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MEASUREMENTS OF RADON-222 AND ITS DAUGHTER'S CONCENTRATIONS IN DWELLINGS OF GAZA STRIP, PALESTINE.

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قياس تركيز غاز الرادون ومشتقاته داخل وخارج منازل قطاع غزة

ملخـص: تحـتوي صـخور الجرانيـت التي تنتشر في الكثبان الرملية على طول ساحل قطاع غزة على مستويات عالية من غاز الرادون . حيث تعرف هذه المواد بأنها غنية باليورانيوم و هي شائعة الاستخدام في بـناء المساكن بقطاع غزة. لذا تهدف الدراسة لبحث سبل معايير قياس تركيز غاز الرادون-222 ومشتقاته فـي الهـواء داخـل منازل قطاع غزة باستخدام كاشف الحالة الصلبة (مجراع الرادون السلبي) للمسارات النووية والمعروف تجارياً باسم CR-39. لقد تم توزيع 500 مجراعاً في المنطقة الوسطي بقطاع غزة لستة مـناطق . وقـد أشارت النتائج إلي أن تركيز الرادون في أماكن الدراسة يتراوح بين 13 Bq/m^3 و 84 Bq/m^3 ، وأقصـاها 97 Bq/m^3 وتبيـن أن القيمة المتوسـطة لتركـيز الرادون ومشتقاته في المنطقة الوسـطى تسـاوي 38 Bq/m^3 مع متوسط الانحراف المعياري 11.23. والنتائج تشير إلي ضرورة القيام بدراسة مستقبلية واسعة النطاق لمسح شامل لقياس تركيز غاز الرادون في فلسطين.

Abstract: High Radon levels are present in the granite and grandiositic rocks that spread in sand dunes along coast of Gaza. Such materials are rich in uranium and widely used in the construction of dwelling in the Gaza, and their contribution to high indoor Radon levels is most relevant. The present work aims to investigate approaches, measures and detection of indoor Radon level throughout Gaza Strip. Five hundred CR-39 dosimeters were distributed over six locations in the middle region of Gaza Strip. Results suggest that Radon concentrations range from 13 to 84 Bq/m^3 and a maximum value of 97 Bq/m^3. The average Radon concentrations was 38 Bq/m^3 with standard deviation of 11.23. The results provide a framework for future studies that include a large, broader survey of Radon concentration in Palestine.

***Keywords**: Radon, Health Physics, Natural Radioactivity, and Dosimeters.*

Introduction

Radon-222 is present in the form of naturally occurring radioactive gas, which emanates principally from soil, produced as result of the decay of radium (^{226}Ra). The process of the migration of Radon is a function of radioactivity concentration, and the porosity and permeability of the medium. Radon has long been known to contribute to risk of lung cancer. Radon and its daughter products emit alpha particles that are implicated in the cellular changes leading to lung cancer. Indoor Radon variations occur hourly, diurnally, and seasonally, and are influenced by numerous factors, including Radon infiltration rates, pressure differentials, soil characteristics weather conditions (e.g rainfall, wind speed) and occupant behavior [1]. The Radon concentration in air varies in accordance with location, high level of the houses, material of the houses built, different room in the same house, and ventilation rate [2]. Radon exhalation rates in the areas, where uranium deposits and phosphate rocks is significant, and this is the main source of exposure to uranium. Radiation hazards may represent one of environmental crises affecting the Gaza Strip and received no serious study in the past. Long-term exposure to elevated levels of Radon increases ones risk of containing lung cancer. In Gaza Strip, recent report of cancer registry unit shows that, the total reported diagnosed cases through the years 1995-2001 were 2,404 {1,264 male, 1,140 female} cancer cases, number of these (314, 13.1%) bronchus and lung cancer [3]. The purpose of the study is to gather information about the natural radiation and to evaluate the Radon concentration throughout Gaza Strip. This is motivated by the concern about the possible consequences of long term exposure to higher concentration Radon and its short-lived product in air. Since, it is known that Radon through its radioactive progeny can cause lung cancer, and thus has become a public health concern [4]. Many countries have carried out surveys of prevailing indoor Radon levels [5, 6, 7, 9]. We have started a program of measurement of Radon concentration in the country, since no serious study has been done in the past. Certainly, this study will provide the basic data for any future study and project planning from the environmental point of view.

Methods And Procedures

Radon concentrations in the houses were measured using passive integral solid-state track detectors CR-39 [8]. Five hundreds (500) dosimeters, were prepared and distributed inside the houses of the middle region of Gaza strip. These houses are chosen to be representative of the whole region. Our sampling strategy was to distribute the dosimeters in houses located at different geographic parts of the region. Moreover, houses built of different materials. Like (stones and concrete), (stone and zinc) and (stone and spostos) were selected: a first group of 100 dosimeters was distributed inside Nuseirat camp (N), a second group of 100 dosimeters placed inside Bureij camp (B), a third group of 100 dosimeters located inside Maghazi camp (M), a fourth group of 100 dosimeters distributed inside Deiralbalah camp (D), a fifth group of 50 dosimeters distributed inside Abraj An-Nuseirat (A), finally a group of 50 dosimeters distributed inside Zahra City (Z). The detectors were placed in a room so as to avoid contribution of ^{220}Rn and its progeny, where the occupants of the house spend most of their time. Some of detectors were placed in bedroom and others in the living room.

The detectors were left in the houses for a period of four months, (from August to December of 2001). Only 433 dosimeters were found in place and collected, while the remaining 67 dosimeters were considered lost, mistreated or damaged. The collected detectors were chemically etched using a 20% solution of KOH, at a temperature of 70^0 C, for 5 hours according to a calibration made in our laboratory. The detectors immersed in the etching solution, in a small container inside a water bath. At the end of the etching process, the detectors were washed thoroughly with distilled water and then left to dry. Each detector was counted visually using an optical microscope with power of (40×10). Tracks in 9 distinct regions were observed; through the unit area of $1cm^2$ the average number of $tracks/cm^2$ was determined. The calibration process for the dosimeters, we used in this survey, four dosimeters were exposed for 30 days of ^{226}Ra (Radon source) of activity concentration 800 Bq/m^3. It gives 572 pCi.d/l (2.12×10^4 $Bq.d/m^3$) concentration for the total exposure. The room's Radon gases monitor was a NITON RAD7. 2500 number of $tracks/cm^2$ was found in these calibration detectors, and then calibration constant was found to be ($8.45\ Bq.d.m^{-3}/track.cm^{-2}$), the overall uncertainty in this calibration was estimated to be ±10%.

Radon and its daughter's concentrations (C) throughout present work are determined by the following equation [9, 10, 11]

Where:

$$C(Bq/m^3) = \frac{C_O\left(Bq.d/m^3\right)}{\rho_0}\left\{\frac{\rho}{t}\right\}_{det.} \qquad (1)$$

C_0=the total exposure of ^{226}Ra (Radon source) in term $Bq.d/m^3$,

ρ_0=track density number of $tracks/cm^2$ of detectors exposed to ^{226}Ra,

ρ=track density (number of $tracks/cm^2$) of distributed detectors,

t= exposure time (days) of distributed detectors.

Results And Discussions

An overview of the Radon concentrations at homes on all camps is evaluated and given in table 1. The minimum and maximum values of Radon concentrations in the camps of each group measured in Bq/m^3 are also determined. The table also shows the average Radon concentrations (C) and the standard deviation (S. D.) for each camp in location of the survey. Radon and its daughter's concentrations over the six locations in the middle region of Gaza Strip were varied between 13.36 to 83.82 Bq/m^3 and had a maximum value of 97.06 Bq/m^3. The average Radon concentrations was 37.83 Bq/m^3 with average standard deviation of 11.23. Average Radon concentrations for each site were determined as follows: Nuseirat camp 37.46 Bq/m^3, Bureij camp 44.95 Bq/m^3, Maghazi camp 38.04 Bq/m^3, Deiralbalah camp 44.51 Bq/m^3, Abraj An- Nuseirat 28.79 Bq/m^3, and Zahra City 17.54 Bq/m^3.

Table 1 Radon concentrations in each camp

Location	No. of det.	Ave. C(Bq/m^3)	Max. C(Bq/m^3)	Min. C(Bq/m^3)	S. D. Bq/m^3
Nuseirat (N)	84	37.5	79.5	16.3	13.4
Bureij (B)	91	45.0	97.1	17.2	12.6
Maghazi (M)	90	38.0	87.1	8.6	12.3
Deiralbalah (D)	85	44.5	93.3	15.5	9.9
Abraj Al Nuseirat (A)	43	28.8	64.3	14.9	8.2
Zahra City (Z)	40	17.5	56.3	3.2	7.3
Ave. value	Sum 433	37.8	83.8	13.4	11.2

Figure 1 shows the average Radon concentrations of B and D camps were higher than M and N camps, but very higher than A and Z as they are new Cities. The result also indicates that the difference between the minimum and maximum Radon concentrations in each camp is very high. This large variation in Radon values inside these camps is due mainly to the difference in the ventilation methods used, different types of locations building (bedroom, living room, … etc) and elevated floor of building (basement, first floor, …etc). The types of building materials such as concrete, spostos, stone and concrete…. etc, are also influence the Radon concentration.

Table 2, shows that the basements are the highest Radon concentrations in all locations. The possibility exists that high Radon concentration is found at lower floors, indicating that air in elevated floor is reasonably well mixed. These results indicate that the Radon concentrations determined are mostly due to the contribution of Radon emanations from soil located under the building. Also, poor ventilation rate plays an important rate of Radon in lower level.

Table 2 Variation of Radon concentrations with the floors levels

Location	Bassement C(Bq/m^3)	1st C(Bq/m^3)	2nd C(Bq/m^3)	3rd C(Bq/m^3)	4th C(Bq/m^3)	5th C(Bq/m^3)	6th C(Bq/m^3)	7th C(Bq/m^3)
N	34.7	28.7	27.1	-	-	-	-	-
B	41.3	38.3	31.0	25.7	-	-	-	-
M	38.1	32.5	22.5	-	-	-	-	-
D	42.4	32.7	26.8	22.3	-	-	-	-
A	37.6	-	30.6	31.2	26.2	24.3	27.4	21.7
Z	32.9	19.6	15.9	11.2	13.6	-	-	-
No. of Det.	92	53	46	23	17	5	4	4
Ave. value	38.8	31.0	24.6	21.8	21.1	24.3	27.4	21.7

Figure 2 indicates that in D camp houses are built of stone and spostos where Radon concentration found higher than 1.32 times of these in N camp. It also shows that the Radon concentrations of D and B houses that built of stone and spostos higher than N and M houses that built of stone and concrete. This represents that houses built of spostos and stone are 1.4 times higher than of houses built of concrete and stone. The highest values were found in houses where the building substructure consisted of stone and zinc. Houses built of stone and concrete had low Radon concentrations in all house locations. The ventilation method in these buildings can be understood to be better than other buildings. This indicates that the different materials of houses built are important parameters in determining Radon concentrations. Figure 3 shows that that the highest Radon concentrations are in bedrooms of D camp, and the lowest in living rooms in M camp. It also shows that highest percentage of Radon concentration is found in the bedrooms 41%, while kitchen 34% and living rooms 25%, within the same housing complex, have about the some Radon levels. The high Radon levels inside bedrooms are due also to the relatively of low ventilation. While living rooms of the houses have large windows, front of open area and well ventilation. In addition, there is an interactive effect between the Radon exposure and smoke cigarettes. Two agents have really causing and developing of lung cancer [12]. Figure 4 shows that Radon concentration of smoking people in B camp is very high comparing to other camps. Thus, higher Radon concentration and smoking together may cause lung cancer. Smokers should keep their exposure to Radon as low as possible. Smokers have many times the risk from Radon than non-smokers. If the house was tested in a frequently used basement, it may have measured a Radon level that is higher than actual level, stop smoking and spend most of your time upstairs.

Figure 1 Radon concentrations in each camp

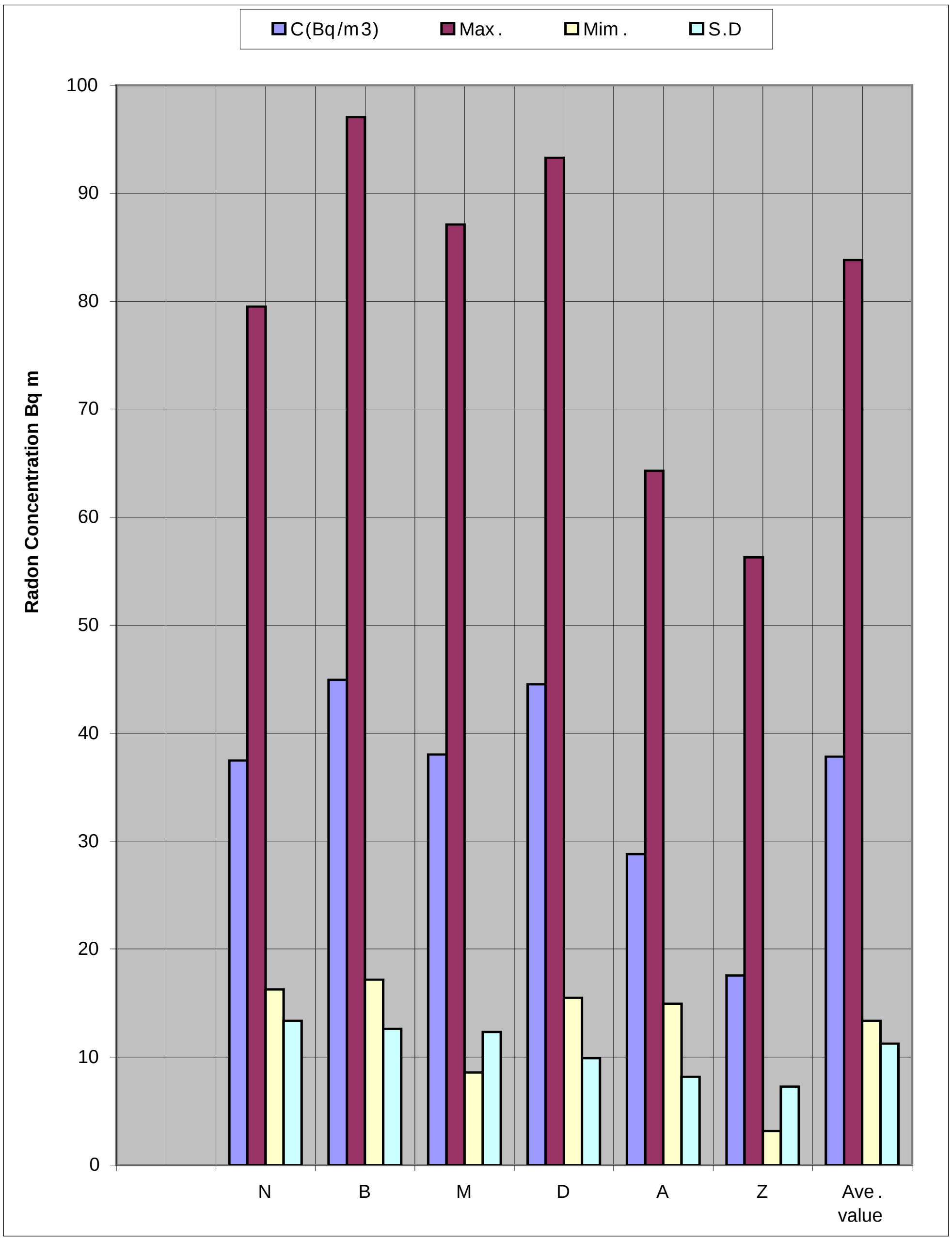


Figure 2 Radon concentrations versus with material of the house

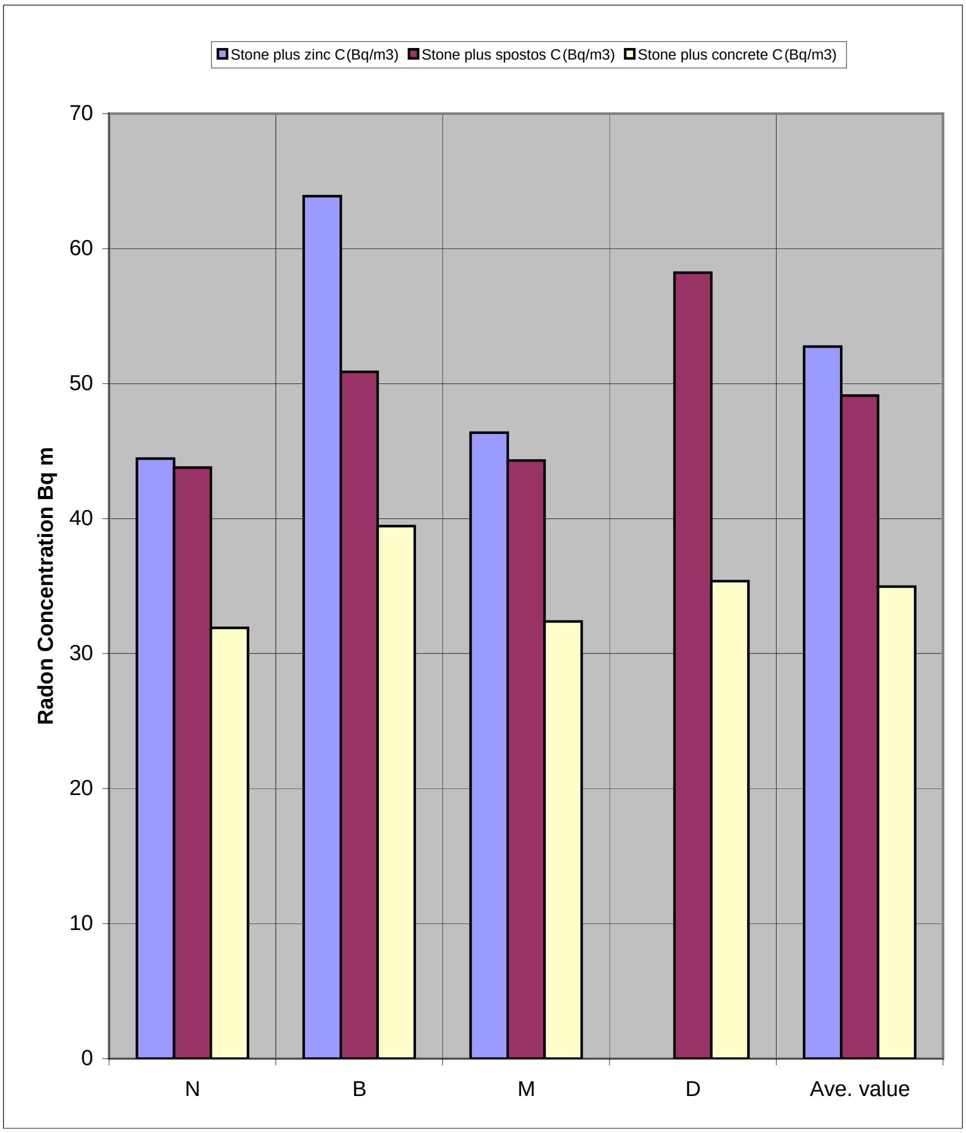


Figure 3 Radon concentrations versus different Rooms of the house built from (stone and spostos)

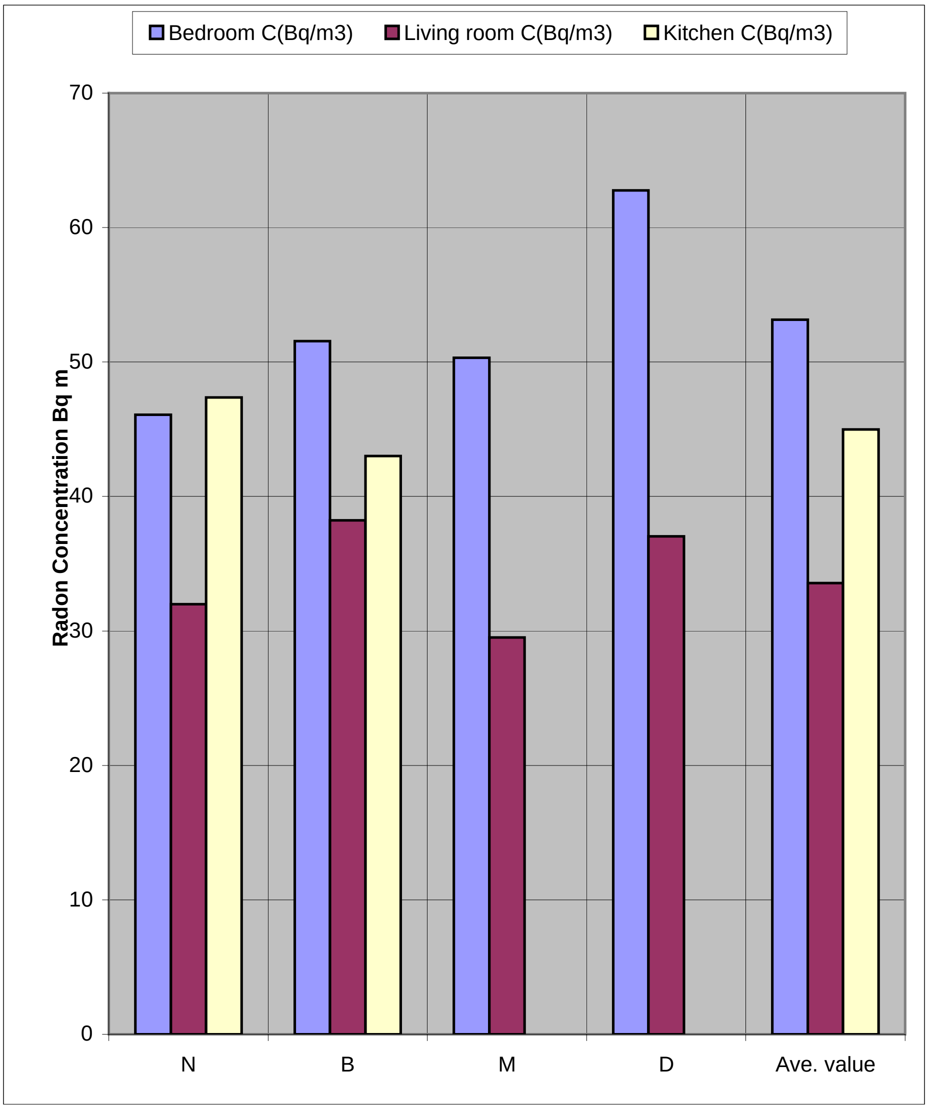
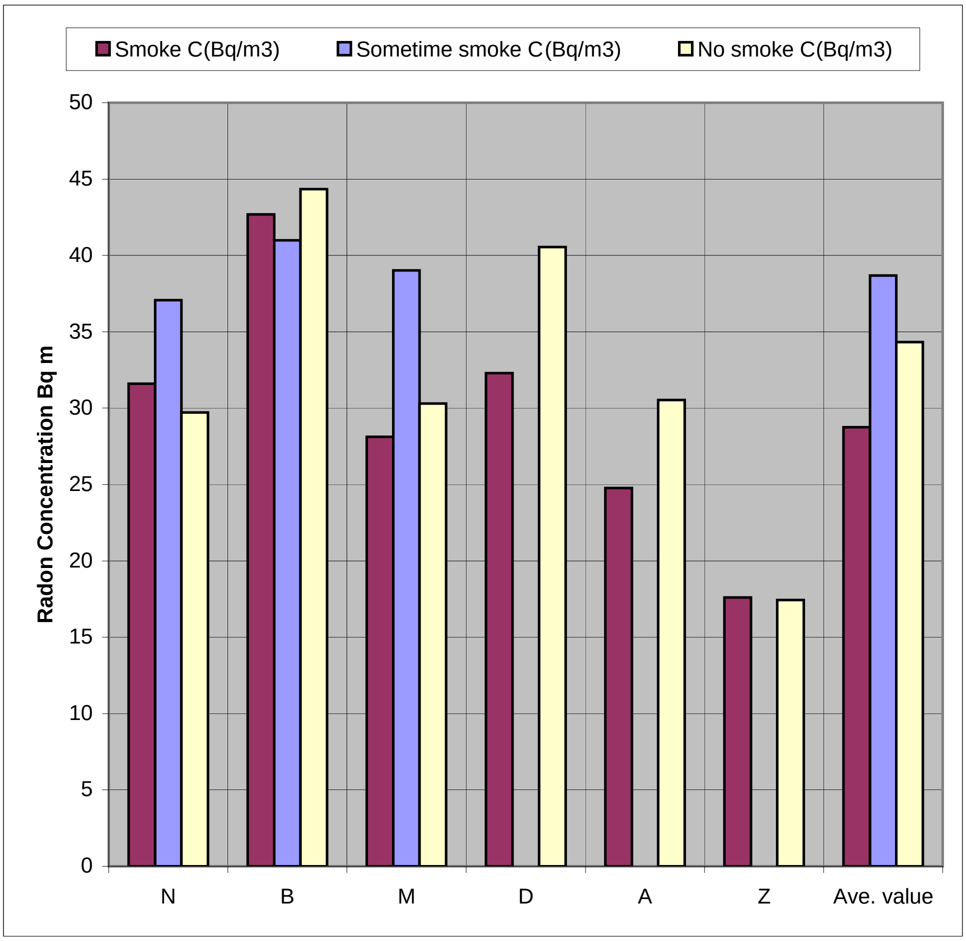


Figure 4 Smoking effect of the houses built from (stone and concrete)



Conclusions

Results indicate that Radon average concentration range from 13.36 up to 83.82 Bq/m^3 with a maximum value of 97.01 Bq/m^3, a sample of houses in all sites of camps. Despite the small number of building studied, the results provide a framework for future studies that include a larger, broader survey of Radon concentrations indoor and outdoor in Gaza. Substantial research efforts are also requested all over Gaza in air, water and soil to evaluate the average Radon concentration of whole country. Certainly, this study undertaken to provide a health oriented Radon assessment of the country to us in addressing long-tang management goals, particularly from the environmental point of view.

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