SYNERGISMS OF RN-222 REDUCTION EMANATIONS WITH DIFFERENT THICKNESS PLASTER FROM RED BRICK

by

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DECLARATION

I declare that this thesis entitled "**SYNERGISMS OF RN-222 REDUCTION EMANATIONS WITH DIFFERENT THICKNESS PLASTER FROM RED BRICK**" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date : ______________________________

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ABSTRACT

Radon (Rn-222) is noble gas formed by the decay of radium (Ra-226), which is one of the nuclides formed in the disintegration series from uranium (U-238). Radon has been considered the second leading cause of lung cancer and leading environmental cause of cancer mortality by the Environmental Protection Agency. The objectives of this research are to investigate the synergism of Rn-222 reduction emanations with three different thickness cements from red brick. Therefore, in this research we want to see whether the radon emanation will reduce by coating with different thickness of cement. In this research, Rn-222 concentrations have been measured with three different thickness layers of red brick by using Radon Sentinel Model 1030. The thickness range for every layer which is the first layer has 1.0 – 1.5 cm. For second layer thickness is 1.5 – 2.0 cm and third layer is 2.0 – 2.5 cm. The data collect for each layer is after 24 hours in 4 consecutive days with interval 1 hour. The average of Rn-222 concentration for three layer were found at 8.15 pCi/L, 5.73 pCi/L and 0.125 pCi/L. The red brick with thicker layer of cement has the lower Rn-222 concentration compare to red brick layer with thin layer of cement. Rn-222 concentration also influenced by ventilation rate, humidity, pressure and temperature even though it had been placed into prototype room to reduce this factors.

PENGURANGAN SINERGISMA RN-222 DENGAN KETEBALAN PLASTER BERBEZA DARIPADA BATA MERAH

ABSTRAK

Radon (Rn-222) adalah gas dibentuk oleh pereputan radium (Ra-226), yang merupakan salah satu daripada radio nuklid terbentuk dalam siri perpecahan dari uranium (U-238). Radon telah dianggap sebagai punca utama kedua kanser paru-paru dan membawa kepada punca alam sekitar dan kematian oleh Agensi Perlindungan Alam Sekitar. Objektif kajian ini adalah untuk menyiasat sinergisma Rn-222 dengan kadar pengurangan radon menggunakan tiga ketebalan simen yang berbeza pada bata merah. Oleh itu, dalam kajian ini kita mahu melihat sama ada terbitan radon akan dikurangkan dengan salutan menggunakan ketebalan simen yang berbeza. Dalam kajian ini, kepekatan Rn-222 telah diukur dengan tiga lapisan ketebalan yang berbeza daripada bata merah dengan menggunakan Radon Sentinel Model 1030. Ketebalan untuk setiap lapisan yang pertama mempunyai 1.0 - 1.5 cm. Untuk ketebalan lapisan kedua adalah 1.5-2.0 cm dan lapisan ketiga ialah 2.0 - 2.5 cm. Data yang dikumpul pada setiap lapisan adalah selepas 24 jam dalam masa 4 hari berturut-turut dengan selangan tempoh 1 jam. Purata kepekatan Rn-222 untuk tiga lapisan ditemui iaitu 8.15 pCi / L, 5.73 pCi / L dan 0.125 pCi/L. Bata merah dengan lapisan simen tebal mempunyai kepekatan Rn-222 lebih rendah berbanding dengan lapisan simen pada bata merah dengan yang lebih nipis. Kepekatan Rn-222 juga dipengaruhi oleh kadar pengudaraan, kelembapan, tekanan dan suhu walaupun ia telah diletakkan didalam bilik prototaip untuk mengurangkan faktor-faktor ini.

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LIST OF ABBREVIATIONS

EPA	Environmental Protection Agency
WHO	World Health Oraniation
pCi/L	Picocuries per liter
Rn-222	Radon-222
U-238	Uranium
Ra-226	Radium
He	Helium
Ne	Neon
Ar	Argon
Kr	Krypton
Xe	Xenon
mm	Millimetre
cm	Centimetre
inHg	Inches of mercury
F	Fahrenheit

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Radon (Rn-222) is noble gas formed by the decay of radium (Ra-226), which is one of the nuclides formed in the disintegration series from uranium (U-238). They can migrate to the earth's surface by transport of Rn-222 relative to the gas or liquid (molecular diffusion) and with the gas or liquid (convection or groundwater flow) (Janik, 2015). Rn-222 has a half-life of 3.82 days. Rn-222 is heaviest noble gas with density 7.5 times larger higher than air. It exhibits the highest melting point, boiling point, critical temperature and critical pressure of all noble gas. Rn-222 is soluble in water and groundwater because it is highly soluble in non-polar solvents. It is odourless, tasteless, colourless and a cancer-causing radioactive gas (Field & Health, 1999). It release from rocks and soils into building and living areas. Once inhaled, it causes, essentially because of its decay product, also alpha emitters, a major health hazard through lung cancer (Girault, 2012).

Rn-222 has been considered the second leading cause of lung cancer and leading environmental cause of cancer mortality by the Environmental Protection Agency (EPA, 2009). Rn-222 decays into radioactive metals ion by alpha radiation. Rn-222 is the main source of internal radiation of exposure to human life. People are exposed to radiation from Rn-222 and its progeny by inhalation and ingestion. Rn-222 is soluble in water and groundwater passes through the uranium-bearing soils and rocks. Drinking water that contains Rn-222 and it progeny is also of Rn-222 exposure to people (El-Zaher, 2008).

Limitations of the measurements for indoor Rn-222 concentration of buildings are important because most of our time spent within buildings (El-Zaher, 2008). Therefore, the measurement of emanations of Rn-222 with different thickness plaster from specific bricks (red brick) is carried out through this research. Rn-222 emanation are depends of several factors such as building materials, humidity, temperature, pressure and ventilation rate. The pressure and ventilation rate are the main factors affect the variation of indoor radon. When the room is smaller, the indoor radon is high because different in air pressure within the rooms affects the movement of radon (Satish, 2011). The air exchange between indoors and outdoors is affected by the ventilation rate. Opening the door and windows will be decreased the indoor concentration level (Ali, 2010).

1.2 Problem Statement

There are many researches that have been conducted to measure the emanations of radon levels in many countries in the world. During the past two decades, many researches in different countries studies about the Rn-222. This shows that the concern of community against the harmful effects of Rn-222 to human body. The public awareness especially in Malaysia is still less about the harmful effect of Rn-222 compare to Western countries especially United States. There are only a few research about radon in Malaysia have been conducted. The Environmental Protection Agency (EPA) recommends that the limits expose to Rn-222 must not exceed 4 picocuries per litre (pCi/L) in any liveable area of house a year-long average concentration (Organization, 2001)

This research is carried out to introduce about effect Rn-222 among community in Malaysia and as a guideline for future use. There are no data and references on radon emanation from building materials (red brick) in University Malaysia Kelantan (UMK). The measurement of Rn-222 emanation is important to investigate the safety of building on human body and health that spends most of their times inside the building.

1.3 Objective

The objectives of this research are to investigate the synergism of Rn-222 reduction emanations with different thickness plaster from red brick. Therefore, in this research we want to see whether the radon emanation will reduce by coating with different thickness of plaster. The objectives of this research are:

1) To determine the Rn-222 emanation from red brick.

2) To study the effect of Rn-222 emanation by different thickness of plaster on red brick.

1.4 Expected Outcomes

Measurement of radon emanations from the concrete of building material (red brick) must be lower than the Environmental Protection Agency (EPA) suggested action level that is for building structures. The radon concentration emanation from red brick with plaster apply should be lower than red brick without plaster. Moreover, thicker plaster thickness applied will be reduce Rn-222 emanation.

1.5 Scope of Research

The scopes of research are to determine the concentration emanation of Rn-222 from red brick. The red brick will apply with different thickness of plaster and will place into prototype room. The concentration emanation Rn-222 will measure using Radon Sentinel model 1030. The research include the red brick, Rn-222, thickness of plaster, prototype room and alpha particles.

CHAPTER 2

LITERATURE REVIEW

2.1 History and Background of Radon

Radiation has been a natural part to our environment. Radiation such as Rn-222 is emitted from natural source in the soil, water and rock. Radon, the element with atomic number 86, is chemically a noble gas, appearing in the same group of the periodic table of elements as He, Ne, Ar, Kr and Xe. It had been discovered by English physicist Ernest Rutherford in 1899. Radon had been classified as gaseous highly radioactive element. The discovery also credited to German physicist Friedrich Ernst Dorn in 1900 while studying radium decay chain.

At normal room temperatures, radon is a colorless, odorless, radioactive gas. The most common forms of radon decay through alpha decay. Alpha decay usually isn't considered to be a great radiological hazard since the alpha particles produced by the decay are easily stopped. However, since radon is a gas, it is easily inhaled and living tissue is directly exposed to the radiation. Furthermore, the mass and charge of the alpha particles is so high that it can cause intense ionization.

2.1.1 Action Level

The Environmental Protection Agency suggests an action level of 4 picocuries per litre (pCi/L) in air. Lutgens & Tarbuck suggest this level corresponds to about 8 to 9 atoms of radon decaying every minute in every litre of air. According to Cohen, the mean radon level in houses throughout the western world is about 1 picocuries per litre (pCi/L). Cohen has expressed the risk of radiation in term of "loss of life expectancy". He place the loss of life expectancy of 20 hours for a year's exposure to 1 picocuries per litter in the building.

The average indoor radon concentration is about 1.3 picocuries per litter in air. It is not uncommon, through, for indoor radon level to be found in the range of 5-50 picocuries per litter, and the have been found as high as 2,000 picocuries per litter.

2.1.2 The Formation and Sources of Radon

Alpha decay is a type of radioactive in which two protons and two neutrons are emitted as shown in Figure 2.1. They are bound together into a particle identical to a helium nucleus. Alpha particles can be stopped by a sheet of paper because they cannot travel far and not dangerous unless ingested.

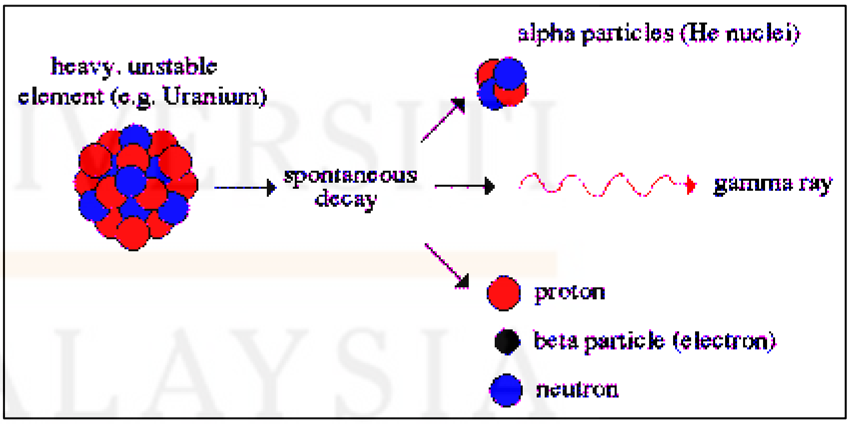

Figure 2.1: Alpha radiation produces a helium atom and one or more gamma rays (Crain, 2001)

Rn-222 comes from during the decay of uranium-238, an element with a fairly interesting decay sequence. Some elements decay to a stable form through a series of alpha and beta emissions, the longest chain being that for uranium, shown below in figure 2.2. Note that each Beta-minus decay increases the atomic number by 1 and each Alpha decay decreases it by 2 (Crain, 2001).

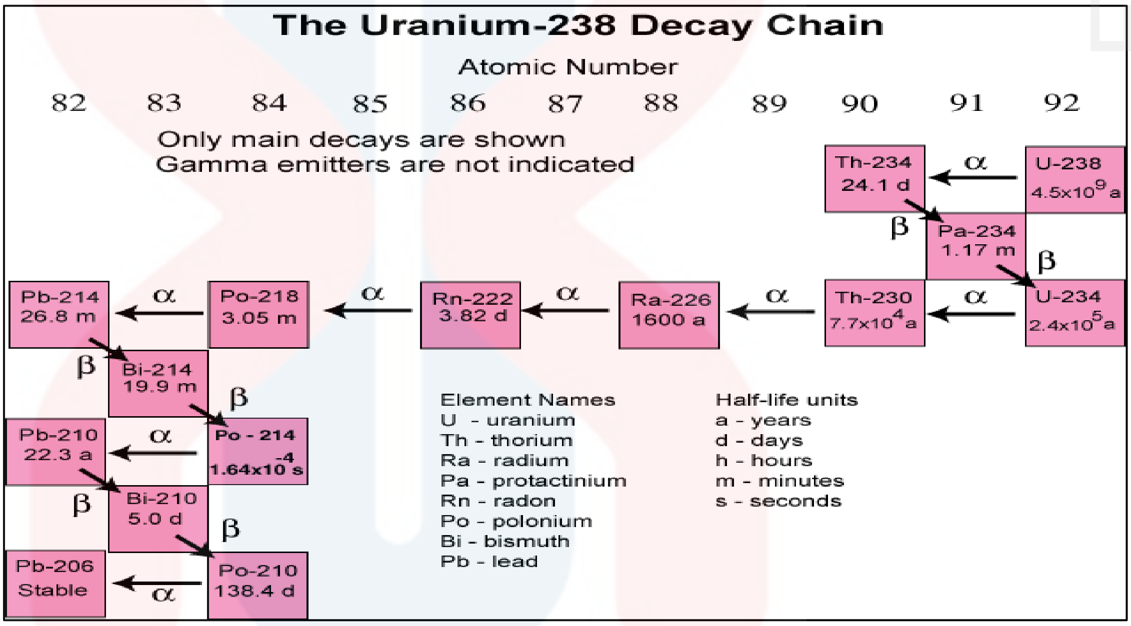

Figure 2.2: The Uranium-283 Decay Chain (Crain, 2001)

All rock contain some uranium,, typically 1-3 ppm. The uranium content of a soil will be about the same uranium content of rock from the soil was derived. The lower air pressure indoors give rise to a pressure-driven flow of radon rich soil into the indoor environment through cracks in bottom slab and cellar wall. Radon can be entering into building by air pressure differentials between soil gas and building air.

2.2 Red Brick

Red brick is one of building material commonly uses in our country for construction. Man has used brick for building purposes for thousands of years. Archaeological excavations have unearthed a brick that authorities dated as 9,000 to 10,000 years old. Bricks are made from adobe soil, comprised of clay, quartz and other minerals. Brick which were used extensively in ancient times, especially in Egypt, were made of clay mixed with straw. Early in civilization, bricks were heat up by using a fuel; these bricks were made of clay mixed with straw to give them added strength (Ramadan, 2015).

2.3 Health Affect

Rn-222 has been considered the second leading cause of lung cancer and leading environmental cause of cancer mortality by the Environmental Protection Agency (EPA). Epidemiological studies indicate that the risk of lung cancer among smokers increases with exposure to residential radon (C. Meenakshi, 2013). Rn-222 is rated as a group one carcinogen by the International Agency for Research on Cancer (Organization, IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, 2012).

Rn-222 is emitted from uranium, a naturally occurring mineral in rocks and soil; thus is present virtually everywhere on the earth. Residential radon exposure is the second cause of lung cancer after tobacco consumption and it is the main risk factor among never smokers (María, 2014). Radon emits radiation in form of α-particles that damage lung epithelia by generating oxygen-anions and hydrogen that produce mutations and other DNA lesions (Alberto, 2014). Radon gas is rapidly exhaled after being breathed in. The radon progeny can combine with other molecules in the air and with particle of dust, smoke and readily deposit in airways of lung.

Furthermore, the radon gas can enter the body via respiring, drinking and eating. Radon existing in rocks of the earth's terrestrial systems diffuses continuously through water in rocks, which leads the presence of radon in ground water. Values of radon concentration in well water were found higher than EPA recommended level and lower than WHO action level while the annual effective doses and level of toxic elements in water (Nisar, 2015).

CHAPTER 3

MATERIALS AND METHODS

3.1 Research Equipment

Research equipment consists three equipment that been use. First, Radon Sentinel Model 1030 is use in this research to measure the radon concentration. Second equipment is vernier calipers. It is used to measure the thickness of plaster apply on the sample. Prototype room is the last equipment use to control the constant factor.

3.1.1 Radon Sentinel Model 1030

The radon concentration be measured using Radon Sentinel Model 1030 (Figure 3.1). These radon monitor was manufactured by Sun Nuclear Cooperation. The Radon Sentinel is a patented detection device to measure the concentration of radon gas. The unit is a continuous radon monitor design for professional inspectors to use in homes and buildings. Radon Sentinel is quick and easy to use. Simply place the device in an appropriate location and press start. When the test is complete we can view the summary, or download result to computer. They are rectangle in shape, 5.5 x 9.6 x 4.4 inch in size and weight about 3.75 lbs.

Figure 3.1: The Radon Sentinel model 1030 (Source: Sun Nuclear Corporation)

3.1.1.2 Vernier Caliper

The Vernier Caliper as shown in Figure 3.2 is a precision instrument that can be used to measure internal and external distances extremely accurately. It has the reading error 1/20 mm = 0.05 mm.

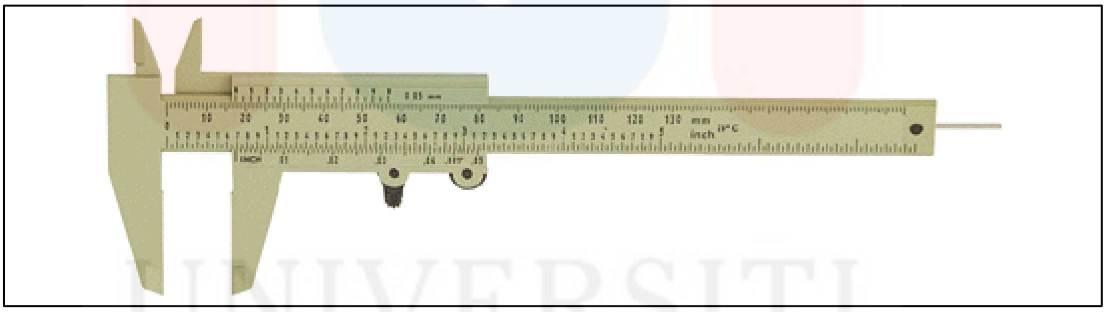

Figure 3.2: The vernier caliper (Dedman College of Humanities and Sciences)

3.1.1.3 Prototype Room

Prototype room (Figure 3.3) are use in this research to place the sample. It been used because prototype room give constant factor such as humidity, temperature and pressure. It also can control measure for this research. The prototype room specification is width 40cm, height 40cm and length 40cm. The thickness of prototype room is 1cm.

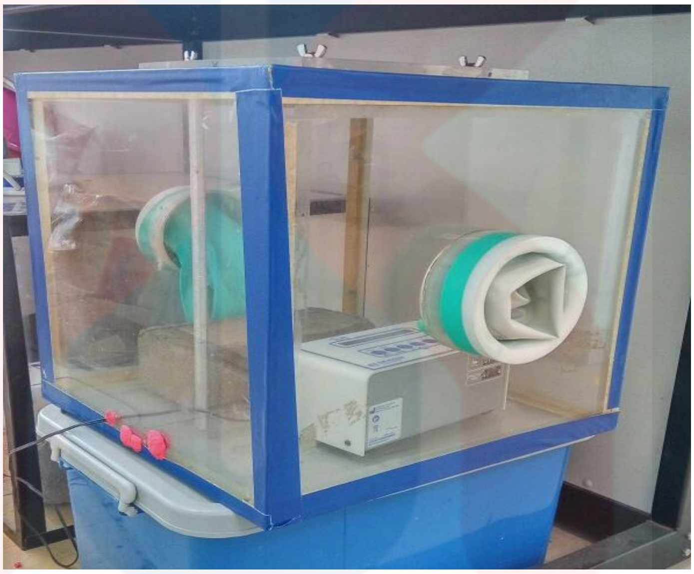

Figure 3.3: Prototype room

3.1.2 Research Material

Research material consist a materials used in this research such as red brick and plaster. Red brick is the building material that been use in this research as sample. Plaster is used to cover the sample in this research in different thickness.

3.1.2.1 Red Brick

Red brick as shown in Figure 3.4 is one of the basic building materials of the construction of homes that have been very commonly used in Malaysia. From ancient times to modern times, red brick has become one of the ingredients required in building a house.

Red brick is bricks made of soil that is printed and then burned at high temperature so that it becomes completely dry, hardened and reddish colour. Land used was not just any land, but rather clay soil that can be fused during the printing process. Therefore, the house whose walls are built of red brick material will feel more comfortable and cool. Furthermore this material is very resistant to heat so it can be a separate protection for your building from fire hazards.

Figure 3.4: Building material (red brick) (The Belden Brick Company, 2013)

Red brick made from clay that is printed, then burned. Not all of the land saw could be used. Its consisting of specific content of the sand. Generally have sizes: length of 17-23 cm, 7-11 cm wide, 3-5 cm thick. The average weight of red brick is 3 kg / seeds (depending on brand and region of origin of manufacture). The raw materials needed for a couple of red brick walls are cement and sand sifter. To wall required watertight mix of 1: 2 or 1: 3 (in example: 1 dose of cement mixed with 3 doses of sand sifted). For walls that are not to be watertight, can use a ratio of 1: 4 to 1: 6.

3.1.2.2 Plaster

Plaster as shown in Figure 3.5 is a building material used for the protective and/or decorative coating of walls and ceilings and for moulding and casting decorative elements (Angela, 2015). A soft mixture of lime with sand or cement and water for spreading on walls, ceilings, or other structures to form a smooth hard surface when dried.

Figure 3.5: Plaster

3.2 Methods

The red brick had been used as a sample in this research to calculate amount of radon concentration release. The radon monitor will detect the alpha particle charge release from the red brick and it will measure the concentration. The plaster applied to red brick with different thickness to prevent radon from red brick to pass through.

3.2.1 Study Area

The study will be take place in the prototype room at University Malaysia Kelantan (UMK). The radon concentration in prototype room will be measured for 24 hours per day. The timer needs to be set during the period of the research. The radon sentinel will take the reading of radon concentration in picocuries per liter (pCi/L).

3.2.2 Preparation of Sample

In this study, the amount of radon concentration produce from red brick was measured with different thickness of plaster. So that, the red brick was applied with three different thickness of plaster as shown in Figure 3.6. After the red brick had been covered with plaster, it been placed into prototype room and radon concentration been measured. This steps repeated for every layers.

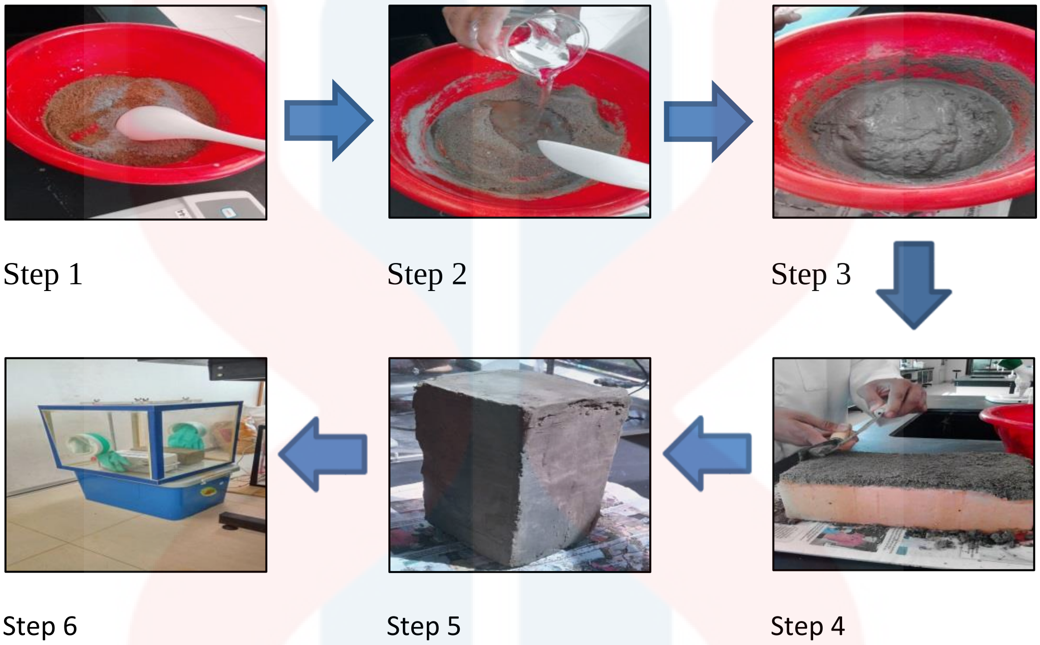

Figure 3.6: Steps to layered up the red brick with plaster.

Every layer of plaster need to be calculated four period of times to collect the average of radon produce and for every one of the period, need 24 hours to collect the result and for every 24 hours, the result will be collect on 30 minutes per one period. There have the range of thickness for every layer which the first layer has 0.5 – 1.0 cm. For second layer is 1.0 - 1.5 cm and third layer is 1.5 – 2.0 cm.

3.2.3 Data collection

The red brick is use in this research so it is the main material to calculate the amount of radon concentration. Radon concentration will detect in this red brick by using sentinel model. Plaster also the material that played important role in this research because the plaster can block the radon through it. It can prevent the radon from red brick through the plaster.

In this research, the result is the amount of radon concentration produce from the red brick with different thickness of plaster so different thickness of water is use to cover up the red brick. The results will put into Table 3.1.

The red brick must be covered by plaster with different thickness. In the other hand, in early of this research the initial amount of radon concentration must be calculated without using the plaster. The initial amount of radon calculates only produce from red brick, so the result must be different after we use the plaster to cover up the red brick.

After the initial radon produce from red brick calculated, the plaster was used to cover the red brick with first thickness and calculate it. The first layer of plaster is more thin because this research want to calculate the amount of radon with different of thickness. This research needs three layer of plaster that want to calculate the amount of radon produce.

Every layer of plaster need to calculate four period of times to collect the average of radon produce and for every one of the period, need 24 hours to collect the result and for every 24 hours, the result will be collect on 30 minutes per one period as explain in Table 3.2, 3.3, 3.4 and 3.5. There have the range of thickness for every layer which the first layer has 1.0 – 1.5 cm. For second layer thickness is 1.5 – 2.0 cm and third layer is 2.0 – 2.5 cm. Every layer must have the different results.

Table 3.1: Concentration of radon in 4 times.

Times Thickness	Concentration Emanation of Radon (pCi/L)			
	1	2	3	4
Initial Reading (No Plaster)				
Layer 1 1.0-1.5 cm				
Layer 2 1.5-2.0 cm				
Layer 3 2.0.2.5 cm				

Table 3.2: Data collected for Initial Reading (No Plaster)

No of Experiment per 24 hours	Time interval (every 30 minutes)	Cumulative Data Collected
1 (24 hours)	30 minutes	48
2 (24 hours)	30 minutes	48
3 (24 hours)	30 minutes	48
4 (24 hours)	30 minutes	48

Table 3.3: Data collected for first layer of plaster

No of Experiment per 24 hours	Time interval (every 30 minutes)	Cumulative Data Collected
1 (24 hours)	30 minutes	48
2 (24 hours)	30 minutes	48
3 (24 hours)	30 minutes	48
4 (24 hours)	30 minutes	48

Table 3.4: Data collected for second layer of plaster

No of Experiment per 24 hours	Time interval (every 30 minutes)	Cumulative Data Collected
1 (24 hours)	30 minutes	48
2 (24 hours)	30 minutes	48
3 (24 hours)	30 minutes	48
4 (24 hours)	30 minutes	48

Table 3.5: Data collected for third layer of plaster

No of Experiment per 24 hours	Time interval (every 30 minutes)	Cumulative Data Collected
1 (24 hours)	30 minutes	48
2 (24 hours)	30 minutes	48
3 (24 hours)	30 minutes	48
4 (24 hours)	30 minutes	48

CHAPTER 4

RESULTS AND DISCUSSION

For this research, continuous measurement had been taken by using Radon Sentinel Model 1030 simultaneously. Rn-222 concentrations of three different thickness layers of red bricks were measured in prototype room. The prototype room was placed at material science lab University Malaysia Kelantan Jeli Campus. The data reported layer 1, layer 2 and layer 3 in Appendix.

4.1 Average of Rn-222 concentration determinations

In this study, the first objective is to determine average of Rn-222 concentration of the red brick with different thickness of layer. Average Rn-222 concentration is calculated by using equation 4.1.

$$A=\frac{N}{S} \tag{4.1}$$

Where A is average (or arithmetic mean), N is the number of terms (Rn-222 concentration by hours) and S is the sum of the number in the set of interest (the sum of number being averaged).

Average of Rn-222 concentrations is calculated based on the Rn-222 concentrations by hours for each day as shown in Appendix A and B. The average of Rn-222 concentration for layer 1, layer 2 and layer 3 were calculated by using equation 4.1.

4.1.1 Average of Rn-222 concentration determination of raw materials

In this study, the raw materials also affect Rn-222 concentration measurement. The raw materials such as brick, sand, water and prototype room also consist factors that release Rn-222. It is because radiation has been a natural part to our environment. Radiation such as Rn-222 is emitted from natural source in the soil, water and rock. Table 4.1 presents the average Rn-222 concentration of raw material.

Cement has found to have the highest average of Rn-222 concentration with 1.0 pCi/L from other raw material. However, this value is still less than EPA recommendation which is 4.0 pCi/L for radon control in homes and buildings. From Table 4.1, the average of Rn-222 concentrations of raw materials are also lower than EPA action level (4 pCi/L), means that radon release from raw materials at very low concentrations.

Table 4.1: The average of Rn-222 emanation for raw materials.

Raw Material	Average of Rn-222 emanation (pCi/L)
Red brick	0.8
Cement	1.0
Water	0.3
Prototype room	0.9
Beaker	0.6
Sand	0.2

The pattern difference average of Rn-222 concentration for raw materials for red brick, cement, water, prototype room, beaker and sand were shown in Figure 4.1.

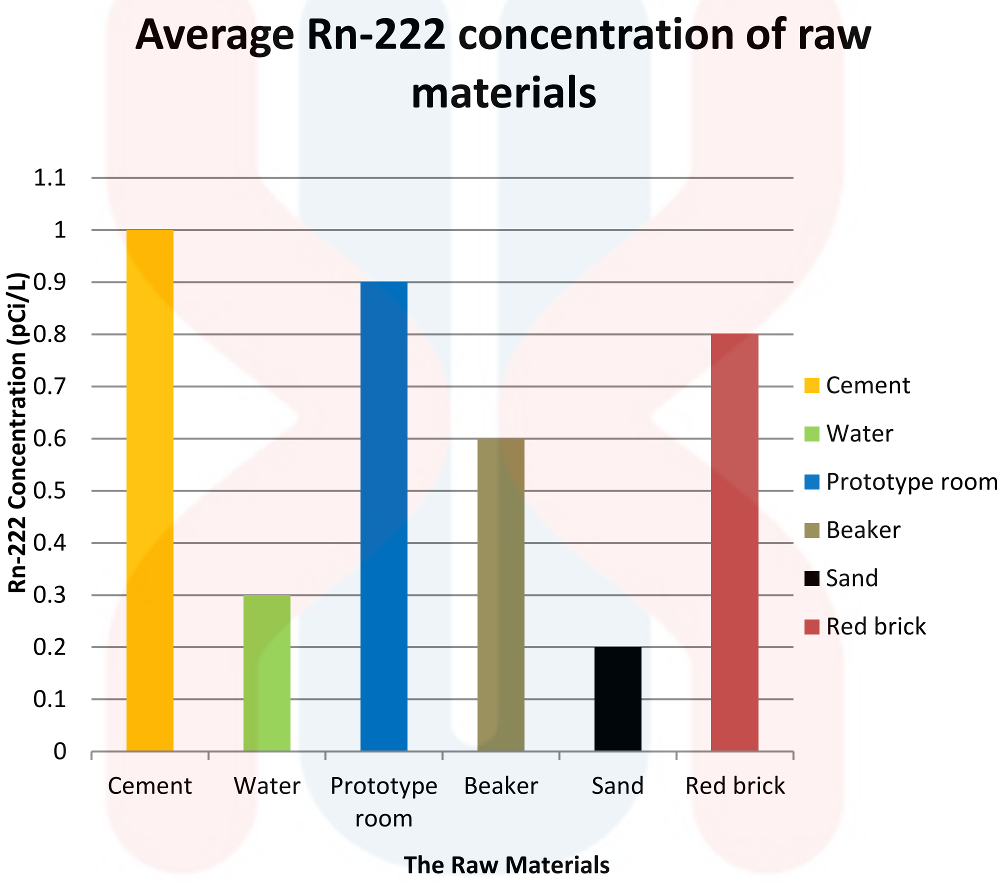

Figure 4.1: Average Rn-222 concentration of raw materials.

4.1.2 Average of Rn-222 concentration determination of layer 1, layer 2 and layer 3

Table 4.2 presents the average Rn-222 concentration from three different thicknesses of layer which are first layer has 1.0 – 1.5 cm, second layer thickness is 1.5 – 2.0 cm and third layer is 2.0 – 2.5 cm for four consecutive days.

Table 4.2: The average Rn-222 concentration from first, second and third layer for 4 days

Average of Rn-222 Concentration (pCi/L)			
Day	Layer 1	Layer 2	Layer 3
1	7.7	1.0	0.0
2	12.0	0.9	0.4
3	7.7	8.6	0.1
4	5.2	12.4	0.0
Total average	8.15	5.73	0.125

From the table we can see that first layer of red brick with cement has higher average of Rn-222 concentration rather than second and third layer. Third layer has the lowest of Rn-222 concentration compare than others. This condition is due to the thickness of third layer which is more thicker compare from thickness first and second layer. The pattern of Rn-222 concentration for first, second and third layer for consecutive 4 days show in Figure 4.2.

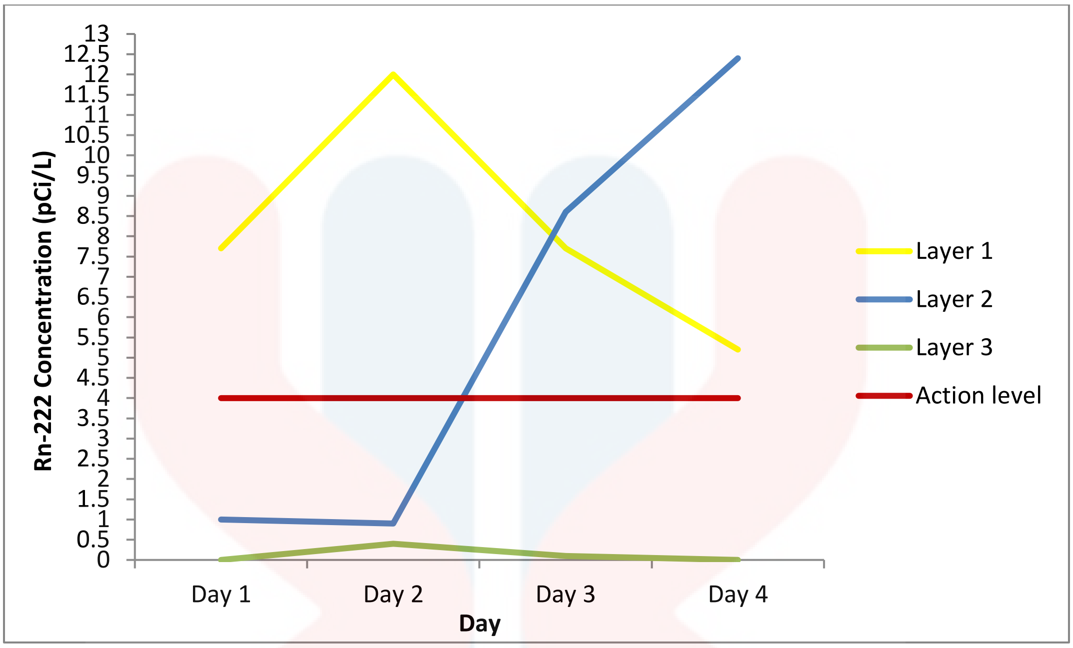

Figure 4.2: Average of Rn-222 concentration for three layers with 4 consecutive days

From the figure 4.2, the Rn-222 concentration for second layer was below action level EPA for first and second day below 4.0 pCi/L. As might been seen in this figure, the data recorded for first layer was higher with averages of Rn-222 concentration more than the line of action level. The maximum average of Rn-222 concentration for first layer occurred in day 2 is 12.0 pCi/L and minimum average of Rn-222 concentration of occurred on day 4 is 5.2. Maximum average Rn-222 concentration for second layer occurred in day 4 is 12.4 pCi/L. The minimum average for second layer occurred in day 2 is 0.9 pCi/L. It has observed that red brick with thicker thickness of cement has lower Rn-222 concentration than a red brick with thin layer of cement.

4.2 Scale of Data

The data obtain need to have standard or scale to easier the analysis and interpretation. In this research, the radon concentrations and its parameters such as temperature, humidity and pressure which were recorded by Radon Sentinel Model 1030 were set to a scale as shown in Table 4.3.

Table 4.3: Scale of the radon concentrations and its parameters

Parameters	Scale	Information
Concentration (pCi/L)	< 0.5 pCi/L	Low concentration
Humidity (%)	< 80%	Low humidity
Temperature (˚C)	< 28˚C	Low temperature
Pressure (inHg)	< 30 inHg	Low pressure

This scale is then used as a reference to analyse the radon concentration obtained from the measurement for three layers of red brick.

4.3 Rn-222 concentration for red brick layer with cement

The radon concentrations for red brick after layer with three layers of thickness were obtained completely throughout the four days of the duration for each layer. The data were collected daily to obtain series of radon concentration for each one hour of time interval that had been set up. The radon concentration s data series were calculated based on the formula in Equation 4.1 to attain the average radon concentration for each layer as shown in Table 4.4.

Table 4.4: Average Rn-222 concentration, humidity, pressure and temperature for first layer in 4 consecutive days.

Day	Concentration (pCi/L)	Humidity (%)	Pressure (inHg)	Temperature (F)
Day 1	7.7	84.45	29.85	80.04
Day 2	12	86.29	29.85	80.27
Day 3	7.7	86.29	29.84	79.16
Day 4	5.2	85.96	29.84	81.87

Figure 4.3 shows the graph plotted based on the average of Rn-222 concentration, humidity, pressure and temperature for first layer of thickness in 4 consecutive days. The data had been calculated and analysed based on the research data for thickness of layer of red brick from the graph. Graph of Rn-222 concentration, temperature and humidity as the pressure maintain around 29 to 30 degree Celsius as shown in Figure 4.3. As seen in the figure, there are differences

between Rn-222 concentrations from first day to forth day. Rn-222 concentration occurred on day 2 is higher Rn-222 concentration than Rn-222 concentration occurred on day 1, day3 and day4. It is because occur the different in humidity and temperature on that day. The weather gives effect to temperature and Rn-222 concentration. When there is different temperature on that day, it will affect the temperature of prototype room that place in that room.

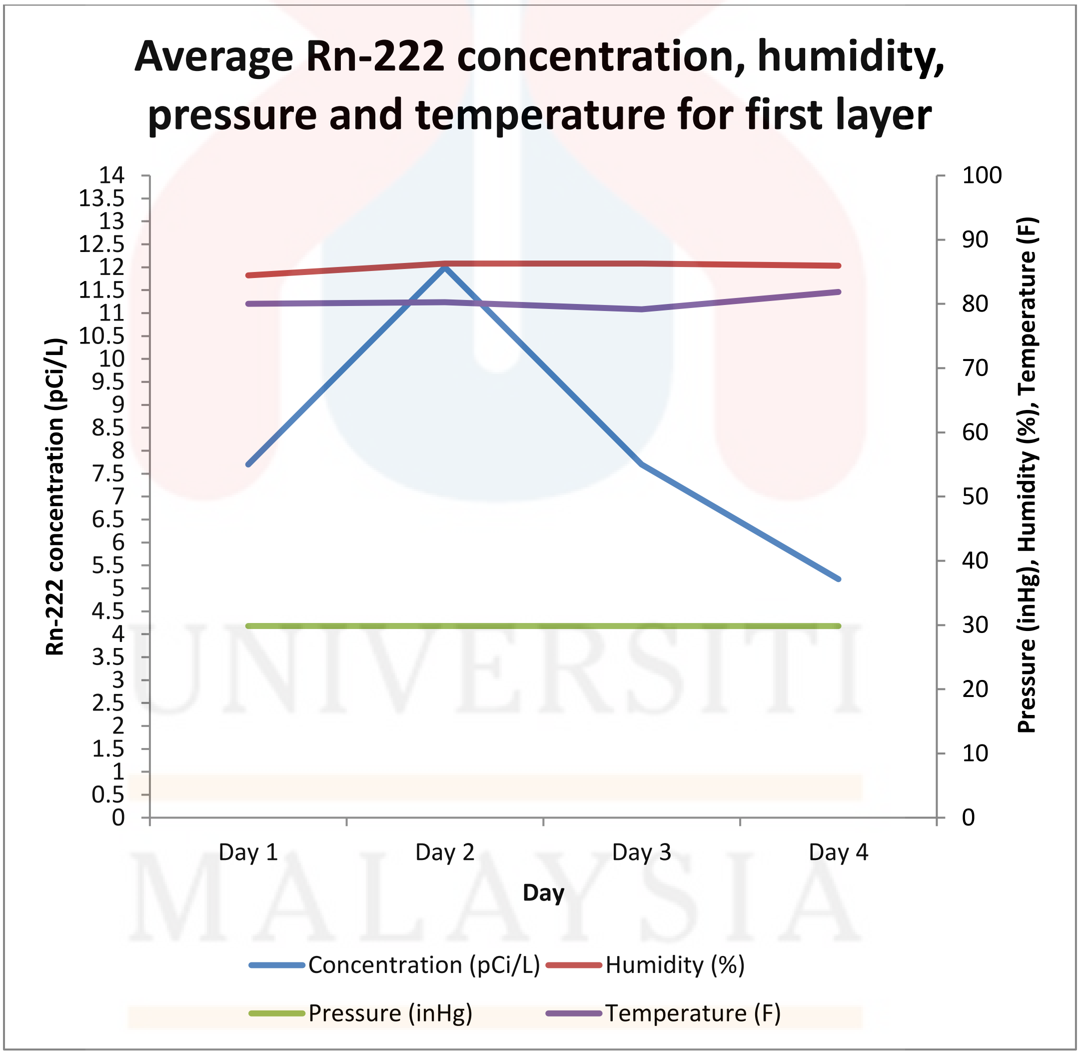

Figure 4.3: The average radon concentration, humidity, pressure and temperature for first layer.

Table 4.5 shows the data from second layer cement of red brick. The data consists average of Rn-222 concentration, humidity, pressure and temperature. Graph of comparison between average of Rn-222 concentration, humidity, pressure and temperature were plotted and shown in Figure 4.4.

Table 4.5: Average Rn-222 concentration, humidity, pressure and temperature for second layer in 4 consecutive days.

Day	Concentration (pCi/L)	Humidity (%)	Pressure (inHg)	Temperature (F)
1	1.0	87.33	29.85	79.4
2	0.9	88.92	29.85	81.66
3	8.6	88.46	29.84	73.94
4	12.4	88.79	29.80	74.15

Figure 4.4 shows the graph plotted based on the average of Rn-222 concentration, humidity, pressure and temperature for second layer of thickness in 4 consecutive days. The data had been calculated and analysed based on the research data for thickness of layer of red brick from the graph. The graph as can we refer in Figure 4.3 and 4.4 almost same but lower in Figure 4.4 because the thickness of red brick for second layer more thicker compare to first layer. The pressure in the prototype room remains constant around 29 to 30 inHg. The humidity is remain constant same as first layer. The temperature for day first and day second unstable due to inconsistent of weather factors in Jeli. The Rn-222 concentrations are lower in first day but suddenly increase highly in another three days. Rn-222 in the fourth day

was the higher reaching 12.4 pCi/L. It happen because the temperature for the fourth day decrease. Dry and warm temperature will affect the the Rn-222 concentration reading.

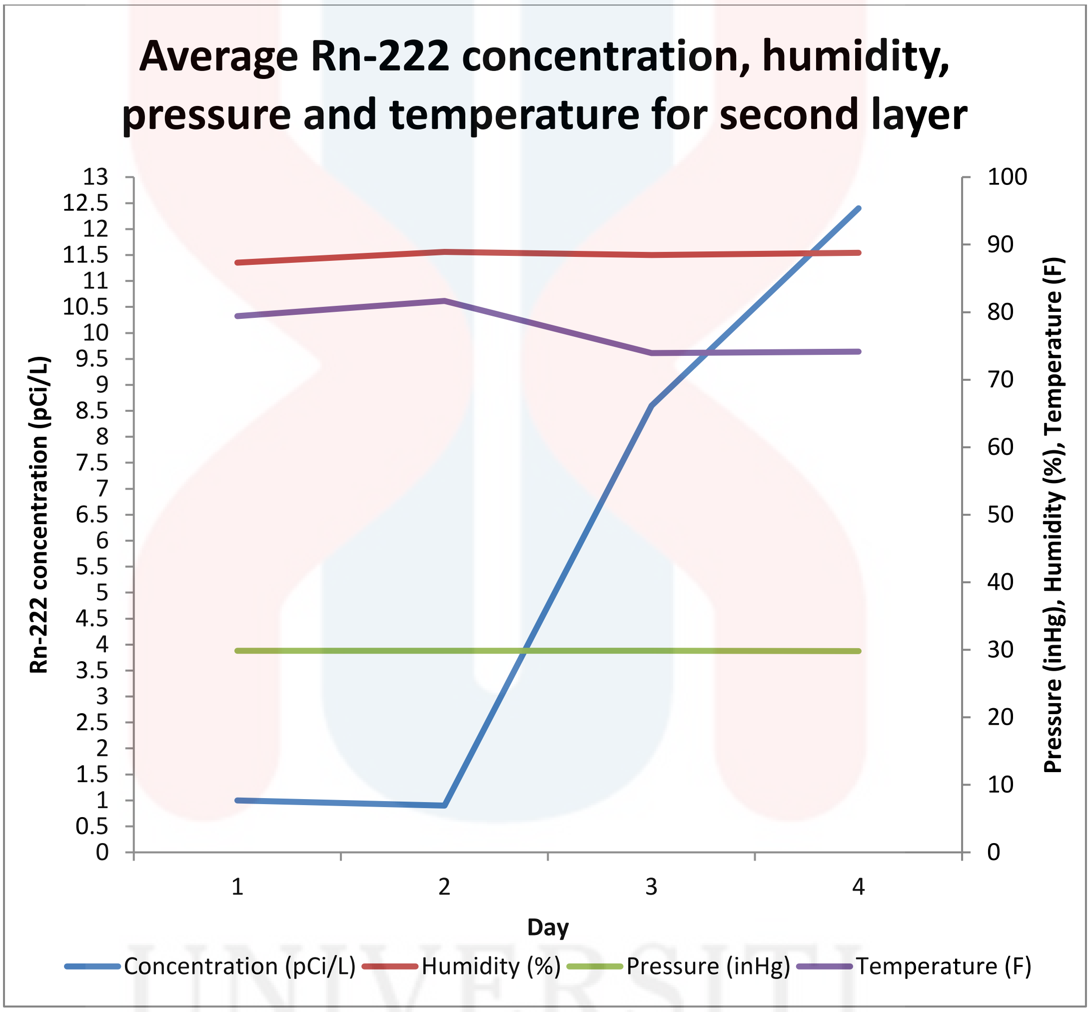

Figure 4.4: The average radon concentration, humidity, pressure and temperature for second layer.

Table 4.6 shows the data collected for third layer cement of red brick. The data consists average of Rn-222 concentration, humidity, pressure and temperature.

Graph of comparison between average of Rn-222 concentration, humidity, pressure and temperature were plotted and shown in Figure 4.5.

Table 4.6: Average Rn-222 concentration, humidity, pressure and temperature for third layer in 4 consecutive days.

Day	Concentration (pCi/L)	Humidity (%)	Pressure (inHg)	Temperature (F)
1	0.0	84.71	29.84	77.64
2	0.4	85.88	29.84	75.38
3	0.1	86.46	29.85	77.41
4	0.0	86.54	29.84	77.99

The graph plotted for third layer cement of red brick as shown in Figure 4.5 consist of lowest Rn-222 concentration compare to others layers. The Rn-222 concentration for 4 consecutive day constant below the action level (4 pCi/L). It showed those layer have greatest thickness and can causes the Rn-222 concentration throughout those layers. There are no spaces for alpha particle to past the plaster because of thickest plaster.

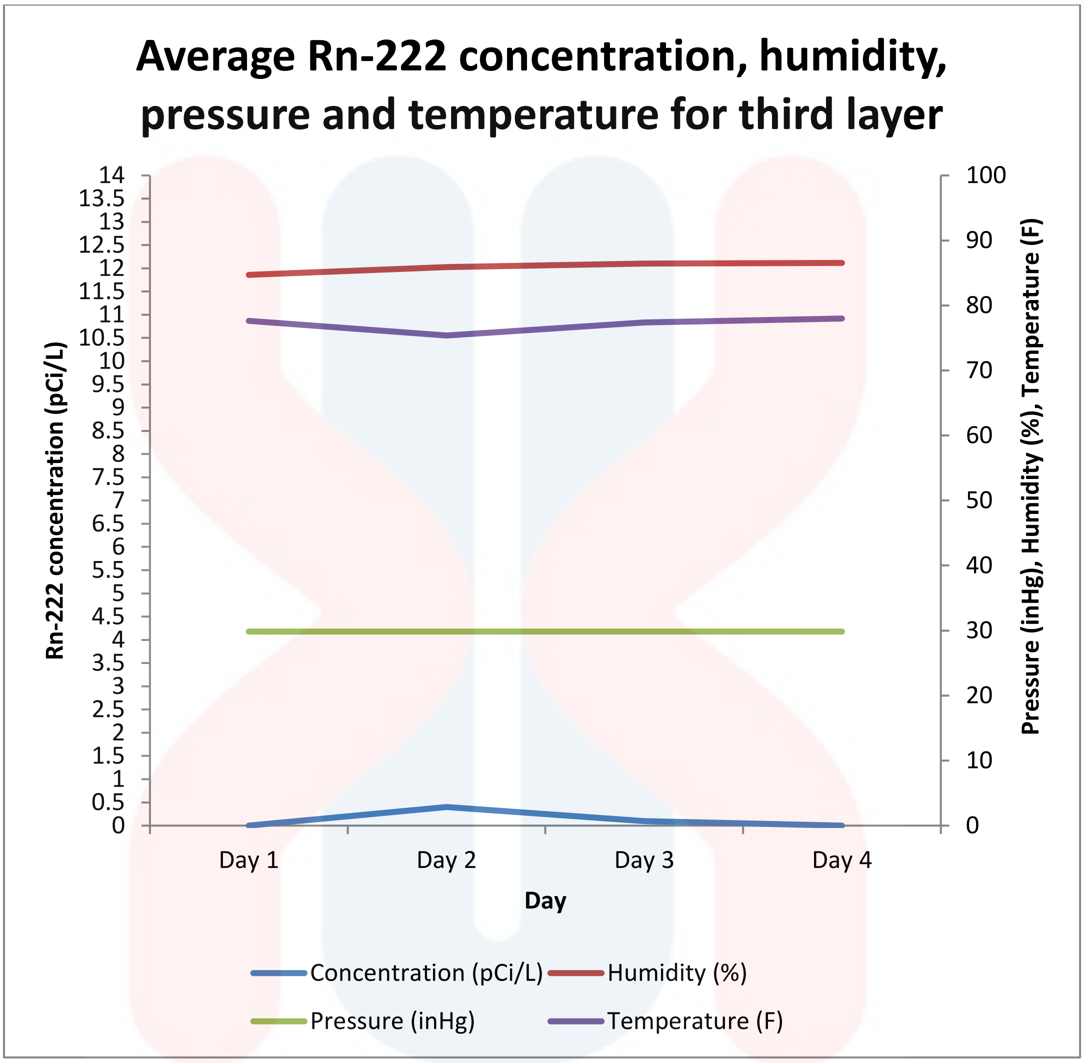

Figure 4.5: The average radon concentration, humidity, pressure and temperature for third layer.

4.4 Others factors affecting Rn-222 concentration for first, second and third layer of red brick

Raw material used effect Rn-222 concentration. The material used for layer the red brick such as sand and water. The raw materials are originally from natural resources contain uranium and radon. Rn-222 concentration can be originated from exhalation from rocks and soils from raw material used for cement the red brick. Radon concentration in soil increase with increasing moisture content and radon is disturbed between air and water at equilibrium. As high moisture contents, diffusion occur dominantly in water-filled pores and air or water equilibrium exists only near interfaces which mean radon concentrations in soil air can be low in this condition.

4.5 Factor affecting Rn-222 concentrations

In general, there are several factors affecting Rn-222 concentration such as flux density of radon exhaled (exhalation of radon gas) from the ground surface and the desperation in the atmosphere with influence of metrological factors such as temperature, humidity and pressure. The actual amount of radon that reaches the surface of Earth is related to the concentration of uranium in the rock and soil as well as the efficiency of the transfer processes from the rock or soil to soil-water and soil-gas. The soil composition under and around, and the material used for a house affect indoors radon levels and the ease which radon migrates toward a house (Syahrul, 2013). Radon variations in buildings are caused by changes in temperature, relative humidity, building materials, barometric pressure, ventilation conditions, the wind speed and the design of the house (Zmazek, 2006).

4.5.1 Thickness

The thickness of plaster applied to the red brick will affect the Rn-222 concentration. In this research, the Rn-222 concentration for third layer was lowest compare to first layer and second layer. This is because the layer of plaster applied on the red brick was thick. Alpha particle cannot through those thickest layer because no space to for alpha particle to past through it.

Thickness of plaster also give the important rule to the emanation of Rn-222 to come out from building materials to the environment (Saidi,2013). This is due to the structure of plaster. If the structure of the plaster more close, the Rn-222 from red brick more difficult to emanation. This is because of the properties of alpha particles.

4.5.2 Radiation properties

Radon is naturally occurring colourless, odourless radioactive inert gases, which come from the radioactive decay of uranium. It is radioactive with a short half-life of 3.8 days, decaying by the emission of alpha-radiation (α-radiation) to polonium, bismuth, and lead (radon progeny/daughters) in successive steps.

Alpha particles are heavy and doubly charged which cause them to lose their energy very quickly in matter. They can be shielded by a sheet of paper or the surface layer of our skin. Alpha particles are only considered hazardous to a persons health if an alpha emitting material is ingested or inhaled. Beta and position particles are much smaller and only have one charge, which cause them to interact more slowly with material. They are effectively shielded by thin layers of metal or plastic and are again only considered hazardous if a beta emitter is ingested or inhaled. That's why the alpha particle cannot tunnel the thick plaster (Razab, 2013).

4.5.3 Radon Monitoring

In this research, monitoring conducted to measure the concentration of Rn-222 is very short. The research carried out for 4 consecutive days. So the collected data was not quite accurate and precise. Brief monitoring give not quite right result to the research because of the properties of Rn-222 which is its half-life is only 3.8 days. Research with a longer period of time should be treated at least 6 months to measured a concentration of Rn-222.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The average concentrations for first layer, second layer and third layer for 4 consecutive days are 8.15 pCi/L, 5.73 pCi/L and 0.125 pCi/L. It is observed that the concentrations of Rn-222 are higher when the layer of red brick with cement is thin. The higher concentration Rn-222 may be due to the brick release the radon contains. The radon monitor read the charge of alpha particle release from red brick that layer with thin cement. The porosity of the material and defect of the material such as crack easily release the alpha particle and will resulting the Rn-222 concentration.

The higher Rn-222 concentration may be due to poor ventilation rate, temperature and pressure in the study area which is material science lab University Malaysia Kelantan Campus Jeli. Weather factors also influence the Rn-222 concentration levels. Humidity has slightly effect the Rn-222 concentration levels means that humidity does not influences radon concentration levels. Effects on lab materials science capable of affecting the prototype room and continue to influence the Rn-222 concentration data.

5.2 Recommendation

During doing the research, there is limited area or space to install the equipment and set up place for the prototype room. Furthermore, the area used are in material science lab which need to be used from other students to carry out their experiments. Selection of strategic area to install the equipment is needed to avoid reading error and disturbance from other student that uses the lab. The research of Rn-222 requires a longer period to obtain more accurate and precise data. At least 6 month monitoring needed to measure Rn-222 concentration. Further investigation is needed to confirm the effect thickness of layers to Rn-222 concentration levels and to determine factors that influence Rn-222 concentrations.

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APPENDIX A

Graph Plotted for Each Layer in 4 Consecutive Day

(Radon Concentration vs Time)

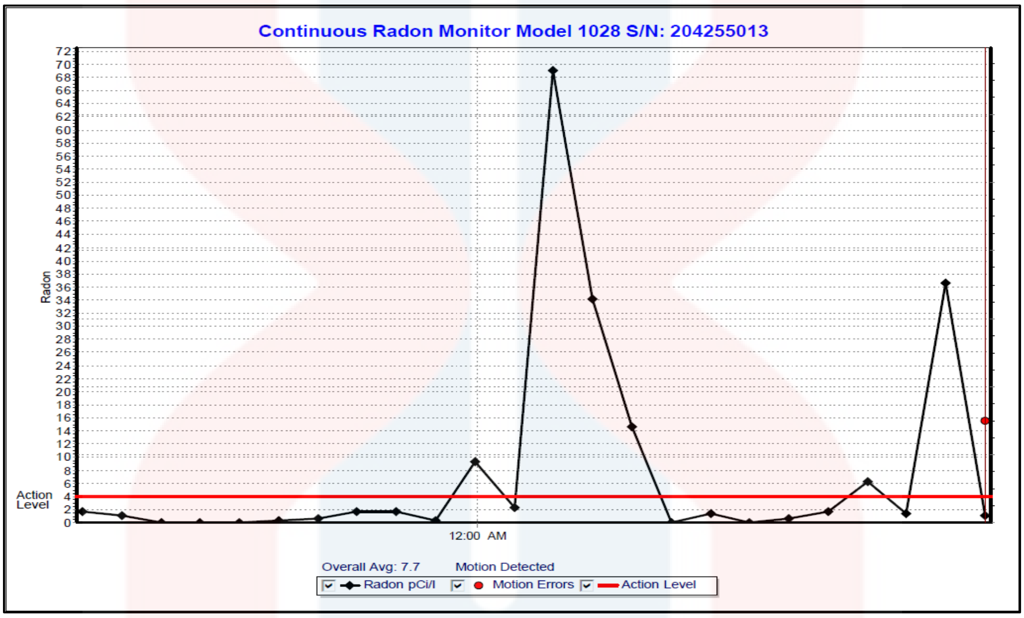

Figure A.1: Layer 1, Day 1

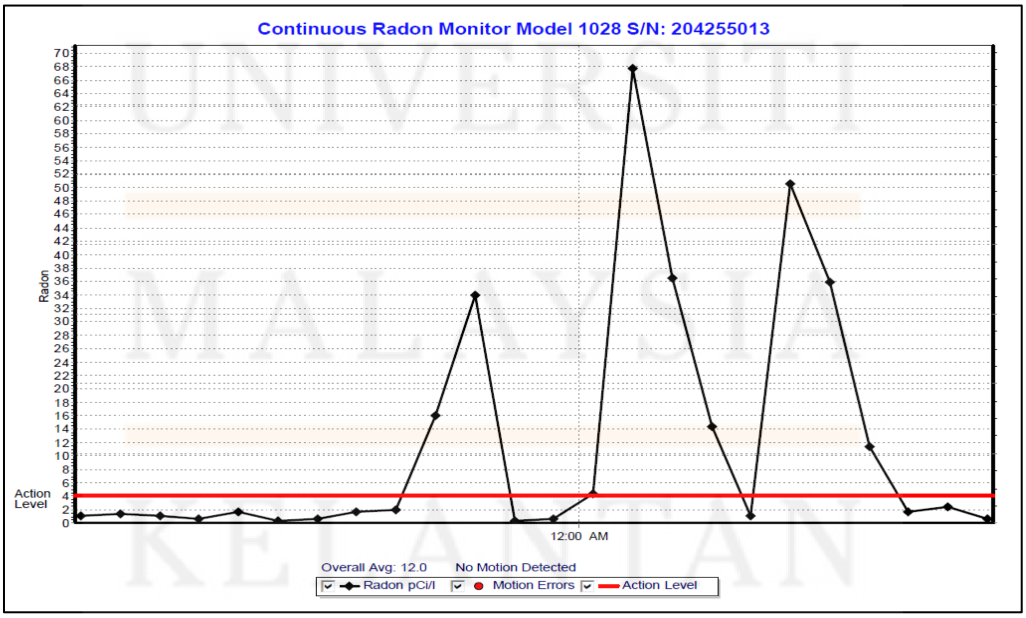

Figure A.2: Layer 1, Day 2

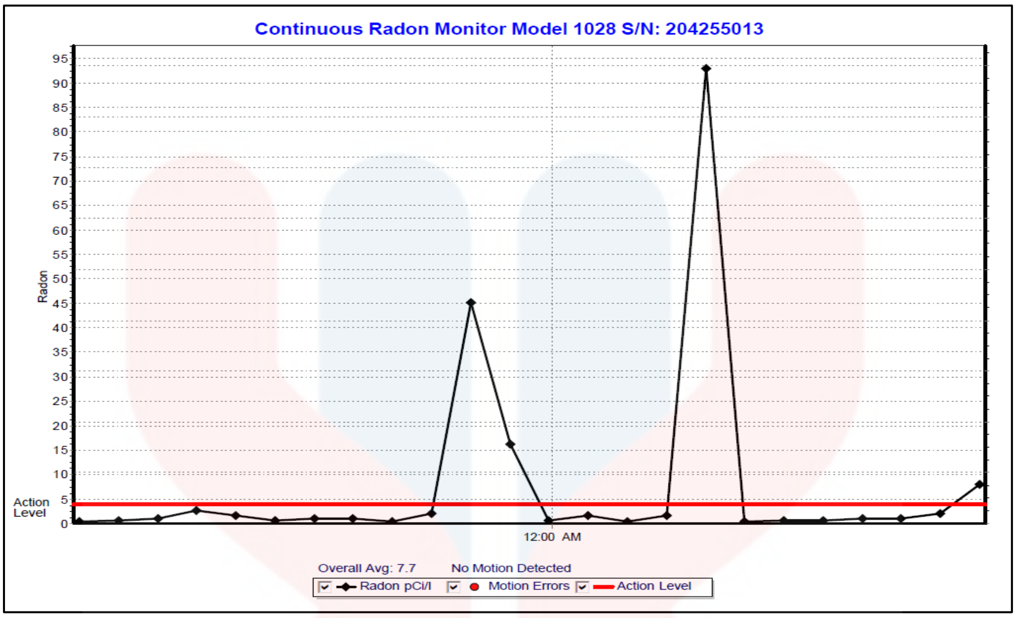

Figure A.3: Layer 1, Day 3

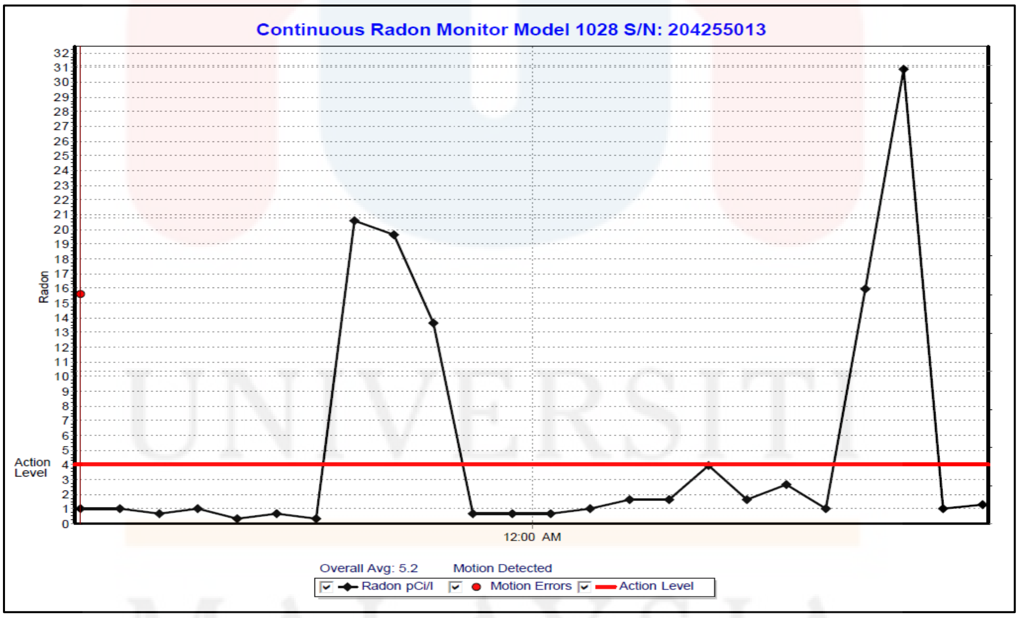

Figure A.4: Layer 1, Day 4

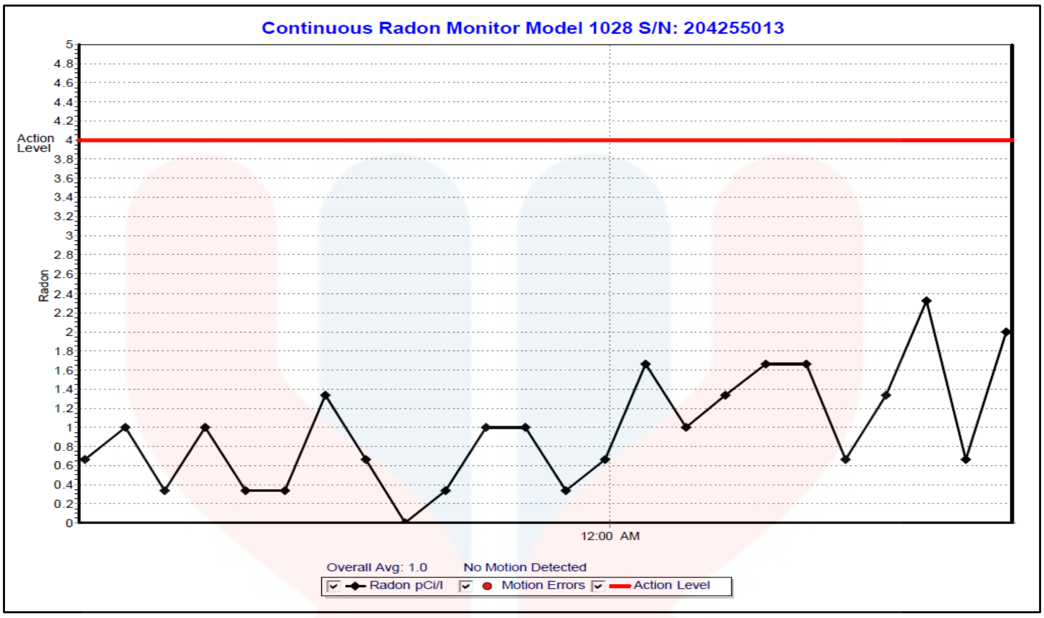

Figure A.5: Layer 2, Day 1

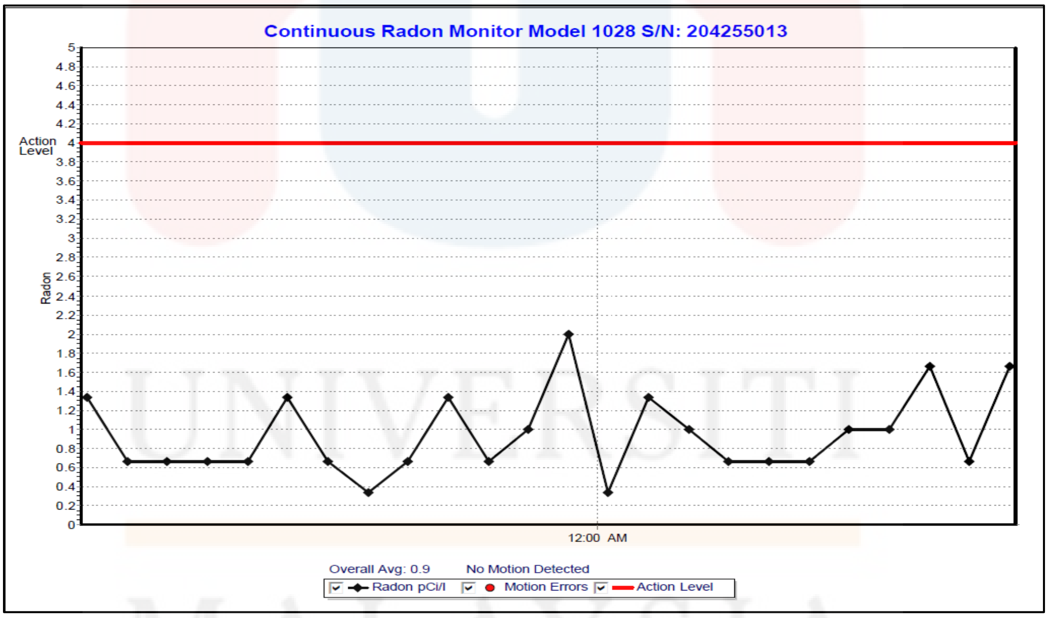

Figure A.6: Layer 2, Day 2

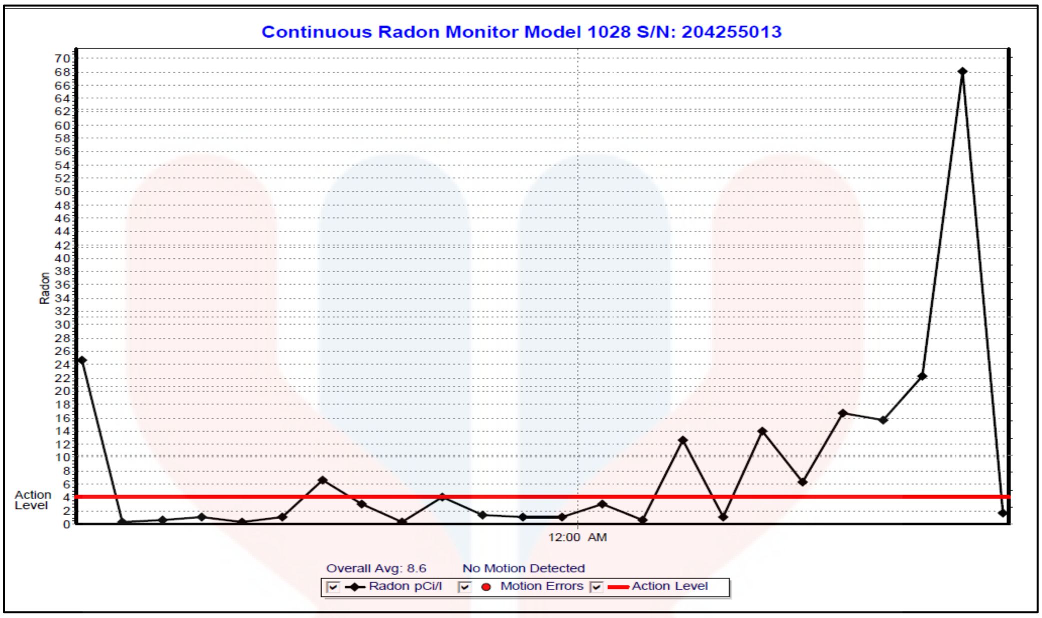

Figure A.7: Layer 2, Day 3

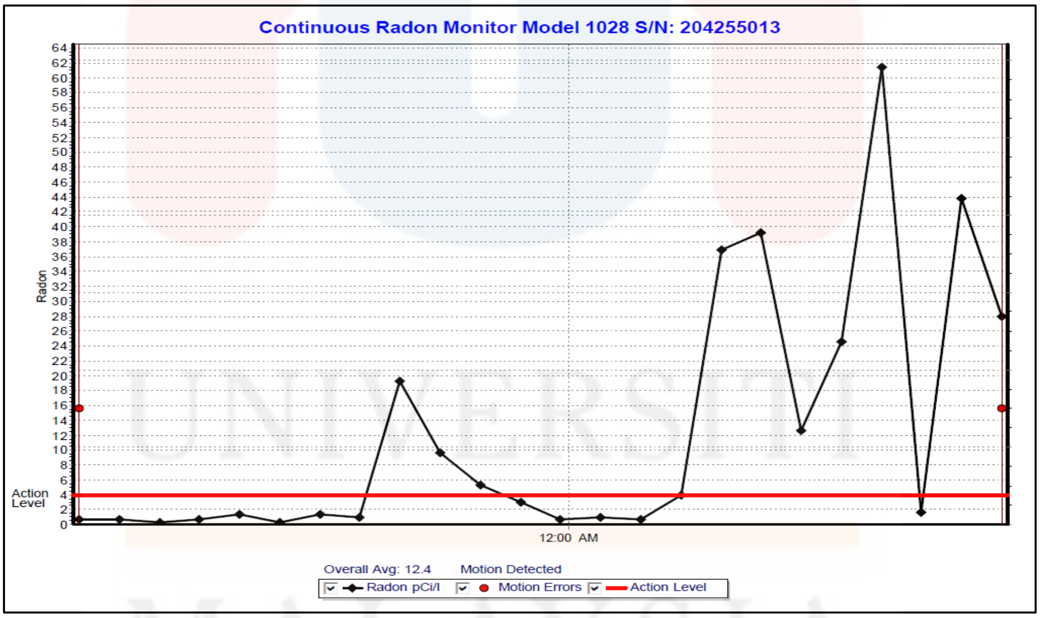

Figure A.8: Layer 2, Day 4

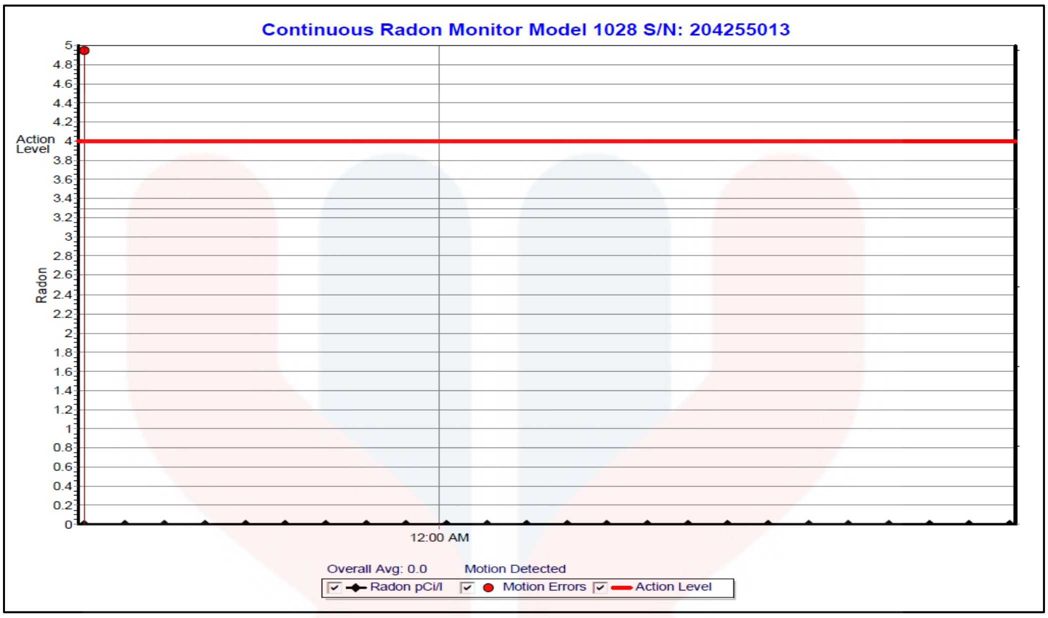

Figure A.9: Layer 3, Day 1

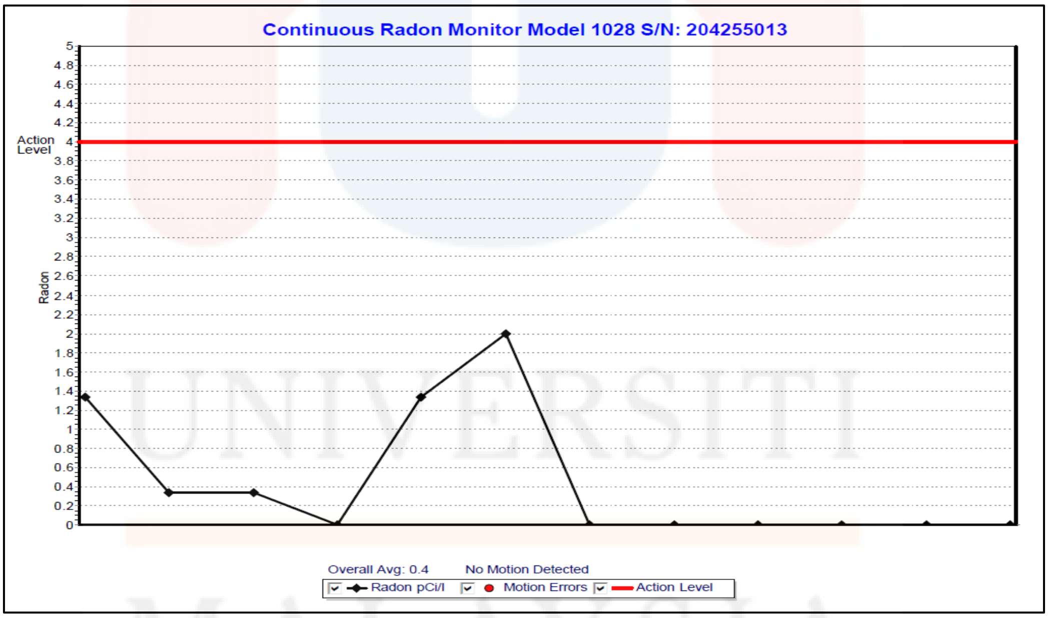

Figure A.10: Layer 3, Day 2

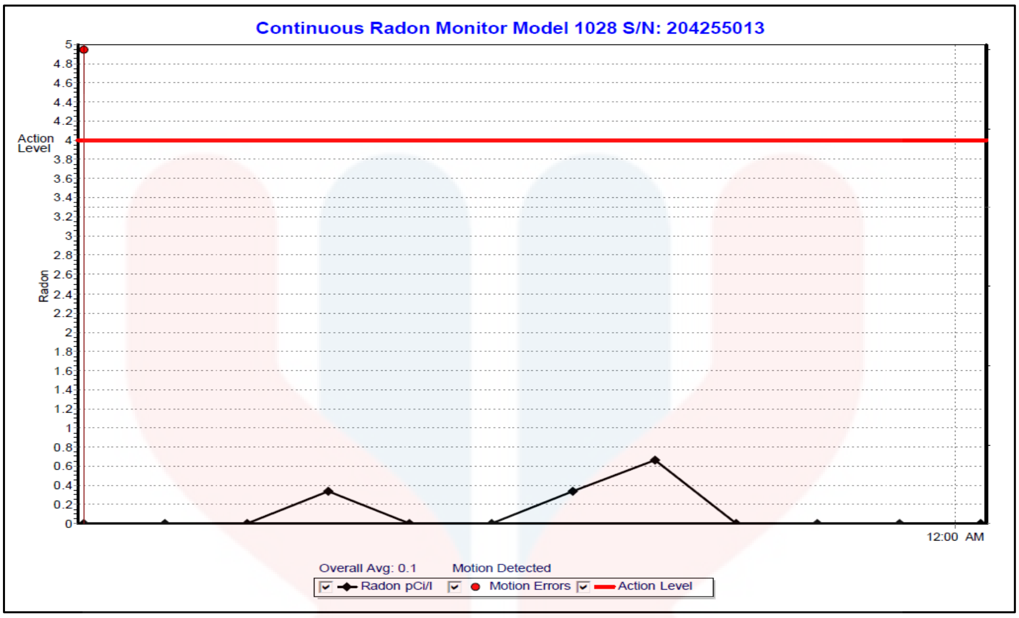

Figure A.11: Layer 3, Day 3

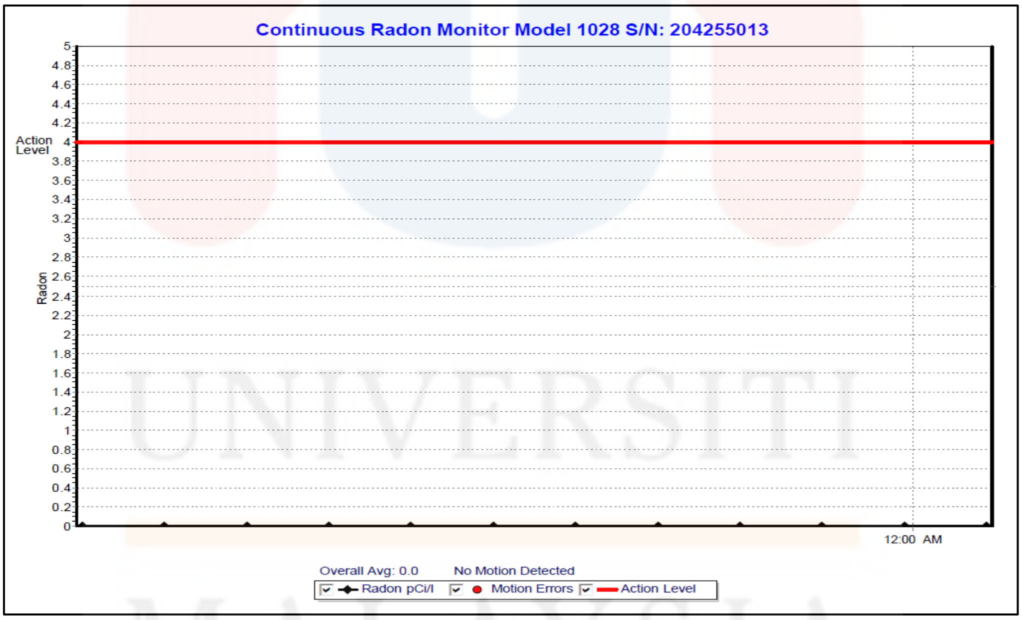

Figure A.12: Layer 3, Day 4

APPENDIX B

Rn-222 Concentration for Raw Data in 24 Hours

Table B.1: Empty Beaker

Date/Time		pCi/l	Temp F	Pressure inHg	Humidity %	Flags
8/14/2016 9:07 AM	0.100	84.400	29.80		69.00	M
8/14/2016 10:07 AM	1.000	83.700	29.80		68.00	0
8/14/2016 11:07 AM	0.800	83.100	29.80		68.00	0
8/14/2016 12:07 PM	0.500	83.100	29.80		68.00	0
8/14/2016 1:07 PM	0.600	83.100	29.80		68.00	0
8/14/2016 2:07 PM	1.200	83.300	29.80		69.00	0
8/14/2016 3:07 PM	0.600	83.500	29.80		68.00	0
8/14/2016 4:07 PM	0.700	83.700	29.70		67.00	0
8/14/2016 5:07 PM	0.800	83.700	29.70		68.00	0
8/14/2016 6:07 PM	0.800	83.800	29.70		68.00	0
8/14/2016 7:07 PM	0.800	84.700	29.80		67.00	0
8/14/2016 8:07 PM	0.800	85.500	29.80		67.00	0
8/14/2016 9:07 PM	0.600	86.000	29.80		67.00	0
8/14/2016 10:07 PM	0.400	86.200	29.80		67.00	0
8/14/2016 11:07 PM	0.600	86.200	29.80		66.00	0
8/15/2016 12:07 AM	0.400	86.000	29.80		67.00	0
8/15/2016 1:07 AM	0.400	85.800	29.80		67.00	0
8/15/2016 2:07 AM	0.500	85.600	29.80		67.00	0
8/15/2016 3:07 AM	0.500	85.300	29.80		66.00	0
8/15/2016 4:07 AM	0.600	85.100	29.80		67.00	0
8/15/2016 5:07 AM	0.600	84.900	29.80		66.00	0
8/15/2016 6:07 AM	0.100	84.600	29.80		67.00	0
8/15/2016 7:07 AM	0.600	84.400	29.80		68.00	0
8/15/2016 8:07 AM	0.400	84.400	29.80		67.00	0

Table B.2: Empty Beaker and Sand

Date/Time	pCi/l	Temp F	Pressure inHg	Humidity %	Flags
8/15/2016 9:24 AM	0.600	84.000	29.80	65.00	M
8/15/2016 10:24 AM	1.300	83.100	29.80	68.00	0
8/15/2016 11:24 AM	0.600	82.900	29.80	70.00	0
8/15/2016 12:24 PM	0.600	82.900	29.80	72.00	0
8/15/2016 1:24 PM	0.700	82.900	29.80	73.00	0
8/15/2016 2:24 PM	1.300	82.900	29.70	73.00	0
8/15/2016 3:24 PM	0.600	83.100	29.70	74.00	0
8/15/2016 4:24 PM	0.700	83.100	29.70	75.00	0
8/15/2016 5:24 PM	1.100	82.900	29.70	75.00	0
8/15/2016 6:24 PM	1.200	83.500	29.70	75.00	0
8/15/2016 7:24 PM	0.400	84.400	29.80	75.00	0
8/15/2016 8:24 PM	0.700	85.100	29.80	76.00	0
8/15/2016 9:24 PM	0.800	85.500	29.80	76.00	0
8/15/2016 10:24 PM	1.000	85.600	29.80	76.00	0
8/15/2016 11:24 PM	0.500	85.500	29.80	76.00	0
8/16/2016 12:24 AM	1.200	85.500	29.80	77.00	0
8/16/2016 1:24 AM	0.600	85.300	29.80	77.00	0
8/16/2016 2:24 AM	0.400	85.100	29.80	77.00	0
8/16/2016 3:24 AM	0.500	84.900	29.80	77.00	0
8/16/2016 4:24 AM	1.000	84.700	29.80	78.00	0
8/16/2016 5:24 AM	0.500	84.600	29.80	78.00	0
8/16/2016 6:24 AM	0.700	84.400	29.80	78.00	0
8/16/2016 7:24 AM	0.500	84.000	29.80	78.00	0
8/16/2016 8:24 AM	0.600	84.000	29.80	79.00	0

Table B.3: Cement

Date/Time	pCi/l	Temp F	Pressure inHg	Humidity %	Flags
8/16/2016 9:43 AM	1.200	82.800	29.80	71.00	M
8/16/2016 10:43 AM	1.400	81.900	29.80	71.00	0
8/16/2016 11:43 AM	1.200	81.500	29.80	71.00	0
8/16/2016 12:43 PM	1.100	81.700	29.80	71.00	0
8/16/2016 1:43 PM	1.100	82.000	29.80	71.00	0
8/16/2016 2:43 PM	1.200	82.400	29.70	71.00	0
8/16/2016 3:43 PM	0.600	82.600	29.70	71.00	0
8/16/2016 4:43 PM	0.800	82.800	29.70	71.00	0
8/16/2016 5:43 PM	0.700	82.600	29.70	71.00	0
8/16/2016 6:43 PM	0.500	83.300	29.80	71.00	0
8/16/2016 7:43 PM	0.400	84.200	29.80	71.00	0
8/16/2016 8:43 PM	0.600	84.700	29.80	71.00	0
8/16/2016 9:43 PM	0.700	85.100	29.80	70.00	M
8/16/2016 10:43 PM	0.400	85.300	29.80	70.00	0
8/16/2016 11:43 PM	0.800	85.300	29.80	71.00	0
8/17/2016 12:43 AM	1.200	85.100	29.90	70.00	0
8/17/2016 1:43 AM	1.000	84.900	29.80	70.00	0
8/17/2016 2:43 AM	1.300	84.700	29.80	70.00	0
8/17/2016 3:43 AM	1.300	84.600	29.80	70.00	0
8/17/2016 4:43 AM	0.700	84.400	29.80	71.00	0
8/17/2016 5:43 AM	0.700	84.200	29.80	71.00	0
8/17/2016 6:43 AM	0.800	84.000	29.80	70.00	0
8/17/2016 7:43 AM	1.100	83.800	29.80	70.00	0
8/17/2016 8:43 AM	0.700	83.700	29.80	71.00	0

Table B.4: Water

Date/Time	pCi/l	Temp F	Pressure inHg	Humidity %	Flags
8/21/2016 10:02 AM	0.100	80.800	29.80	72.00	M
8/21/2016 11:02 AM	0.000	80.100	29.80	76.00	0
8/21/2016 12:02 PM	0.400	81.500	29.80	75.00	0
8/21/2016 1:02 PM	0.600	81.700	29.80	77.00	M
8/21/2016 2:02 PM	0.400	81.900	29.80	78.00	0
8/21/2016 3:02 PM	0.500	82.000	29.70	78.00	0
8/21/2016 4:02 PM	0.200	82.200	29.70	78.00	0
8/21/2016 5:02 PM	0.400	82.200	29.70	78.00	0
8/21/2016 6:02 PM	0.500	82.000	29.70	79.00	0
8/21/2016 7:02 PM	0.100	82.200	29.70	78.00	0
8/21/2016 8:02 PM	0.200	82.900	29.80	79.00	0
8/21/2016 9:02 PM	0.200	83.700	29.80	78.00	0
8/21/2016 10:02 PM	0.200	84.000	29.80	78.00	0
8/21/2016 11:02 PM	1.000	84.400	29.80	78.00	0
8/22/2016 12:02 AM	0.200	84.400	29.80	78.00	0
8/22/2016 1:02 AM	0.500	84.200	29.80	79.00	0
8/22/2016 2:02 AM	0.200	84.000	29.80	78.00	0
8/22/2016 3:02 AM	0.200	83.800	29.80	79.00	0
8/22/2016 4:02 AM	0.100	83.700	29.80	81.00	0
8/22/2016 5:02 AM	0.500	83.700	29.80	80.00	0
8/22/2016 6:02 AM	0.100	83.500	29.80	80.00	0
8/22/2016 7:02 AM	0.000	83.500	29.80	81.00	0
8/22/2016 8:02 AM	0.200	83.300	29.80	82.00	0
8/22/2016 9:02 AM	0.200	82.900	29.80	81.00	0

Table B.5: Prototype room

Date/Time	pCi/l	Temp F	Pressure inHg	Humidity %	Flags
8/8/2016 9:06 AM	0.200	82.200	29.90	67.00	M
8/8/2016 10:06 AM	1.200	81.300	29.90	66.00	0
8/8/2016 11:06 AM	0.800	81.100	29.90	67.00	0
8/8/2016 12:06 PM	0.700	81.500	29.90	65.00	0
8/8/2016 1:06 PM	1.100	82.000	29.80	66.00	0
8/8/2016 2:06 PM	1.000	82.200	29.80	66.00	0
8/8/2016 3:06 PM	1.600	82.600	29.80	66.00	0
8/8/2016 4:06 PM	0.700	82.800	29.80	66.00	0
8/8/2016 5:06 PM	1.500	82.800	29.80	66.00	0
8/8/2016 6:06 PM	0.800	82.900	29.80	65.00	0
8/8/2016 7:06 PM	0.800	83.500	29.80	65.00	0
8/8/2016 8:06 PM	1.300	84.400	29.80	65.00	0
8/8/2016 9:06 PM	0.700	85.100	29.90	65.00	0
8/8/2016 10:06 PM	0.700	85.300	29.90	65.00	0
8/8/2016 11:06 PM	1.400	85.300	29.90	65.00	0
8/9/2016 12:06 AM	1.000	85.100	29.90	65.00	0
8/9/2016 1:06 AM	1.100	84.700	29.90	66.00	0
8/9/2016 2:06 AM	1.000	84.400	29.90	66.00	0
8/9/2016 3:06 AM	0.500	84.200	29.80	66.00	0
8/9/2016 4:06 AM	0.200	84.000	29.80	66.00	0
8/9/2016 5:06 AM	0.500	83.700	29.90	66.00	0
8/9/2016 6:06 AM	0.900	83.700	29.80	66.00	0
8/9/2016 7:06 AM	1.200	83.500	29.90	66.00	0
8/9/2016 8:06 AM	1.100	83.300	29.90	66.00	0

Table B.6: Red Brick

Date/Time	pCi/l	Temp F	Pressure inHg	Humidity %	Flags
8/9/2016 9:28 AM	1.000	83.300	29.90	66.00	M
8/9/2016 10:28 AM	0.800	82.800	29.90	69.00	0
8/9/2016 11:28 AM	1.000	82.400	29.90	71.00	0
8/9/2016 12:28 PM	1.200	82.400	29.80	72.00	0
8/9/2016 1:28 PM	1.600	82.600	29.80	73.00	0
8/9/2016 2:28 PM	0.800	82.600	29.80	73.00	0
8/9/2016 3:28 PM	0.600	82.600	29.80	74.00	0
8/9/2016 4:28 PM	0.800	82.600	29.70	75.00	0
8/9/2016 5:28 PM	0.500	82.600	29.70	75.00	0
8/9/2016 6:28 PM	0.800	83.300	29.80	75.00	0
8/9/2016 7:28 PM	0.700	84.200	29.80	76.00	0
8/9/2016 8:28 PM	0.400	84.900	29.80	76.00	0
8/9/2016 9:28 PM	0.600	85.100	29.90	76.00	0
8/9/2016 10:28 PM	0.600	84.700	29.90	76.00	0
8/9/2016 11:28 PM	1.300	84.400	29.90	77.00	0
8/10/2016 12:28 AM	0.500	84.000	29.90	77.00	0
8/10/2016 1:28 AM	0.400	83.800	29.90	77.00	0
8/10/2016 2:28 AM	0.700	83.700	29.90	78.00	0
8/10/2016 3:28 AM	1.100	83.500	29.80	78.00	0
8/10/2016 4:28 AM	0.600	83.100	29.80	78.00	0
8/10/2016 5:28 AM	0.700	82.900	29.80	78.00	0
8/10/2016 6:28 AM	0.800	82.800	29.80	79.00	0
8/10/2016 7:28 AM	0.600	82.600	29.90	79.00	0
8/10/2016 8:28 AM	1.000	82.600	29.90	79.00	0