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Synergism Effects of Coating and Concrete Plaster to Reduce ^{222}Rn Emanations from Red Brick

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Abstract. The study revealed the synergism effects of concrete plaster and coatings in reducing ^{222}Rn from a marketable red brick. The methodology applied is the common practice in construction industry for wall finishing. ^{222}Rn concetrations level from red brick coated with three different type of coatings were measured within 5 consecutive days within 30 min times interval. The nett ^{222}Rn concentration of raw red brick (uncoated) was -0.22 pCi/L. From the results, ^{222}Rn concentration has drastically decreased after coated with coating B and C. ^{222}Rn cocentration seems to decreased with the range of -0.9 pCi/L to -0.3 pCi/L after coated with coating B and -0.8 pCi/L to -0.7 pCi/L after coated with coating C. Coating B shown the best performance in reducing ^{222}Rn emanations with lowest ^{222}Rn range concentration, high adhesion strength and good dynamic viscosity properties.

Keywords: *α particle, Health implications, Coating adhesivity, Radon sentinel;*

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1. INTRODUCTION

Radon (^{222}Rn) is one of the radiation sources which occurs naturally in the environment. It is a form of radioactive gas and one of the contributors for lung cancer besides smoking due to the emission of alpha particles [1]. ^{222}Rn concentration released from brick was originated from its aggregates which are sand, cement and clay [2].

The red brick as shown in Fig. 1 (a) is widely used in building construction without knowing the presence of high radioactivity of ^{222}Rn gas. Theoretically, ^{222}Rn was emanated from the red brick through the porosity and cracking line along its surface [3-5]. Furthermore, this radioactive gas continuously emanated from the wall and floor of buildings, which significantly increased with poor ventilation system [6-7].

Throughout this research, three types of coating as well as cement plaster were applied on the red brick in preventing the emanation of ^{222}Rn gas. The coating characteristics will influence the brick porosity level and directly reduce the amount of radon emanations in the building.

2. MATERIALS AND METHODS

To prevent emanation of α-particles (^{222}Rn progenies) from red bricks, a layer of plaster was applied. This plaster was then coated with selected coating which are coatings A, B, and C as shown in Figs. 1(b,c). Coatings A, B and C were purchased from hardware nearby Jeli district, Kelantan, Malaysia which was the common brand that had been used among Malaysian contractors and community for building wall painting and industial purposes. In this study, Radon Sentinel 1030 monitor manufactured by Sun Nuclear Corporation, United Sate of America (USA) was used to measure the concentrations of ^{222}Rn gas that emanates from the coated and uncoated red brick as shown in Fig. 2.

Fig. 1 (a) Ordinary red brick with standard size of 8 x 4 cm^3, (b) Fully coated brick with concrete plaster before coating process and (c) Coating materials was applied on the surface of concrete plaster

Prior to start the ^{222}Rn gas measurements, the adhesive testing has been conducted on each coated brick using Positest Adhesion Tester manufactured by DeFelsko Corporation, USA. This test revealed the coating adhesive force on the brick surface, which is one of the major factors for ^{222}Rn concentration emanations. The characteristics of these type of coatings was presented in Table 1.

Table 1 Coating characteristics; Adhesive force, dynamic viscosity and its main components

Type of coatings	Adhesive Force (N)	Dynamic Viscosity (Pa. s)	Main Components
Coating A	0.05	149.58	Poly(oxy-1,2-ethanediyl), alpha-nonylphenyl-omega-hydoxy-5-chloro-2methyl-4-isothiazolin-3-1, 2-methyl-2H-isothiazol-3-1
Coating B	0.06	315.83	Titanium dioxide (TiO_2), Iron oxide (Fe_2O), Carbon (C), Black and organic pigments and mineral extender
Coating C	0.04	33.37	Naphta (Petroleum), hydreated heavy, Talc, Magnesium silicate, Ethyl methyl ketoxime

Radon Sentinel 1030 monitor was setup to record the reading within 30 min time interval. Each coated and uncoated bricks were measured in 24 hours for 5 concecutive days. Hence, there were 240 of ^{222}Rn data have been recorded for each type of coated and uncoated bricks. Through this method, average of ^{222}Rn oncentrations for each coated and uncoated red bricks as well as raw materials were obtained.

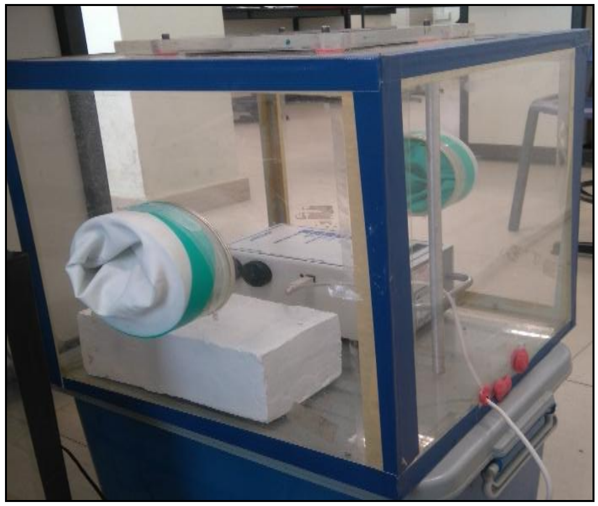

Fig. 2 Measurement of ^{222}Rn concentration using Radon Sentinel 1030 in a close perspex box

3. RESULTS AND DISCUSSION

^{222}Rn concentrations for each raw material was obtained within 5 concecutive days; a. empty room prototype, b. cement, c. sand, d. red brick, e. beaker, f. water, g. coating A, h. Coating B and i. Coating C as shown in Fig. 3. From the graph, room prototype with 0.977 pCi/L was fixed as the background reading in this study. Hence, each average of ^{222}Rn reading for raw materials were deducted to the background reading (0.977 pCi/L) to obtain the nett ^{222}Rn concentrations by using the formula in Eq. 1 [2,8]. Thus, nett of ^{222}Rn concentration from raw red brick was revealed at -0.22 pCi/L. All the recorded reading becomes negative values due to the background of close air in the prototype room was measured as the highest ^{222}Rn concentrations in this experiment. This is due to the random characteristics of radiations [9-10].

$$\text{Nett } ^{222}Rn = (Avg^{222}Rn) - (Bck^{222}Rn) \quad (1)$$

*Avg = Average

**Bck = Background

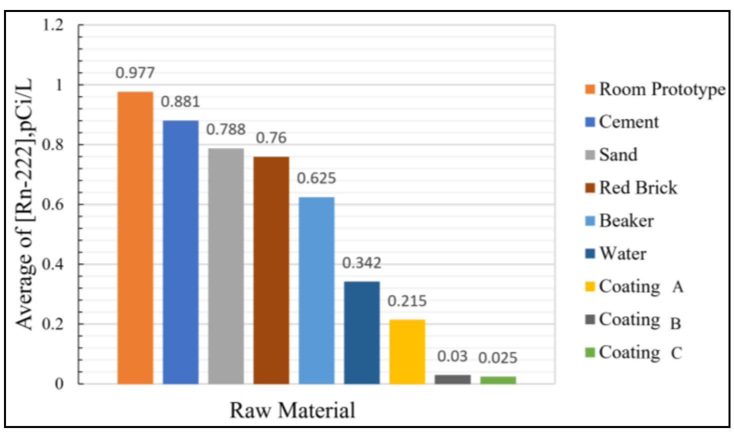

Fig. 3 Average of ^{222}Rn concentrations for raw materials and empty prototype room

Theoretically, the concentration of ^{222}Rn from red brick will be decreased after being coated with coating materials. However, the red brick coated with coating A shows the opposite result, where the ^{222}Rn concentrations was slightly higher than raw red brick. This result might be due to the characteristics of coating material itself, where the ^{222}Rn concentrations emanated from coating A was significantly higher than other coatings as shown in Fig. 3 (0.215 pCi/L). High ^{222}Rn concentrations possibly contributed from the components into coating A as shown in Table 1.

In this study, nett concentrations of ^{222}Rn was in between -1.0 pCi/L to 0.8 pCi/L for layered with plaster and coated with coating A, -0.9 pCi/L to -0.3 pCi/L for layered with plaster and coated with coating B whereas -0.8 pCi/L to -0.7 pCi/L for layered with plaster and coated with coating C as shown in Figs. 4-6, respectively.

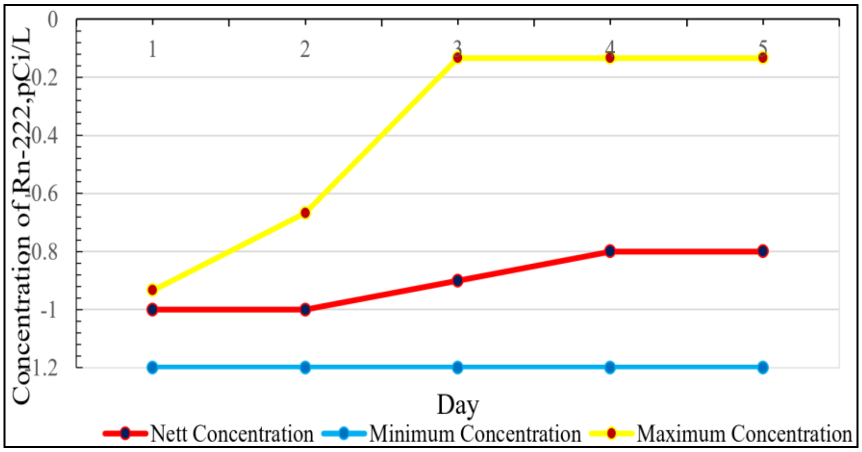

Fig. 4 Nett, minimum and maximum of ^{222}Rn concentrations in red brick layered with plaster and coated with coating A

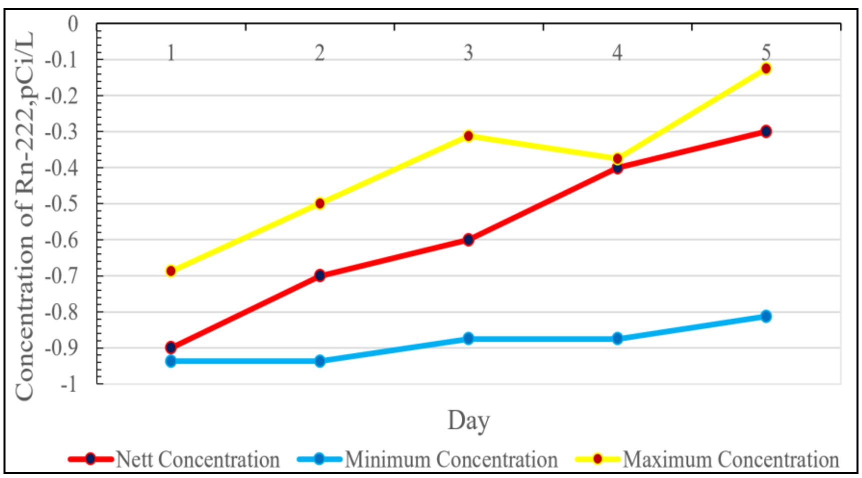

Fig. 5 Nett, minimum and maximum of ^{222}Rn concentrations in red brick layered with plaster and coated with coating B

Meanwhile, ^{222}Rn emanations from coated bricks were increased from time to time within 5 consecutive days' measurement as shown in Fig.s 4-6. This phenomenon is closely related with natural characteristics of ^{222}Rn gas, which has half-life of 3.8 days and decayed to its progenies of α particles, polonium, bismuth, and lead [8]. Hence, the reading obtained was continuously increased in close air, depending on the natural half-life and random emanations of ^{222}Rn progenies originated from internal aggregates material of the respected brick.

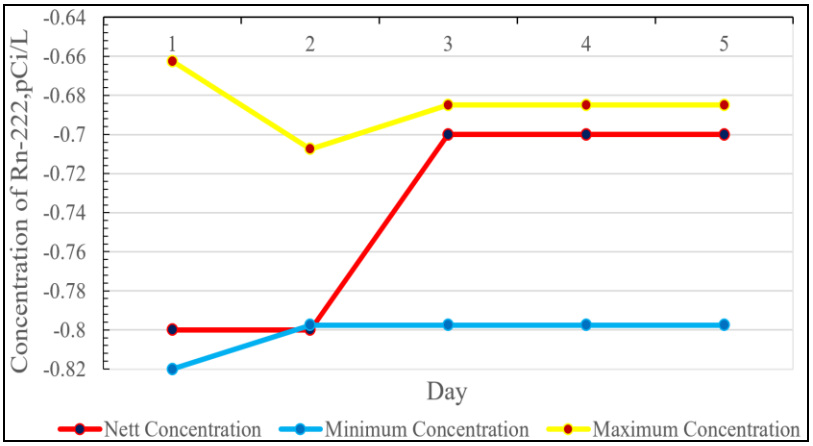

Fig. 6 Nett, minimum and maximum of ^{222}Rn concentrations in red brick layered with plaster and coated with coating C

In additions, the coating materials with high viscosity and adhesivity is believed to be more effective in reducing the emanation of ^{222}Rn concentration towards the surrounding. Viscosity of coating materials was measured by using Stoke's Law as shown in Equation 2 and represented in Table 1.

$$\eta = \frac{2}{9}\left[(\rho 2 - \rho 1)(g)\left(\frac{r^2}{v}\right)\right] \quad (2)$$

*η = viscosity

**ρ_2= Density of coating materials

***ρ_1= Density of ball bearing

****g= Standard gravity

****r = Radius of ball bearing

*****v= Particle velocity.

It can be observed that the highest viscosity recorded from coating B, followed by coating A and C, respectively. The higher viscosity of coating can be considered as the most effective coating type in reducing the emanation of ^{222}Rn. This is because the good viscosity coating has good tendency in filling the brick porosity, which directly blocking α particles emanations. Moreover, high adhesivity of coating will tightly close any micro porous along the brick surface, and resulted to reduce the emanations of energetic α particles. This was proved by the lowest of nett ^{222}Rn emanations ranges in Fig. 5 with -0.9 pCi/L to -0.3 pCi/L, where coating B shows the best viscosity and adhesive characteristics than to other comparative coatings. Nevertheless, the paint somehow will lose their viscosity as the thickening agents was used in degree of polymerization [11,12].

4. SUMMARY

From conducted research, reduction of ^{222}Rn emanation from the red brick was achieved by using coating B and C. The concentration of ^{222}Rn seems to decreased with the lowest ranges of -0.9 pCi/L to -0.3 pCi/L after coated with coating B and medium ranges of -0.8 pCi/L to -0.7 pCi/L after coated with coating C. ^{222}Rn concentration was increased for red brick coated with coating A, which was contributed from coating material itself. Overall, each type of coating materials used have different strength and compatibility in reducing ^{222}Rn emanation from marketable red brick, depending on their physical and chemical characteristics. Coating B was observed as the best material in reducing ^{222}Rn emanations from red brick with lowest ^{222}Rn concentration range, high adhesion strength and good dynamic viscosity properties.

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