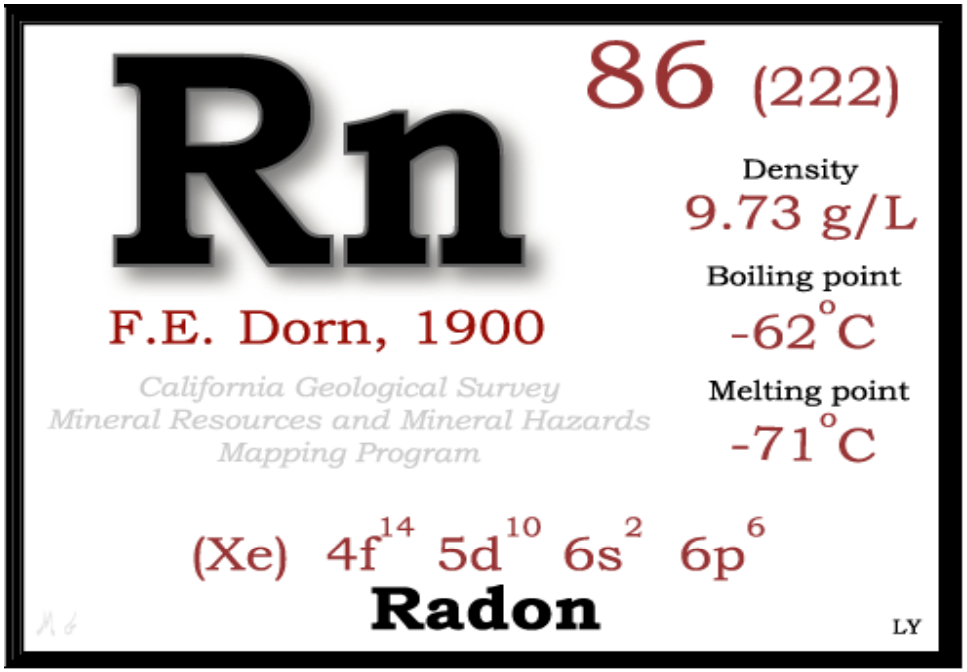
[1] Selçuk University Physics Department , 42079 Konya, Turkey

[2]Dumlupınar University Physics Department 43100 Kütahya, Turkey

Second East European Radon Symposium (SEERAS)

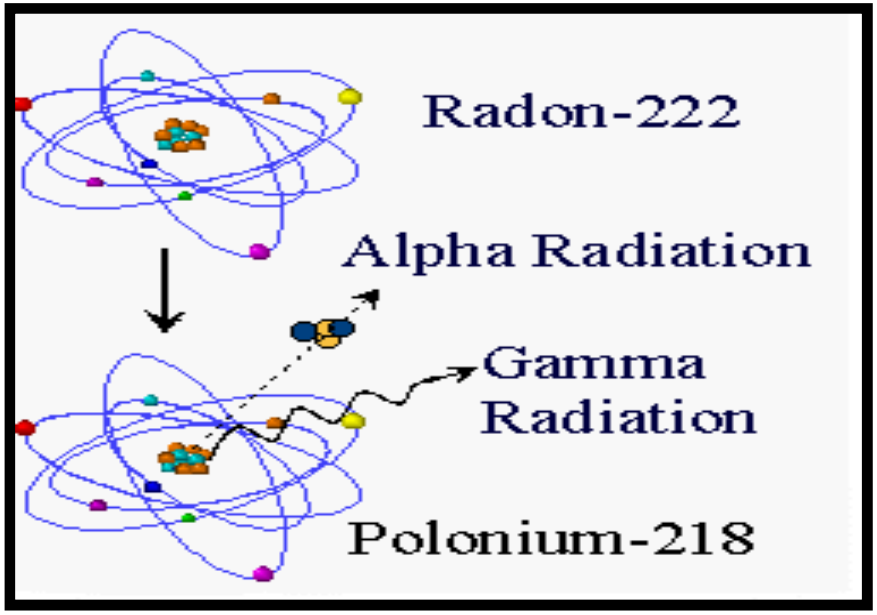
May 27-30, 2014 Niş-Serbia

What is Radon?



Radon (Rn-222) is the first and most important natural source of the radiation which people are exposed.

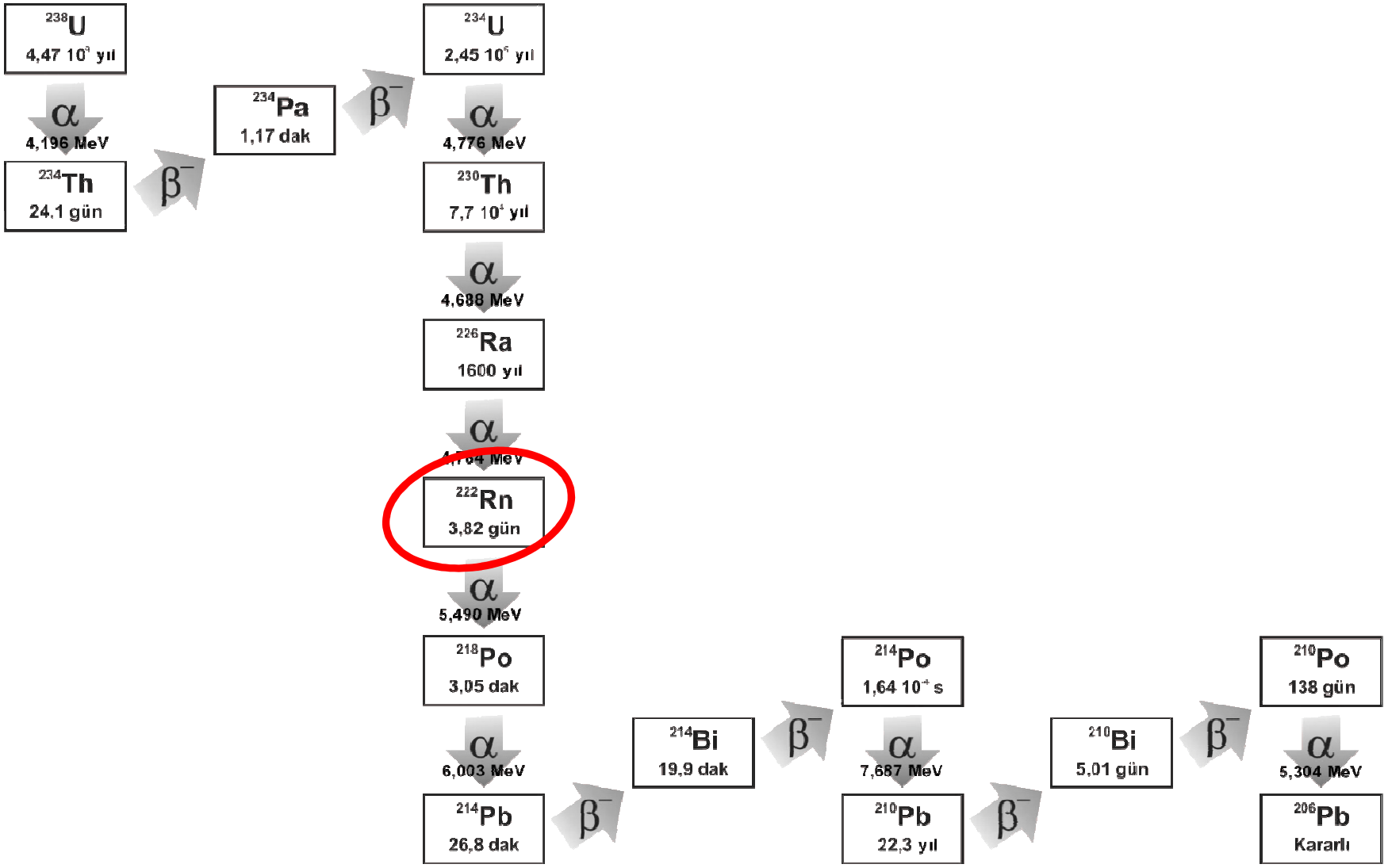
Radon is tasteless, odourless, colourless and radioactive noble gas (is the heaviest known gas) that comes from naturally occuring uranium in the soil.



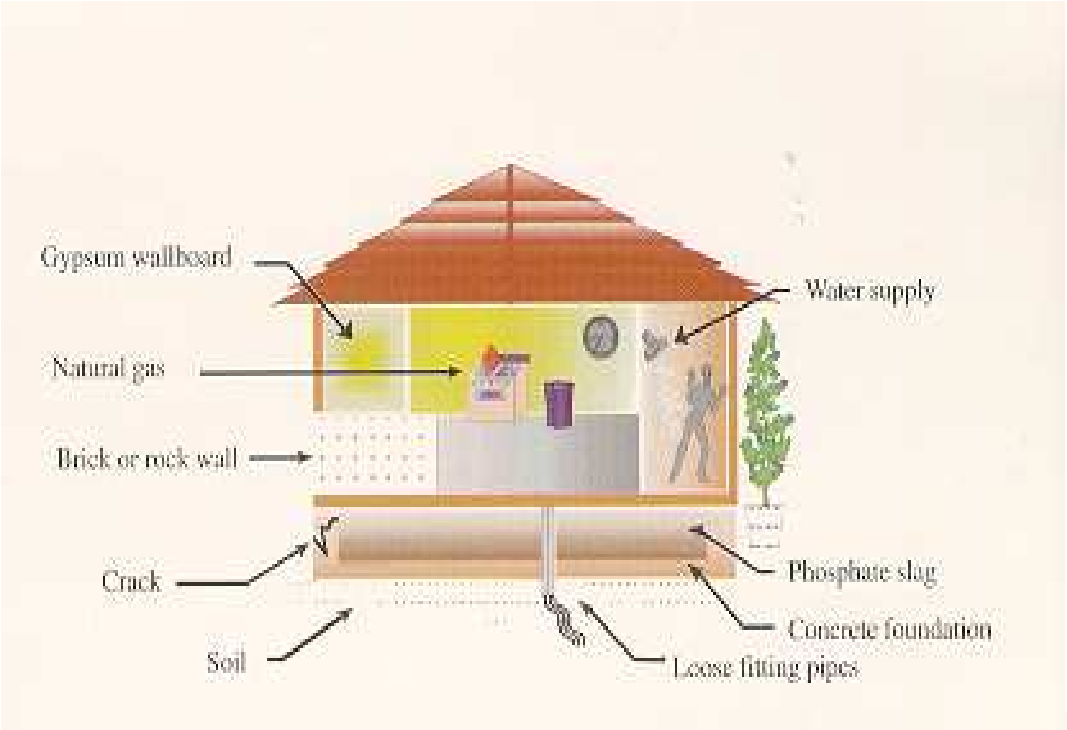
Radon can be found in various concentrations in soil, air and different kind of water.

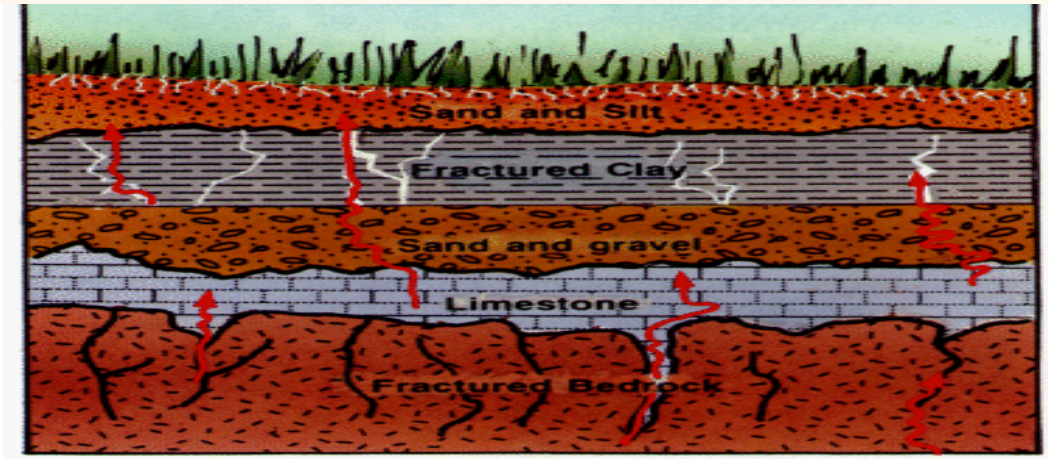
Radon decays into radioactive elements, two of which polonium-218 and polonium-214 emit alpha particles, which are highly effective in damaging lung tissues.

U^{238} Decay Chain



Sources of Radon





- **Outdoors radon poses significantly less risk than indoors.**
- **Indoors radon can accumulate to significant levels.**
- **The magnitude of radon concentration indoors depends primarily on a building's construction and the amount of radon in the underlying soil.**
- **Radon gas can enter a buildings from the soil through cracks in concrete floors and walls, floor drains, sump pumps, construction joints, and tiny cracks or pores in hollow-block walls.**
- **Radon levels are generally highest in basements and ground floor rooms that are in contact with the soil.**
- **Well water is another source of radon.**

Radon in Water

Radon is solible in water and its solubility increases rapidly with decreasing temperature.

The radon gas later escapes from the water and goes into the air, raising the room's radon content. An average concentration of radon in water of 10 kBq.m^{-3} implies a contribution of 1 Bq.m^{-3} to radon in air.

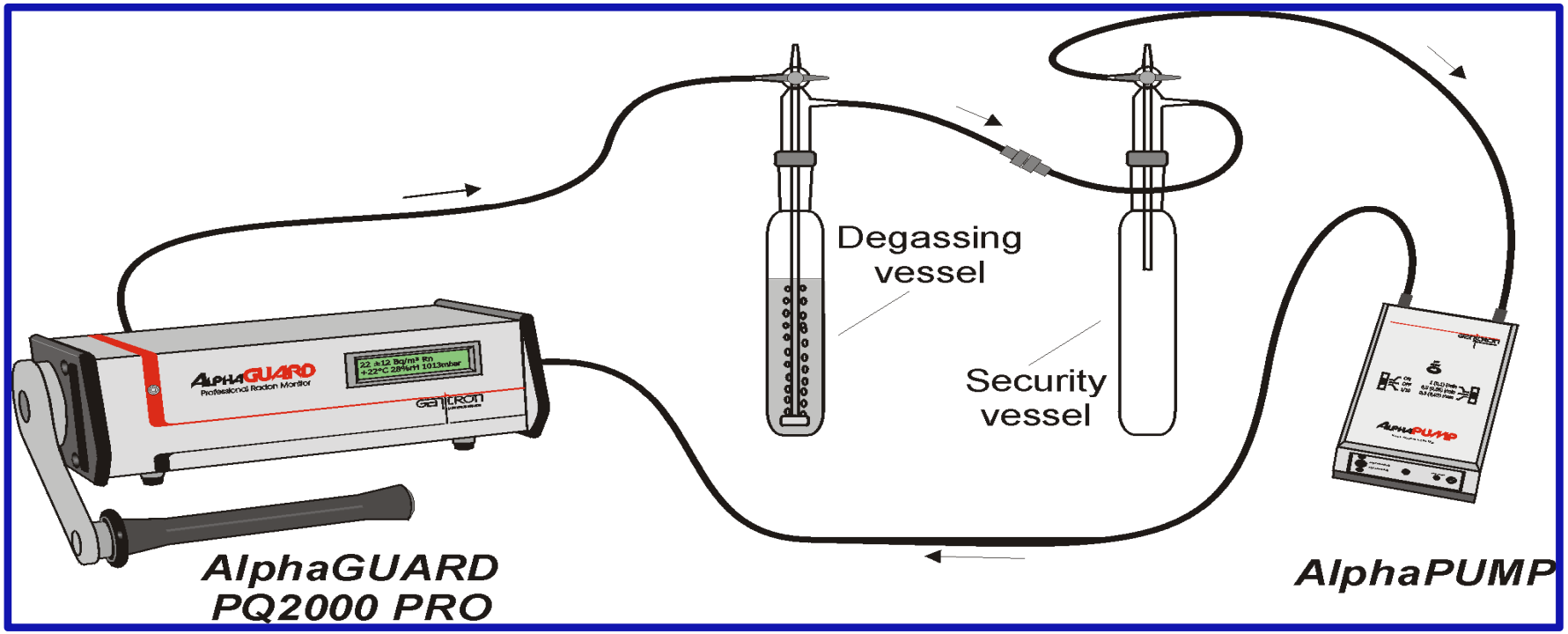
How Does Radon Cause Cancer?

- **If inhaled, radon decay products (polonium-218 and polonium-214, solid form), unattached or attached to the surface of aerosols, dusts, and smoke particles, become deeply lodged or trapped in the lungs, where they can radiate and penetrate the cells of mucous membranes, bronchi, and other pulmonary tissues.**

- **The ionizing radiation energy affecting the bronchial epithelial cells is believed to initiate the process of cancer causing process.**

- **Radon in water may lead to exposures from the ingestion of drinking water and from the inhalation of radon released to air when water is used.**

Materials and Methods
Schematic view of the experimental set-up



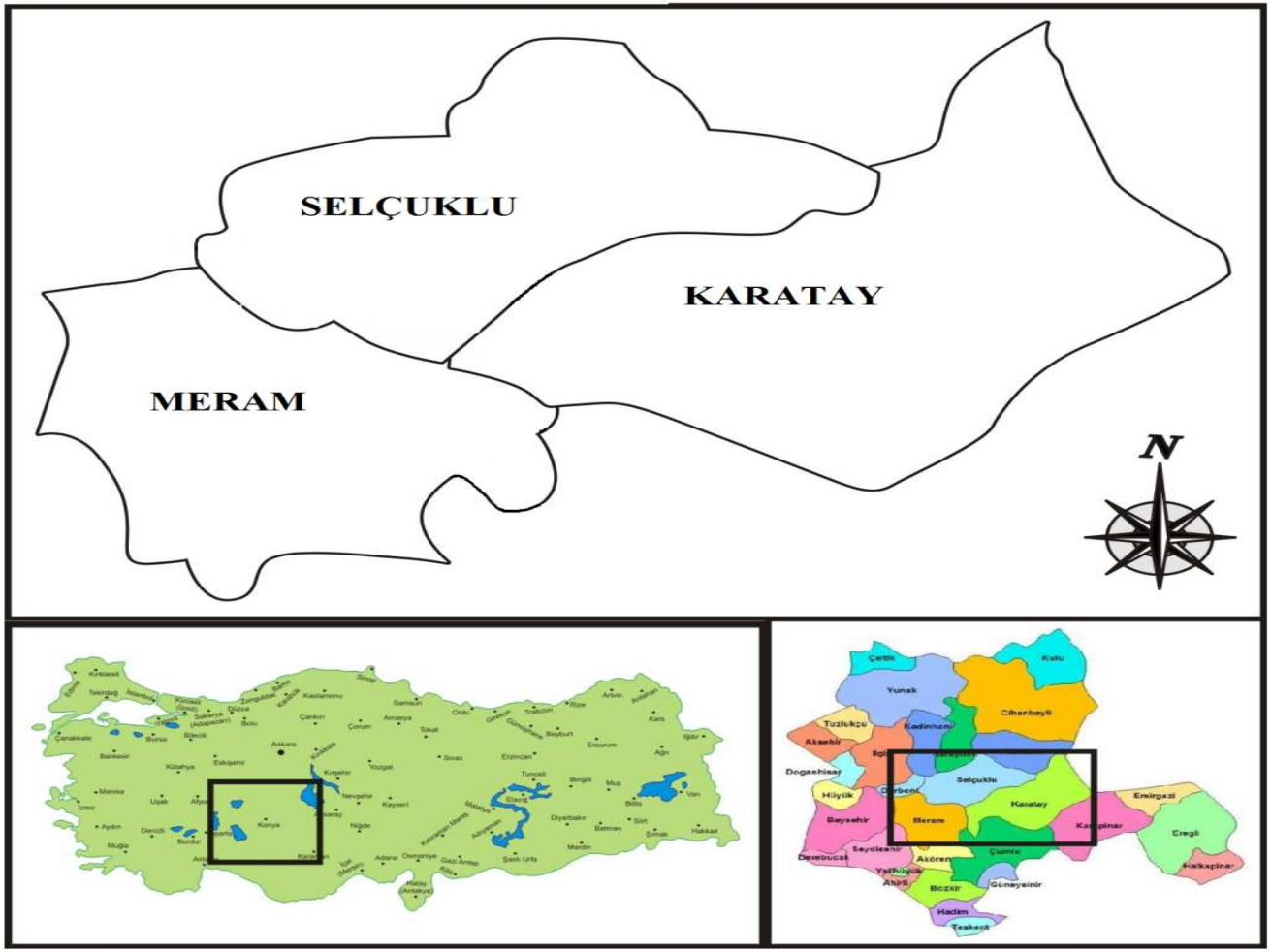
Radon concentration in water

was measured using AlphaGUARD monitor system.

In a close gas cycle,

radon gas expelled from the water samples using a pump.

Map of the Region Showing the Location of Water Sampling



Results

Sample code	Radon concentration ± SD[a] (Bq l^{-1})		AM[b] of ^{222}Rn concentration for two seasons (Bq l^{-1})	Effective dose for ingestion (μSv)	Effective dose for inhalation (μSv)
	Autumn	Winter			
S1	2.66 ± 0.40	0.72 ± 0.04	1.69	0.34	4.23
S2	2.73 ± 0.18	0.89 ± 0.28	1.81	0.36	4.53
S3	3.68 ± 0.26	1.40 ± 0.12	2.54	0.51	6.35
S4	7.16 ± 1.43	0.33 ± 0.07	3.75	0.75	9.36
S5	1.47 ± 0.11	0.82 ± 0.04	1.15	0.23	2.86
S6	10.38 ± 0.66	3.57 ± 0.22	6.98	1.40	17.44
S7	1.30 ± 0.26	1.74 ± 0.11	1.52	0.30	3.80
S8	18.21 ± 0.92	12.90 ± 2.59	15.56	3.11	38.89
M1	5.67 ± 0.15	0.36 ± 0.05	3.02	0.60	7.54
M2	3.00 ± 0.28	2.85 ± 0.36	2.93	0.59	7.31
M3	5.39 ± 0.15	4.00 ± 1.19	4.70	0.94	11.74
M4	14.58 ± 0.49	12.32 ± 0.68	13.45	2.69	33.63
M5	14.31 ± 0.51	4.24 ± 0.50	9.28	1.86	23.19
M6	16.05 ± 0.71	9.16 ± 1.12	12.61	2.52	31.51
M7	3.65 ± 0.24	2.20 ± 0.17	2.93	0.59	7.31
M8	0.89 ± 0.15	0.85 ± 0.13	0.87	0.17	2.18
K1	8.16 ± 0.61	4.63 ± 0.28	6.40	1.28	15.99
K2	1.29 ± 0.02	2.09 ± 0.40	1.69	0.34	4.23
K3	6.47 ± 0.18	3.52 ± 0.20	5.00	1.00	12.49
K4	10.37 ± 2.05	14.62 ± 1.02	12.50	2.50	31.24
K5	4.59 ± 0.76	11.10 ± 1.25	7.85	1.57	19.61
K6	19.17 ± 3.12	13.62 ± 0.31	16.40	3.28	40.99
K7	23.22 ± 2.12	13.45 ± 1.03	18.34	3.67	45.84
K8	16.97 ± 1.08	12.78 ± 0.70	14.88	2.98	37.19
K9	14.26 ± 0.64	5.66 ± 0.22	9.96	1.99	24.90
K10	10.56 ± 0.44	4.73 ± 0.11	7.65	1.53	19.11
K11	12.52 ± 0.28	12.24 ± 0.69	12.38	2.48	30.95

- **Mean radon activity varies from 0.87(M8) to 18.34(K7) Bq l^{-1} for two seasons.**
- **Seasonal variation can be related to seasonal factors and the waiting-period of the water in the water supply network.**
- **While eleven of the twenty seven tap water samples (S1-S5, M1-M3, K1-K3) were collected from dwellings with a water reservoir, the remaining samples, (S6-S8, M4-M8, K4-K11) were collected without water reservoirs.**
- **The highest radon activity was measured to be 16.40 Bq l^{-1} (K6) and 18.34 Bq l^{-1} (K7) in the region of Karatay.**
- **Mean value of radon concentrations of the 11 samples with water reservoirs was well below the levels of the other samples due to the fact that dissolved radon gas with a half-life of 3.82 days in the water reservoir decays into radioactive ^{218}Po (Polonium-218) and escapes to air.**

Results

Location	Mean of Radon Activity (Bq l^{-1})	
Region	With Water Resevoir	Without Water Resevoir
Selçuklu	2,01	8,02
Meram	3,55	7,83
Karatay	4,36	12,5

•Radon activity of the tap water samples of dwellings with water reservoir is lower than other water samples.

•While the mean radon activity of the tap water samples with a water reservoir is 3.15 Bq l^{-1}, for the others, this value is found 10.20 Bq l^{-1} for the two seasons.

•If the radon concentration is at a high level, large surface-reservoir can be used for the dwellings.

•WHO (World Health Organization) has recommended 100 Bq/l of radon in water as safe limit for drinking purpose. However, USEPA (United States Environmental Protection Agency) has recommended a maximum level of 11.11 Bq/l of radon activity in water as a safe limit. 8 water samples (K4,6,7,8,11 and M4,6 and S8) has radon concentrations over the upper limit (11.11 Bq/l) declared by USEPA.

References

- **Erdogan M., Eren N., Demirel S., Zedef V., Determination of Radon Concentration Levels in Well Water in Konya, Turkey, Radiation Protection Dosimetry, Volume: 156 Issue: 4 Pages: 489-494, 2013.**

- **Erdogan M., Ozdemir F., Eren N., Measurements of Radon Concentration Levels in Thermal waters in the Region of Konya, Turkey, Isotopes in Environmental and Health Studies, Volume:49, Issue:4, Pages:567-574, 2013.**

- **USEPA, United States Environmental Protection Agency. National primary drinking water regulations for radionuclides. EPA/570/9–91/700, United States Environmental Protection Agency (1991).**

- **The World Health Organization (WHO). Guidelines for Drinking Water Quality. WHO (1993).**

Thank you for your attention…

“Peace at Home, Peace in the World”.

Mustafa Kemal ATATÜRK

(He is founder of Turkish Republic)

“Either exist as you like, or be as you look”.

Hz. Mevlana Celalettin RUMİ

(He is Islamic Philosopher)

Further Reading

- **In order to estimate the effective indoor dose, one has to take into account the conversion coefficient from an absorbed dose of air to the effective dose and the indoor occupancy factor. In the UNSCEAR report[21], a value of 9 nSv h^{-1} per Bq m^{-3} was used for the conversion factor (effective dose received by adults per unit ^{222}Rn activity per unit of air volume), 0.4 for the equilibrium factor of ^{222}Rn indoors and 7,000 hours for the indoor occupancy factor per year. We calculated an effective dose for inhalation of 2.18 µSv a^{-1} as a minimum and 45.84 µSv a^{-1} as a maximum for radon in the water samples shown in Table 1.**

- **For the effective doses for ingestion, the annual weighted estimate of consumption rate and the dose coefficient of the concerned radon isotope per unit intake which is equal to 3.5 nSv.Bq^{-1} were used. According to the UNSCEAR report[21], it has been estimated that the consumption rate of the tap water is 60 l a^{-1}. Thus, we assessed the expected doses 0.17 µSv a^{-1} for minimum and 3.67 µSv a^{-1} for maximum due to the radon activity in the water samples as show in Table 1.**