Measuring Radiological Parameters in Some Samples of Local and Imported Paints Buildingsin Najaf, Iraq

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Abstract

Exposure of the natural radioactivity available in soil and construction materials around the world occupies great concern because of the health risks associated with it. In this work, samples were collected from various markets in Najaf city, Iraq .The measurements of the paints samples have been carried out using gamma ray spectroscopy NaI(Tl) with that (“3×3”). The average value of specific activities were for^{238}U, ^{232}Th and ^{40}K in different types of paints and dyes were 44.19±4.73Bq/Kg, 30.17±3.64 Bq/Kg and 478.84±10.34 Bq/Kg respectively. It is show that, the average value in samples under study were higher than the corresponding global values documented in (UNSCEAR2000) publications. All radiological parameters (Activity of Radium equivalentRa_{eq} and out annual effective dose AEDout)were lower than the permissible limits except absorbed dose rate were higher than worldwide average (UNSCEAR, 2000).

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Keywords: natural radioactivity, gamma ray spectrometry, Samples of paints.

قياس المعاملات الراديوبايلوجيةلبعضالنماذج المحلية والمستوردة لطلاءات المباني في محافظة النجف, العراق

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الخلاصة:

الهم الكبير الذي شغل العالم هو التعرض للنشاط الاشعاعي الطبيعي الموجود في التربة وتراكيب المواد الذي يسبب المخاطر الصحية المرتبطة به. في هذا العمل جمعت النماذج من أسواق متنوعة من مدينة النجف في العراق. قياسات نماذج الدهانات أجريت باستخدام مطياف أشعة كاما لبلورة الصوديوم المطعم بالثاليوم (" 3×3").معدل القيمة للفعاليات النوعية للنويدات المشعة لليورانيوم والثوريوم والبوتاسيوم كانت متنوعة لجميع النماذج (4.73±44.19 بكرل لكل كيلو غرام على التوالي. هذا يوضح معدل القيمة لكل النماذج تحت الدراسة 478.84±10.34 و 30.17±3.64 وكانت اعلى من المعدل العالمي حسب تقرير المنظمة العالمية للسيطرة على الاشعاع عام 2000. كل عوامل الخطورة المتضمنة الفعالية المكافئة للراديوم والجرعة السنوية الخارجية المؤثرة كانت اقل من الحد العالمي المسموح بها عدا الجرعة الممتصة كانت اعلى من المعدل العالمي حسب تقرير المنظمة العالمية للسيطرة على الاشعاع عام 2000.

الكلمات المفتاحية: النشاط الاشعاعي الطبيعي – مطياف اشعة كاما – نماذج من الدهانات (الاصباغ).

1. Introduction

One of the most important matters is people which it is exposure to ionizing radiation of naturally occurring sources such as radionuclides in building materials. The air of houses and work locations is a main cause for human's exposure to ionizing radiation from ^{222}Rn, and ^{234}Th as well their conforming daughters [1] .Building materials contain naturally radioactive elements. Most of them are important namely potassium, radium and thorium isotopes. Radionuclides are capable of causing external and internal exposure to humans living in the buildings. Exposure rate are depending on the radionuclides' concentrations in the building material, their quantity and the kind of building. The cover and last coat of the building material are also essential, perhaps because the last coat is consistent with the emitting surface effect, However coat material is of less emission that unpolished material.

It is famous that most construction materials are originated from different kinds of rocks and Earth's crusts produce most of building materials. Naturally Occurring Radioactive Materials (NORM) often contained in building materials. concentrations of these radionuclides in construction materials vary following the local geological conditions [2]. The construction manufacturing also utilizes lots of waste from other industrial establishments [3]. For instance, in spite of the high level of radioactivity, phosphogypsum of the industry of phosphate fertilizer, coal-fired electricity plants that produce fly ash, oil shale ash, alum shale, and some infrequent radioactive resources are frequently utilized in construction production[4]. In addition, some paint might contain a percentage of radionuclides. Paint is defined as a chemical substance that can be brushed on a solid surface and then it will dry and harden to give a thin layer of a certain colour. It is used to protect surface from natural influences[5]. In order for radioactivity to be considerably higher than background levels may be caused by construction materials [3]. The radioactivity study of construction materials is essential for setting the criteria and directions for their safe use and in conjecturing the radiation risks conjunct with these materials. An undesirable health risk is caused by excessive exposure to ionizing radiation. In the last few years, scientists indicated the low-level exposure from (NORM).Apart from γ radiations there are other harmful effects of NORM. One is the uranium and radium toxicity and the other is the serious effects on lungs by ^{222}Radon[6].Radon origin is (7 - 90)% originates from building materials [7].They make a contribution of about ten percent of the normal dose annually received by the human body among all kinds of radiation [8]. Increase healthrisks to humans are seriously caused by long exposures to low levels of ionizing radiation [9]. This study can't compared with previous studies because there is no previous studies for these samples.

The aim of the current study is to measure natural radioactivity of ^{238}U, ^{232}Th, and ^{40}K in the paints and dyes samples and estimated of the radiation hazard for it.

2. Material and methods

2.1. Collection and sample preparation

Samples of paints and dyes are used as building materials in Iraq generally. Twelve samples of paints and dyes were collected from different local markets in AL-Najaf city. All samples of dye were powder while the samples of paint were liquid. Samples of paint had dried in an oven at about 100°C for changing it to solid completely. Time of hardening was twelve hours. These samples have milled to a fine powder. Powder samples had weighed to 500 gm, and they were positioned in polyethylene beaker. The beakers were completely sealed for three weeks. The purpose of that was reaching secular equilibrium in which the decay rate of the progeny equalizes that of the parent (Thoron and Radium). Process of sealed storage was also necessary for ensuring that radon gas confined within the volume and the Progeny will remain in the sample [10]

2.2. Gamma-spectrometric analysis

Gamma-ray spectrometer composed of scintillation detector 3"×3" (Alpha Spectra, Inc.-12I12/3) was used to measure the specific activities. It is hermetically sealed assembly, which includes a NaI (Tl) crystal, coupled to a multi-channel analyzer 4096 channel (ORTEC-Digi Base) with energetic ranging at (0–3) MeV [11] . For reducing background of gamma ray, a lead shield shaped as cylinder 5cm thickness. Copper material (0.3 mm thick) is an inner concentric cylinder in lead shield for absorption of X-rays which is generated in the lead. For determining the background distribution in the environment around the detector, a blank sealed beaker was calculated likewise in a similar geometrical way as done with the samples. The real time of background was 18,000 s. The spectra of background were used for rectification of the net peak area of ɣ-rays of measured isotopes. The system use (utilized) MAESTRO-32 (version 6.06) software package from the same company[12] The efficiency of the gamma spectrometry systems must be calibrated before the measurement to avoid any uncertainty in gamma ray intensities. Calibration of system was performed using the standard sources ^{60}Co, ^{137}Cs, ^{22}Na and ^{54}Mn,IAEA (2009). As well as, self-absorption effects of the emitting gamma photons and the influence of coincidence summation [13].The photo peak at 1.460 MeV was employed for the measurement of ^{40}K whereas those at 1.760 MeV peak from ^{214}Bi and 2.614MeV from ^{208}TI were utilized to measure Radium (^{238}U) and ^{232}Th, respectively. [4] The detector resolution was 6.8%.

3. Calculation of the Radiological Effects and Dose Appraisal

3.1. Specific activities

The specific activities (A) of ^{238}U, ^{232}Th and ^{40}K in each sample in Bq/kg were calculated using the following equation: [14]

$$A = \frac{C}{\varepsilon \gamma M} \quad \dots\dots\dots (1)$$

Where, C : the net area under photo peek (counts/second)

ε : the detectors efficiency of the specific γ-ray,

γ : the absolute transition probability of γ - decay ,

M : mass of the sample (kg).

3.2. Radium equivalent Activity ($Ra_{eq.}$)

For representation the activity level of radionuclides (^{238}U, ^{232}Th and ^{40}K) by a single quantity, a common radiology index was presented. It's famous activity of equivalent radium was labeled by $Ra_{eq.}$. It's calculated by the following formula [15]:

$$Ra_{eq.} = C_{Ra} + \left(\frac{10}{7}\right) C_{Th} + \left(\frac{10}{130}\right) C_k \quad \dots\dots (2)$$

This relationship is obtained by assuming that the activities (1Bq/kg) of ^{238}U, (0.77 Bq/kg) of ^{232}Th and (1.43 Bq/kg) of ^{40}K produce the same dose of ɣ- rays [16]. It must be noted that the maximum value of the activity of radium equivalent in construction materials must be less than 370 Bq/kg.

3.3. Absorbed Dose Rate

Absorbed dose rate D which is measured in (nGy/h) from natural radionuclides in the air at 1m height is defined by expression: [13]

$$D = 0.462\, C_{Ra} + 0.604\, C_{Th} + 0.0417\, C_k \ldots (3)$$

The symbols C_{Ra}, C_{Th} and C_K are the specific activity for radium, thorium and potassium, respectively.

3.4. The Annual Effective Dose Equivalent (AEDE)

By applying the dose conversion factor of 0.7 Sv/Gy with an outdoor occupancy factor of 0.2 and 0.8for indoor, the annual effective dose equivalent (AEDE) was calculated from the absorbed dose [17,18]

$$AEDE_{out} = \left\{ D\left(\frac{nGy}{h}\right) \times 8760(h) \times \mathbf{0.7} \times (10^{-6})\left(\frac{mSv}{nGy}\right)\right\} \mathbf{0.2} \ldots (4)$$

$$AEDE_{in} = \left\{ D\left(\frac{nGy}{h}\right) \times 8760(h) \times \mathbf{0.7} \times (10^{-6})\left(\frac{mSv}{nGy}\right)\right\} \mathbf{0.8} \ldots (5)$$

For estimation (AEDE), account must be taken from the conversion coefficient of absorbed from absorbed dose in air to effective dose and the indoor occupancy factor. The averages numerical values of those parameters was varied according with the age of the population and the climate at the considered location [19].

4. Results and Discussion

The results of minimum, maximum and average of specific activities for Uranium, Thorium and Potassium for all samples the paints and dyes are given in table (1). This table referred to the specific activity of ^{238}U varies from (16.82±2.86 to 130.09±7.04) Bq/kg with average 044.19±4.73 Bq/kg. The specific activity of ^{232}Th varies from (9.52±1.20 to 73.95±4.14) Bq/kg with average30.17±3.64 Bq/kg. The specific activities of ^{40}K exists in the range from (138.14±04.64 to1123.52±13.85) Bq/kg with average 0478.84±10.34Bq/kg.The average values in most sample were higher than reported worldwide average value (30, 35 and 400) Bq/kg [17].

Percentage of specific activities for each radionuclide is seen as in figures.(1)

Table 2. has been shown that Ra_{eq}. in the samples under study ranged from 54.15 Bq/kg to 221.42 Bq/kg in sample code(B_{12} and B_{10}) continually. The maximum value of Ra_{eq}. was less than the limit value of 370 Bq/kg recommended by UNSCER 2000, as can be seen in fig.(2).

Values of absorbed dose rate were alternated between (77.172 and 526.640) nGy/h, whereas its averagevalue was (238.324 nGy/h), while the results of absorbed gamma dose rate in all studied samples were higher than the recommended value of (55 nGy/h) [18], because the contribution of ^{40}K large ratio is shown in table(2) .

Values of the indoor annual effective dose for the samples were alternated between (0.378 and 2.583) mSv, with an average (1.169 mSv), while the values of the outdoor annual effective dose were ranged between (0.094 and 0.645) mSv, with an average (0.292 mSv). The results showed that the indoor annual effective dose of the samples (B_1, B_5, B_7, B_8 and B_{10}) was higher than the world limits, while the outdoor annual effective dose for all samples were within the acceptable limit of 1 mSv, as in Fig. (3).

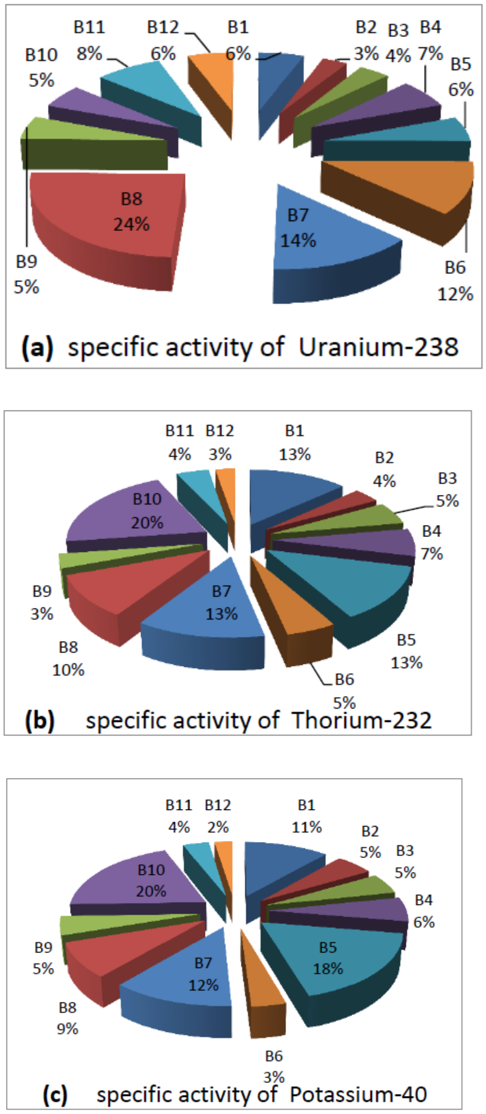
From the obtained results, it's clear that the specific activities of radionuclides (^{238}U, ^{232}Th and ^{40}K) and the radium equivalent activity varied considerably in samples depending on different geological origin of the soil and chemical process of the ore during dyes manufacture.

Table 1: Shows the specific activities of ^{238}U, ^{232}Th and ^{40}K (Bq/kg) in paint samples.

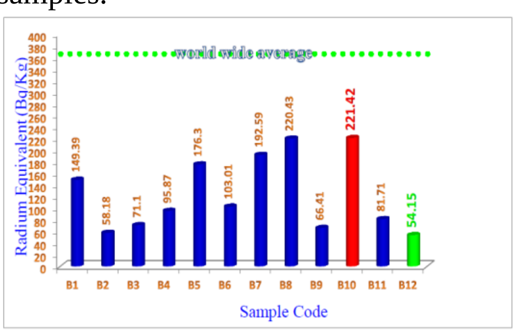
Sample Code	State	Name	Country	Specific Activity (Bq/Kg)		
				^{40}K	^{238}U	^{232}Th
B1	Liquid	Synthetic	China	656.28±15.61	30.38±5.48	47.88±5.79
B2	Liquid	Antifouling Marin	USA	297.72±7.74	16.82±2.86	12.88±3.14
B3	Powder	Bepermo	China	287.81±6.60	20.73±2.47	19.72±2.68
B4	Liquid	Aqua Sat	Belgium	343.35±8.70	35.26±2.73	23.89±3.30
B5	Powder	Synthetic	Iran	1031.12±17.30	30.11±9.89	46.70±6.41
B6	Liquid	Betakril	Turkey	201.47±8.28	62.04±3.97	17.79±2.48
B7	Liquid	Fabiano	China	703.21±15.03	73.53±6.17	45.38±5.18
B8	Powder	Al-Najar	Iraq	495.74±13.97	130.09±7.04	36.48±4.43
B9	Powder	Al-Marjan	Iraq	264.51±7.37	28.52±3.06	12.25±2.70
B10	Liquid	Makmolit	China	1123.52±13.85	29.15±8.53	73.95±4.14
B11	Powder	Silan Texture	Germany	203.25±5.06	43.79±2.62	15.57±2.22
B12	Liquid	Jota shield Colour Last	Iran	138.14±4.64	29.90±1.99	9.52±1.20
Max.				1123.52±13.85	130.09±7.04	73.95±4.14
Min.				0138.14±04.64	016.82±2.86	09.52±1.20
Ave.				0478.84±10.34	044.19±4.73	30.17±3.64

Table 2: Shows Absorbed Dose (Bq/kg) and radiological parameters for different samples.

Sample Code	Radium Equivalent (Bq/Kg)	Absorbed Dose (nGy/h)	Annual Effective Dose (mSv)	
			Indoor	Outdoor
B1	149.39	316.633	1.553	0.388
B2	058.18	139.711	0.685	0.171
B3	071.10	141.511	0.694	0.173
B4	095.87	173.903	0.853	0.213
B5	176.30	472.105	2.315	0.578
B6	103.01	123.430	0.605	0.151
B7	192.59	354.631	1.739	0.434
B8	220.43	288.864	1.417	0.354
B9	066.41	130.883	0.642	0.160
B10	221.42	526.648	2.583	0.645
B11	081.71	114.395	0.561	0.140
B12	054.15	77.172	0.378	0.094
Max.	221.42	526.640	2.583	0.645
Min.	054.15	077.170	0.378	0.094
Ave.	124.21	238.324	1.169	0.292



Figure(1): (a, b and c).is showing the percentage of specific activities of 238U ,232Th and 40K of the paints and dyes samples.



Figure(2): The radium equivalent activity of the paints and dyes samples.

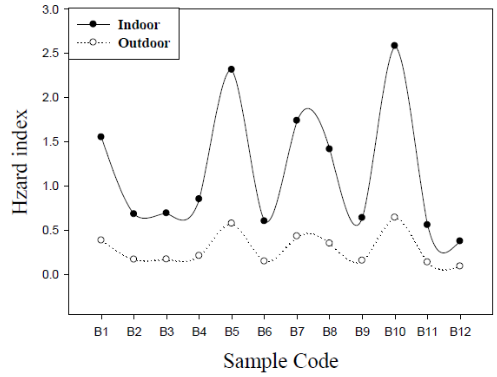


Figure (3). Comparison between Indoor and outdoor annual effective dose equivalent of the paints and dyes samples.

5. Conclusions

All the analyzed samples in this present work were unsafe for use as a construction material, because it average of specific activities was high. The absorbed dose rate and most of indoor annual effective dose of samples were big too. Perhaps these materials can contain uranium salts bucace some paints are derived from gypsum materials and other are derived from oil .Future study will be interested of the variation of activities amongst different sample brands.

6. Recommendations

It is necessary to be recommend by:

1. Periodic radiological examination of paints in the production factories.
2. Preventing the import of any pigments containing a high concentration of radiation.

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