Adsorption of Radon at different gamma energies using different activated carbon

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Abstract: Three activated Carbon types were produced using groundnut shell, sawdust and cocoanut shell. They were used along side with a commercial activated carbon to construct four radon detectors. Radon gamma emission was measured at energies of 352Kev, 609Kev, 1764Kev and 2204Kev. CAC tends to show an increase in gamma emission as energy increase, while, GSA gave a linear energy response than the remaining at all energies. Sawdust activated carbon shows no recorded gamma emission at window 2342.20Kev-2653.30Kev.Radon activity of six arbitrarily selected points shows an average of 23.34Bq. Adsorption ability of activated carbon produced from ground nut shell has been found to have a linear response at all the gamma energy of radon. It therefore can be used to construct a detector canister. [Report and Opinion 2010;2(6):23-27]. (ISSN:1553-9873).

Key words: CAC (commercial activated carbon, GSA (groundnut shell activated carbon, Activated carbon.

Introduction

Adsorption, which is often confused with absorption, refers to the adhesion of molecules of gases and liquids to the surface of porous solid. Adsorption is a surface phenomenon; while absorption is an intermingling or interpenetration of two substances. (Peter, 1994). The relatively large surface area of the absorbent allows absorbate atoms, ions or molecule to be taken up. In some cases the atoms of the absorbate share electrons with atoms of the absorbent surface, forming a thin layer of chemical compound. Absorption occurs when the molecules of the absorbate penetrate the bulk of the solid or liquid absorbent. Adsorption denotes absorption of a gas or a solute by a surface or an interface. Adsorption implies action at the surface .It is a spontaneous process accompanied by reduction of surface free energy of the adsorbing surface(Tait, 1980).

Adsorption is a type of adhesion with weak Van de Waal force which takes place at the surface of a solid or a liquid in contact with another medium, resulting in an accumulation or increased concentration of molecules from that medium in immediate vicinity of the surface. For example if freshly heated charcoal is placed in an enclosure with ordinary air, condensation of certain grasses occurs upon it, resulting in a reduction of pressure.

Charcoal when activated (i.e freed from adsorbed matter by heating) is especially effective in adsorption, due to it great surface area presented by it porous structure. (Corapciolu, 1987).

Theory of Adsorption

At a given fixed temperature, there is a definite relation between the number of molecules adsorbed upon a surface and the pressure (if a gas) or the concentration (if a solution) which may be represented by an equation or graphically by a curve called the adsorption isotherm. (Duncan, 1981).

The freundlich or classical adsorption isotherm is of the form.

$$\frac{x}{m} = Kp^{\frac{1}{n}} \text{......................(1)}$$

Where x is the mass of gas adsorbed
m is the mass of adsorbent
p is the gas pressure
k and n are constant for the temperature and system.
In certain system it is necessary to express this relationship as

$$\frac{x}{m} = K(h\gamma)^{\frac{1}{n}} \text{......................(2)}$$

where h is the relationship of the partial pressure of the vapour to it saturation value and γ is the surface tension. Numerous isotherm equations have been proposed. The lagmuir adsorption isotherm is of the form.

$$\frac{x}{m} = \frac{K_1 K_2 p}{1 + K, p} \text{......................(3)}$$

The degree of adsorption depends on five factors.

1. The composition of the adsorbing material
2. The condition of surface of the adsorbing material
3. The material to be adsorbed
4. The temperature
5. The pressure (if a gas)

Radon adsorption

Radon (^{222}Rn) is the most stable of all the radioactive gasses in Natural Occurring Radioactive

Material(NORM).It exist as ^{220}Ra (Thoron) in the thorium series and ^{219}Ra(Actinon) in the Actinium series and ^{222}Rn in the uranium series(Henry and John, 1987). The existence of these radioactive gasses in the three chains is one of the reasons for the presence of Natural occurring environmental radioactivity. The radon daughters which are solid attach themselves to the atmospheric dust, thereby increasing its concentration in the air. The probable atmospheric concentration is in the order of 2Bq/m^3 (Cember,1992).

Radon (^{222}Rn) is a heavy radioactive natural gas. It is odourless, colourless, noble gas, generated by radioactive decay of radium. This tasteless gas, with density of 9.13Kg/m3 and more than 100 times heavier than hydrogen, is difficult to detect. It liquefies at –61.8°C, freezes at –71°C and primarily transport itself to the environment through the soil and air, where it can accumulate in space and build up to a high level. Although, higher concentration is at the ground level, It accumulate in buildings especially confined areas such as basement, spring water, borehole water and hot spring. Of recent, it had come to be realised as a potential source of health hazards. (Peter, 1994).When radon is inhaled into the lungs; it can decay by means of alpha emission. An alpha particle is an ionised helium nucleus, which causes ionisation damage, when it strikes the lungs tissue. Over time, this damage can cause lungs cancer. (EPA, 2009).

The major challenge in radon measurement is appropriate instrumentation, and detection method suitable for Nigeria environment. To overcome this, there is need to use a local materials for it adsorption capacity for Radon, which shall be analyzed for radon concentration and further compared with an acquired calibrated continuous Radon detector.
With this, a cheap and affordable means of detecting raon in Nigeria home would have been arrived.
Most radiation detectors needs to be powered for a very lengthy period of time, without any power interruption; to acquire sufficient samples necessary to create an integrated accurate reading. Unfortunately due to the unstable power situation of the country, the use of such detector becomes practically impossible except with an independent power generating set, which makes the detector expensive to operate(George, 1984). Therefore, a passive detector is the only means of getting an accurate representation of existing radio nuclides.

Radon exhalation

The random movement of the radon gas atoms mixed in the air results in a net migration of the radon gas toward the direction of its decreasing concentration in the air. This phenomenon is called molecular or atom diffusion. The diffusion of radon in open air can be described by Fick's law, which states that the flux density of the diffusing substance is linearly proportional to its concentration gradient. Fick's law can be expressed as follows:

$$J = -D_0 \Delta C \quad \text{...............}(4)$$

where *J* is a vector representing the density flux of radon activity in units of activity (Bq), ∇C is a vector representing the gradient of radon activity concentration in the air in units of activity, and D_o is the molecular (or atom) diffusivity or the diffusion coefficient of radon in open air . Therefore, the diffusion coefficient D_o can be defined from Fick's equation and expressed as the ratio of the magnitudes of the vectors .

$$D_0 = \frac{IJI}{I\Delta CI} \quad \text{..}(5)$$

For radon diffusion in open air, Fick's law is uniquely expressed and, consequently, the diffusion coefficient of radon in open air, D_o, is also uniquely defined. However, when applied to the conditions of radon diffusion in porous media, such as in soil materials; Fick's equation can be written in different ways, depending on how the variables flux density *J* and concentration *C* are defined. Fick's equation can be written in four distinct ways when applied to the molecular diffusion phenomenon in porous media, depending on whether the bulk or pore volume is used to define the concentration and whether the bulk or pore area is used to define the flux density. (Nazaroff et al. 1988)

Materials and methods

Three activated charcoal types were produced and a commercial activated carbon was used throughout this work. An activated adsorbed canister was constructed using plastic can with diameter 4.5cm and height 5.0cm having perforated lid and a position for membrane filter. A cone shaped collector was used to hang the canister on a 20.0cm diameter hole drilled to a depth of 1m in Kaduna Polytechnic Environment.

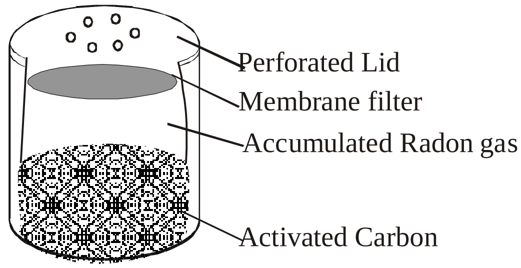

Fig. 1.0 A Sketch of interior of charcoal canister

Fig 1.0A is the interior of the canister, showing the perforated lid, membrane filter, activated carbon, and accumulated Radon gas, while fig 1.0 B shows the exterior of the canister

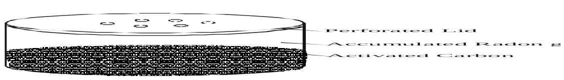

Fig. 1.0 B Sketch of exterior of charcoal canister

Radon detection
A cone shaped air shield was constructed with a metal plate, the plate was folded into a cone with a hook to hang the canister, and a base which prevent air movement and allow for radon concentration within the cone. This was used to hang the detector as shown in fig..2.0

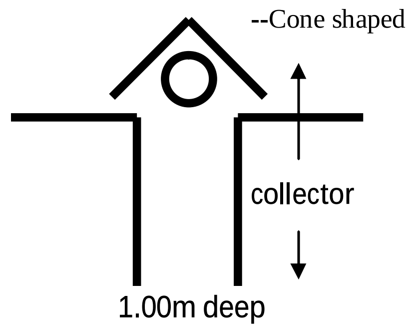

Fig. 2.0 Sketch of cone shaped air shield

Results and Discussion

4.1.1 Recorded counts

The activity of four different activated carbon namely commercial activated carbon (CAC), cocoanut shell activated carbon (CSA), groundnut shell activated carbon (GSA), and sawdust activated carbon (SAC), were obtained using their respective net count, The net background counts for 10,000 s at 609keV and 1763keV for the four unexposed canisters shows no difference with the background of the detector hence, the net count was obtained from the difference between the recorded count and the background of the detector Four different energy windows were considered for the recorded count, however. Net count for sawdust at 2343.2keV to 2653.3 keV was not determined because count was within the Compton background considering the abundance value of 5.6%. Fig.3.0 depicts the bar chart

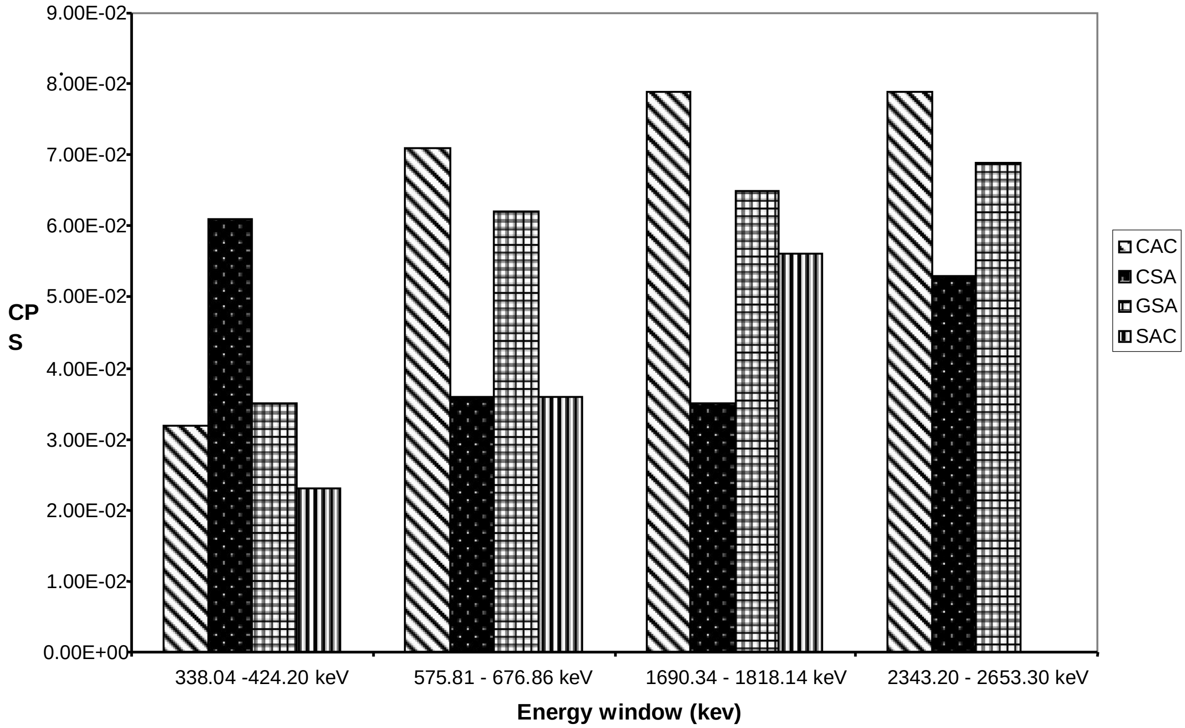

Fig 3A. dsorption of four activated carbon types

Table 1. The result of six arbitrarily selected points within Kaduna polytechnic with the use of groundnut shell activated charcoal exposed on the surface of the soil for twenty four hours and counted for a live time of 1800s.

Sample point	Recorded Net count at 609KeV	CPS	Activity of ^{214}Bi (Bq)	Activity of Radon (Bq)
A	63 ± 2	0.035	26.92	23.96
B	65 ± 5	0.036	27.69	24.64
C	42 ± 1	0.023	17.69	15.74
D	70 ± 3	0.038	29.23	26.01
E	72 ± 4	0.040	30.77	27.39
F	60 ± 2	0.033	25.38	22.59

Net count is highest in commercial, activated carbon at high gamma energies; this is expected for all the carbon because at low energies, there was high Compton background, CAC tends to show increase in adsorption as energy increases. GSA gave a better net count than the remaining at all energies. Optimum gamma emission was recorded at gamma energy window of 3443.20keV to 2653.30keV and 1690.34keV to 1818.14keV.

Groundnut shell activated carbon gave a better net count than the remaining, at all energies, this could be seen in bar form as shown in fig 3.0. Hence, we recommend the use of commercial activated carbon and groundnut shell activated carbon for adsorption and construction of radon detectors.

Table 1 shows the result of six arbitrarily selected points within Kaduna polytechnic with the use of groundnut shell activated charcoal exposed on the surface of the soil for twenty four hours and counted for a live time of 1800s.

The point C shows a remarkable low net count, however, the experiment was repeated on the same point, four times a relative count of 0.028cps was obtained compared with the initial count of 0.023cps, standard deviation from mean was obtained to be 0.705.

Conclusion

Adsorption ability of activated carbon produced from ground nut shell has been found to have a linear response at all the gamma energy of radon. It therefore can be used to construct a detector canister.

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4/2/2010