Study on Rn-222 concentration in the soil (*)

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Summary. — The measurement of radon 222 concentration in the soil is made on the gases collected from the soil at 1 metre depth by a low-flow intake pump and which are conveyed into a system of detection and evaluation of the radiations emitted by radon and its decay products. Two kinds of approaches were used which carry out the measurements by means of alpha-particles counters or beta-radiation counters, respectively. The study was performed in a hole dug in the basement of the Institute of Physics; the soil is the one typical of the Lombard plain. The measurements were performed during two yearly campaigns from 1993 through 1996. The study shows wide oscillations of radon concentration which occur every 24 and 12 hours. These effects were noticed during the whole campaign. Radon concentration oscillations are compared with the pressure oscillations related to atmospheric tides.

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1. – Introduction

The granules of sand and gravel sediments in the Po Plain contain substantial amounts of radium 226: its decay by alpha-emission gives rise to radon 222. A part of radon 222 is trapped within the granules themselves, while a part escapes through the surface of the granules and mixes with underground gases. The study of variations in underground concentrations of radon may provide a useful indication of the movements of underground gases.

The main aim of the present study was to record underground concentrations of radon in order to ascertain whether they fluctuate, and if so, whether this was related to the behavior of atmospheric pressure.

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2. – Materials and methods

Underground measurements were conducted in Milan from August 1995 to July 1996, following a few preliminary measurements in 1993 [1]. Underground gases were collected in a container placed at a depth of 1 metre in a hole. A pump with a flow-rate of 5 l/minutes drew air from the hole into a measurement chamber. Radon concentration was measured in two ways:

– Measurement of the alpha-particles emitted by radon 222; the radon counter consists of a transparent lucite disk with a thin activated zinc-sulphide layer that emits a scintillation when hit by an alpha-particle. The disk is set on a specular surface aluminium paraboloid, the focus of which houses a photomultiplier; the photomultiplier is connected to a data counter-recorder chain.

– Measurement of the beta-particles due to radon progeny by means of a plastic scintillator disk.

Both systems recorded radon concentration hourly.

In order to determine what, if any, might be the effect of atmospheric pressure on fluctuations in underground radon concentrations, atmospheric pressure readings for the same period were obtained, and these data, along with those for underground radon, were subject to Fourier's analysis in order to obtain comparable representations of fluctuation patterns in the two variables.

3. – Results

3·1. *Radon.* – We report the analysis of the first series of measurements, made from August 1995 to October 1995.

The average underground radon concentration was more or less constant throughout the period of measurement. Regular oscillations were observed over single days. Figures 1 and 2 show the trend in underground radon concentration.

Fourier's analysis (see fig. 3) yielded one wave with a period of 24 hours and one with a period of 12 hours.

Table I shows the amplitudes and the phases of the 24 and 12 hour waves for weeks from 5 August to 27 October 1995.

It can be seen from table I that the waves are present continuously in every week throughout the period in which measurements were conducted. The 24 hour wave reaches its peak between 8:00 and 11:00; while the 12 hour wave has two peaks, at 4:00 and 16:00, respectively.

3·2. *Pressure.* – Atmospheric pressure shows large synoptic variations (fig. 4), which in Lombardy reach amplitudes of 10–20 millibar, along with smaller daily variations of amplitude of 1–2 millibar.

The application of Fourier's analysis to the pressure data (fig. 5) gave a wave with a period of 24 hours and a wave with a 12 hour period; a smaller wave with a 8 hour period sometimes appears.

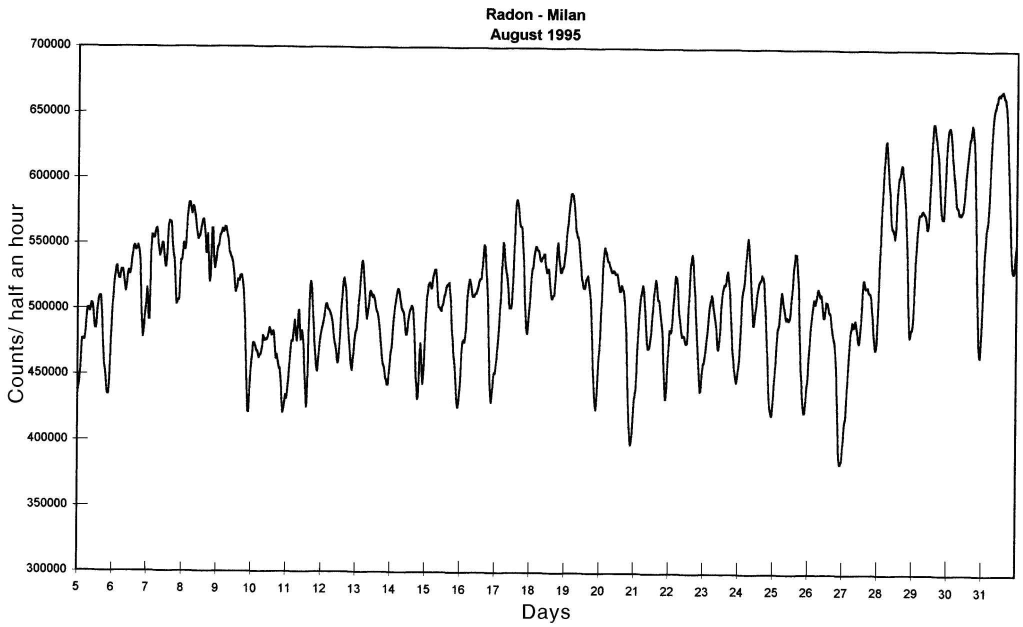

Fig. 1. – Radon, Milan, August 1995.

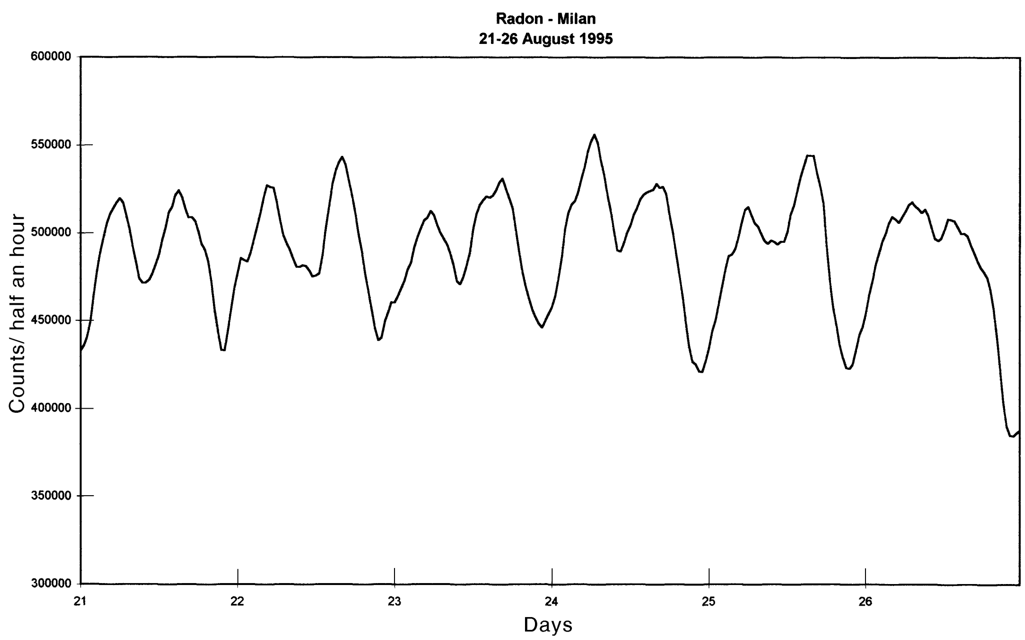

Fig. 2. – Radon, Milan, 21-26 August 1995.

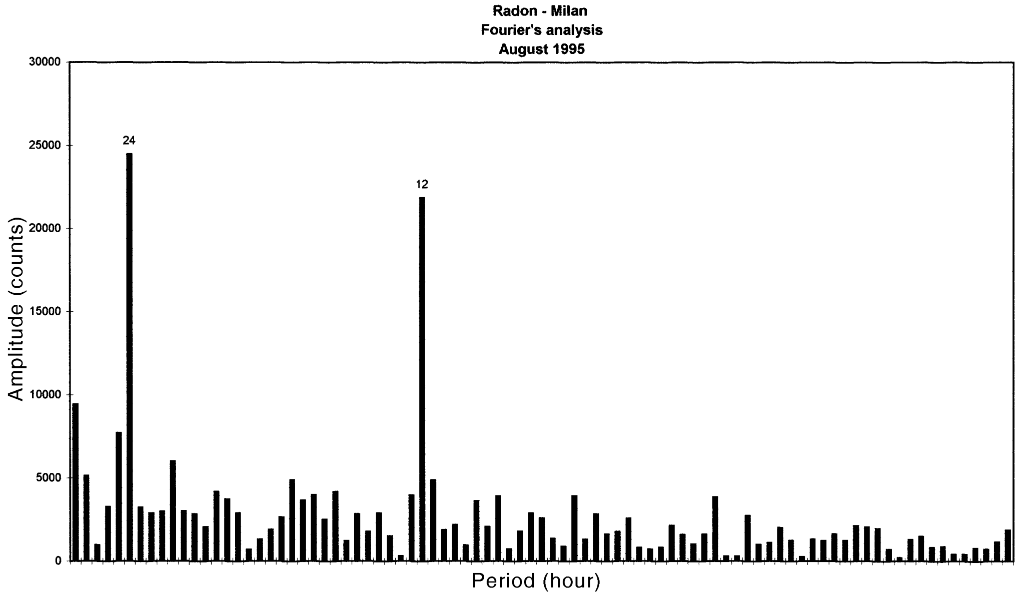

Fig. 3. – Radon, Milan, Fourier's analysis August 1995.

Table II shows the amplitudes and the phases of the 24 and 12 hour waves.

It can be seen that whereas the 12 hour wave is present in all the weeks measured, the 24 hour wave is not always present.

A great number of studies have focused on the origins and characteristics of 24 and 12 hour pressure variation waves (see the book by Chapman and Lindzen [2]). Among

TABLE I.

Week	24 hour wave		12 hour wave	
	Amplitude (counts/half an hour)	Phase (hour)	Amplitude (counts/half an hour)	Phase (hour)
5-11/08	18086	9.70	13116	4.39
12-18/08	18277	10.04	18179	4.28
19-25/08	30579	9.70	31863	4.18
26/08-1/09	39008	11.27	24892	4.35
2-8/09	31329	10.92	27667	4.28
9-15/09	24831	7.75	13684	4.81
16-22/09	25296	8.48	19119	3.55
23-29/09	26614	8.86	18604	3.63
30/09-6/10	31722	7.89	18562	3.55
7-13/10	16460	9.47	14735	3.72
14-20/10	33595	8.75	17020	3.44
21-27/10	32889	8.36	11312	4.34

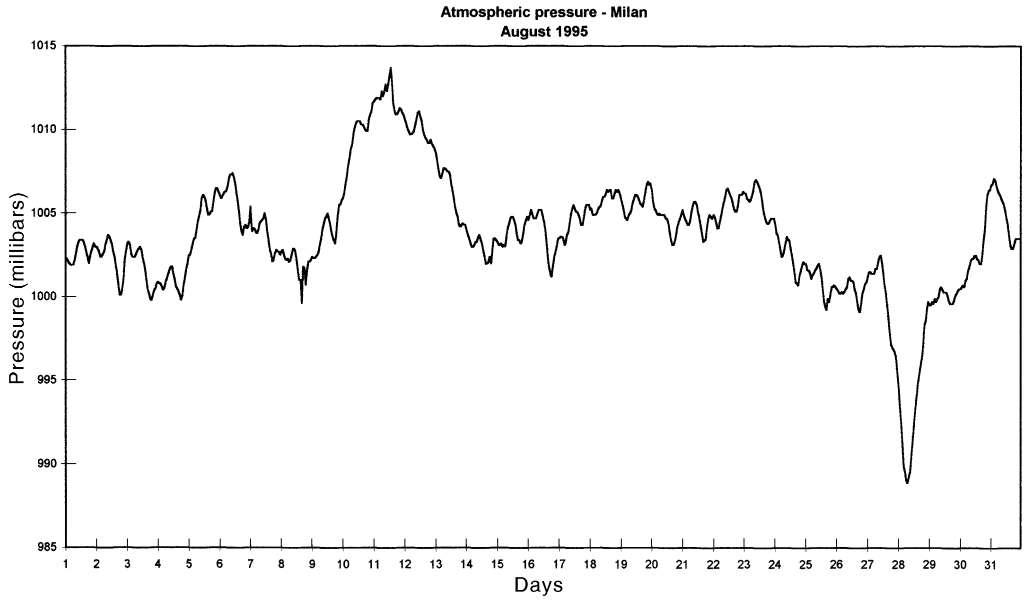

Fig. 4. – Atmospheric pressure, Milan, August 1995.

the findings reported, it results that the waves were due to warming processes of the atmosphere due to absorption of the sun's rays either by water vapour and, in upper layers, by ozone.

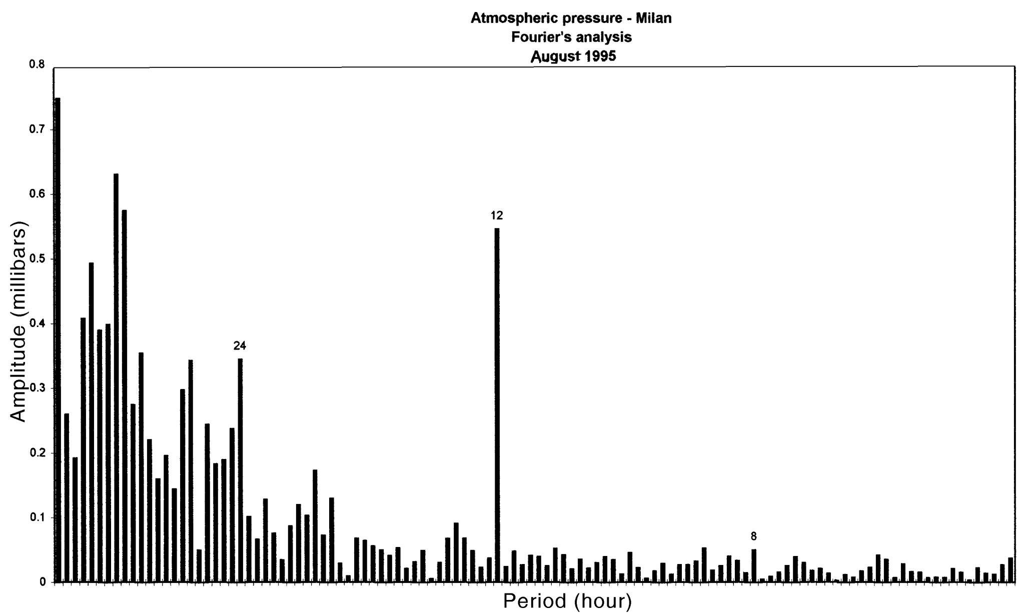

Fig. 5. – Atmospheric pressure, Milan, Fourier's analysis, August 1995.

TABLE II.

Week	24 hour wave		12 hour wave	
	Amplitude (millibar)	Phase (hour)	Amplitude (millibar)	Phase (hour)
5-11/08	—	—	0.59	11.09
12-18/08	0.49	8.79	0.49	12.17
19-25/08	0.47	7.14	0.60	11.74
26/08-1/09	—	—	0.49	11.78
2-8/09	0.76	8.14	0.57	12.00
9-15/09	—	—	0.40	11.80
16-22/09	—	—	0.69	10.92
23-29/09	—	—	0.59	11.40
30/09-6/10	—	—	0.64	10.82
7-13/10	0.53	9.63	0.60	11.65
14-20/10	0.60	7.87	0.54	11.40
21-27/10	0.43	7.98	0.64	11.30

The 24 hour wave peaks between 8:00 and 10:00 a.m. The 12 hour wave peaks twice, between 11:00 a.m. and 12:00 midday when the sun is at its zenith in Milan; and around midnight.

4. – Discussion and conclusions

The oscillations in radon concentration observed at a depth of 1 metre may indicate an oscillation in the movements of underground gases.

In our comparison, no relationship was found between the larger synoptic variations of pressure and underground radon concentrations.

Comparison of pressure waves with the waves obtained for radon gave the following results: both underground radon concentrations and atmospheric pressure yielded 24 and 12 hour waves, although the waves for radon and pressure did not overlap, that for radon peaking a few hours later than that for pressure.

REFERENCES

[1] VALSECCHI R., Tesi di Laurea in Fisica, Università degli Studi di Milano, Anno Accademico 1992-1993.

[2] CHAPMAN S. and LINDZEN R., *Atmospheric Tides* (D. Reidel Publishing Company, Dordrecht) 1969.