Risk Assessment from Radon Gas in the Greenhouses

N. M. Fahmi[a], M. Abd el-Zaher[b], A. M. El-Khatib[a]

a- Physics Department, Faculty of Science, Alexandria University, Egypt
b-Department of Basic and Applied Science, Faculty of Engineering, Arab Academy for Science, Technology and Maritime Transport, Alexandria, Egypt
***Corresponding author. E-mail address:** naglafahmi@yahoo.fr,

ABSTRACT

Radon is a naturally occurring radioactive gas found in varying amounts in all soils. Therefore, it is very important to study radon emanation from different soils in different circumstances; especially, in green houses which widely used to propagate and cultivate of plants. In greenhouses radon comes from either soil or the substances which make suitable flooring in the greenhouse. Radon and its progeny are accumulated in the air and on the plants themselves, which causes hazard for workers and customers in a later stage. Radon gas is measured in two kinds of greenhouses, one of them is constructed from plastic sheet and the other from glass (Agriculture Research Center – Horticulture Research Institute) using CR-39 NTDs as a passive technique. It based on the production of track in the detector due to alpha-particles emitted from radon and its progeny. The observed track densities are then converted to annual radon dose to be 12.36 mSv and 8.3 mSv for the plastic and glass greenhouses under investigation, respectively. It is also found that the workers have been subject to regulatory control.

Key Words: *CR-39 detector/ greenhouses/ Annual effective dose/ working level month (WLM).*

INTRODUCTION:

Radon gas, naturally occurring radioactive gas, appears mainly by diffusion process from the point of origin following α-decay of Ra—226 in either soil or building materials. The presence of radon in the soil depends upon the uranium contents in it and on the complex soil chemistry that varies from place to place[(1-3)]. Radon diffusion and transport through different media is affected by several factors like, humidity, temperature and ventilation[(4-7)]

Now it is interesting to study the radon concentration in a greenhouse. Greenhouse is a generic term referring to the use of a transparent or partially transparent material supported by a structure to enclose an area for the propagation and cultivation of plants. It is used to grow different varieties, protect crops from cold weather, hail, damaging wind and rain and keep pests and diseases out of the crop. Greenhouse is used to protect crops and sensitive plants from intense sunlight, heat and wind. It presents important productive advantages in comparison with non-protected agriculture. Especially; a greenhouse or polyhouse refers to the use of plastic films or plastic sheeting. Where the covering material is glass, the structure may be referred to as a glass-house. That is because different plants require different combinations of environmental conditions and variables amounts of those environmental controlled requirements. Generally, the better the system of protection and artificiality is the higher are usually crop yields. There are many substances which make suitable flooring in the greenhouse (cement, sand, gravel, brick), or it may be constructed on the ground beds directly. The structure of the greenhouse affects the atmosphere, ventilation, control of temperature and relative humidity, which are the result of the technological innovation and of agricultural knowledge.

As the cover material (glass or plastic film) acts as a heat trap as they don't allow the soil-reflected radiation to go across. On the other hand, evaporation and evapotranspiration are limited due to air circulation being considerably reduced in a closed environment. Also the pitch, angle of the roof to the horizontal, should be more than 23^o so that condensation will not drip onto plants and pass through the extreme sides [(8)]

In the greenhouses; it is found that, the humidity and the ventilation are the two most important factors rise the accumulation of the radon concentration. Accordingly; in the greenhouses a certain fraction of radon progeny becomes attached to the aerosol particles. It is well known that exposure of workers to even a low concentration of radon gas and its daughters for a long period lead to pathological effects like the respiratory functional changes and the occurrence of lung cancer[(9-10)].

The aim of the present study is to determine the radon gas concentration in two types of greenhouses of the Horticulture Research Institute, Alexandria using CR-39 detector. The principle of this passive technique is based on the production of track in the detector due to alpha-particles emitted from radon and its progeny. The α-track density is then converted to annual effective dose received by the workers in the greenhouses under investigation. This study helps in protecting the workers from the hazards of this radiation.

Radon doses from physical dosimetey:

The United Nations Scientific Committee for the Effects of Atomic Radiation—UNSCEAR assessments on sources and effects of ionizing radiation are used as a basis for radiation protection programs and research in the scope of nuclear and radioactivity issues by international organizations, national regulatory bodies, and research institutions[(1)].

Radon progeny which attached to aerosol particles in the confined spaces can accumulate to harmful levels. Radon concentration is normally given in the unit Bqm^{-3}. Radon dose is another quantity which gives energy deposition from radon and its progeny per unit mass of the absorber, such as human body or human lung (in the case of radon exposure). Many publications have dealt with radon dose to the lung determined from physical dosimetry[(12-16)]. At a certain radon concentration C in Bqm^{-3}, the annual radon dose, E,:is usually expressed in the unit of mSv from the following relation.

$$\mathbf{E = C.D.H.F.T} \qquad \mathbf{(1)}$$

Where D is the conversion factor used to assess radon dose for unit radon exposure. That is because of the physical difference between the radon concentration and radon dose. In the literature, its value is varying between divergent values[1]. The central value is estimate to be $9x10^{-6}$ $mSvh^{-1}$/ Bqm^{-3}, which represents the effective dose received by adults per unit Rn-222 activity per unit air volume. Also there the two more factors, an occupancy factor, H, of 27.4% (for workers), and an equilibrium factor, F, of 0.4 as used in ICRP publications. The equilibrium factor represents the ratio of the activity of all the short-lived daughters to the activity of the parent radon gas. Finally T is hours in a year = 8760 h/y. Now to calculate the effective dose, one has to apply a tissue and radiation weighting factors, 0.12 and 20; respectively, according to ICRP (1991) [17].

The workers exposure to radon daughters is expressed in Working Level Month (WLM). According to ICRP (1993) [18]:

1 WL = 130,000 MeV alpha energy per litre air
= 20.8 μJ alpha energy per cubic meter
WLM = Working Level Month
= 1 WL exposure for 170 hours
Assuming 2400 work per year, 1WLM = 4.2 mSv[18].

EXPERIMENTAL TECHNIQUE:

In the present study, the radon concentration has been determined in two types of greenhouses followed to Agriculture Research Center – Horticulture Research Institute, Alexandria. They are used to agriculture different types of ornamental plants which need natural soil. One of them is constructed with glass and cement is the basic material of flooring. It has a rectangular shape, its width is 8 m and length 30 m. its ridge (the distance from the floor to the greenhouse's highest point) is 7 m (Fig. 1). This glasshouse is provided with two entrances with dimensions 5mx5m and they are so far good ventilated. The other one is covered by plastic sheets and it is constructed directly on the ground bed. It has a rectangular shape with dimensions 30mx8m and a ridge of 3.5 m (Fig. 2). It has only one small door and no vent opening to offer effective ventilation.

Fig. 1: Photograph for a glass-greenhouse

Fig. 2: Photograph for a plastic greenhouse

Thirty CR-39 NTD_s sheets with size 1.5cmx2 cm are fixed in a cylindrical can and suspended at 5m height and 3m height along the glass house and the plastic one; respectively, to study the radon gas distribution and deduce a mean value for the radon concentration. CR-

39 is chosen because of its high sensitivity to alpha-particles emitted by Rn-222, Po-218 and po-214 with initial energies of 5.5, 6.0 and 7.7 MeV, respectively. Also, it has a very good stability against various environmental factors and a high degree of optical clarity[19]. The exposure was in the period between second of February and second of Mai 2008. This period covers the end of the cold weather and the average temperature was ranging around 20 ^{o}C with humidity between 47% and 60%. After this three months of exposure, the detectors are collected and subjected to chemical etching in 6.25 M NaOH for 4h at 70^{o}C in temperature controlled etching bath (to $\pm$ 0.1 ^{o}C). In order to have a homogeneous solution during the etching and avoid the deposit of etched products on the detector surfaces, the stirring was kept constant during the whole etching cycle.

After the revealing process, the CR-39 NID_s sheets are washed for 30 min with running water and finally with 50% water/alcohol solution. After drying the detectors in air, the etched tracks are counted using an optical microscope at 400 magnifications. The area of field of view was calculated by stage micrometer and track density, ρ, is calculated in terms of number of track per cm^2 (tr cm^{-2}). By applying the conversion factor, K, for CR-39 detector in the can-technique dosimeters as $2.7x10^{-3} \pm 2x10^{-4}$ tr $cm^{-2}h^{-1}/Bqm^{-3}$ of Rn-222[20,10,21], the radon concentration, C, in Bqm^{-3} is calculated from the following relation:

$$\boldsymbol{\rho = K\,C} \qquad \textbf{(2)}$$

Applying Eq. 1, this concentration ($trcm^{-2}h^{-1}/Bqm^{-3}$) is converted to effective dose for one year radon exposure in mSv. Also the WLM is calculated according ICRP, 1993.

RESULTS AND DISCUSSION

According to the measured number of tracks in the thirty exposed CR-39 sheets in each greenhouse, the average track density is calculated. This value can be converted into radon concentrations (Bqm-3) by applying the calibration factor (Eq. 1). Then, a radon concentration is calculated for the glass and plastic greenhouses under investigation to be 638 Bqm^{-3} and 942 Bqm^{-3}, respectively. To understand what is really meant by a value of radon concentrations for workers, these values are converted to effective dose for one year radon exposure, using Eq. 2, to be 8.3 mSv and 12.36 mSv, for the glass and plastic greenhouse respectively. By applying the weighting factor for the α-particles and lung tissues, it is found that corresponding values of equivalent dose are 19.92 mSv and 29.66 mSv.
Again, assuming 2400 hours per year for the workers in the greenhouses under investigation, a corresponding Working Level Month is calculated to be 4.74 WLM and 7.06 WLM in the two examined greenhouses.

In summary, the authors scanned the literatures to find that; it is the first time, at least in Egypt, that the radon dose may be inhaled by workers is assessed in two types of greenhouses. It is found that the workers generally receive radon dose in the range of action level (3-10 mSv per year) recommended by ICRP, 1993. In more specific discussion, one can notice that the house, constructed from glass, gives less WLM than the one constructed from plastic. That may also refer to the poor ventilation in the plastic one, and it contains only one small door and it is kept close about 20 h per day. It is also trap heat and has very high humidity which offers a very suitable atmosphere which can raise the radon dose accumulation.

CONCLUSION

This work assesses the WLM for workers in the greenhouses (followed to Agriculture Research Center – Horticulture Research Institute, Alexandria) it is concluded that the poor ventilation, high temperature and high humidity raise the accumulation of the radon gas to a risky level for the workers. Even it is in the recommended range of ICRP (1993), but it tends towards the high end of this range. The authors recommend consider the safety conditions when constructing the greenhouses to reduce this risky radon dose for workers. This dose may also affect the plants themselves and consequently the public consumers. This may be a future work to follow the effect of this radioactive gas which is considered as higher risk than any other accident like house fire or else. Also it is suggested that more investigation about the radon dose in different greenhouses all over Alexandria City is required

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