24704

Aiavi, Olubusola Motunravo et al./ Elixir Pollution 71 (2014) 24704-24708

Available online at www.elixirpublishers.com (Elixir International Journal)

Pollution

Elixir Pollution 71 (2014) 24704-24708



Radon occurrence in homes: Assessing residents' awareness in the LE1 postcode area of Leicester, UK

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ARTICLE INFO

Article history: Received: 23 April 2014; Received in revised form: 25 May 2014; Accepted: 4 June 2014;

Keywords

Radon, Health implication. Level of awareness. Cost of monitoring, Remediation action. Lough borough.

ABSTRACT

Radon 222 is a radioactive gas that evolves from the radioactive decay of uranium and thorium in rocks and soils and is dangerous when inhaled indoors. Although some areas in the United Kingdom are at higher risks than the others, the effect on the health of its victims is generally devastating as several studies have linked radon to lung cancer. This research was carried out by administering structured questionnaire to voluntary participants dwelling in Loughborough, Leicestershire. The result showed that one out of every seven survey participants had never heard of radon and the effect on health. In addition to this, majority of the participants do not have an idea of the cost of monitoring radon in the home and therefore have never tested for radon. Also, one out of every eight smokers is not aware of the health effects of radon. This study concluded that there is the need for greater awareness of indoor radon health effect in the home. Further studies may be extended to other parts of the UK. Furthermore, there is also the possibility of wider study of assessing the level of indoor radon awareness amongst smokers in the United Kingdom.

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Introduction

Radon-222 is an odourless, tasteless, and invisible radioactive gas released when naturally occurring thorium and uranium found in diverse quantity in rocks and soil decays [1]. Radon enters dwellings from the ground, through cracks and joints in building slabs, drainages, and by ventilation [2]. Another route of entry includes porous building materials [3]. The concentration of radon is dependent on the underlying bedrock; rocks containing granite, old red sandstone and limestone, coupled with high permeability are required for radon to be released to the surface [4]. Radon-222 gas occurs mostly in granite and migrates through the rock surfaces into the environment [4]. Based on ordinance survey map of Loughborough [5], the following underlying bedrocks are attributed to areas within the LE11 postcodes:

The eastern part of Loughborough (LE11 1) contains fluvoglacial gravel, while the underlying bedrock in Loughborough moor (LE11 1) is alluvium.

Garendon area (LE112 and LE11 4) contains shales and the type of rock in this area is Precambrian rock.

► Loughborough University area (LE11 3) contains shales.

Black brook area (LE11 4) contains sand and gravel.

► Loughborough South (LE11 5 and LE11 9) contains syenite, also quarrying activities is noted with this area.

During quarrying activities, piles of radioactive sand known as uranium tailings which contains radon gas can be blown by wind and deposit solid radon progeny on ground, in water, vegetation, and food chain [6]. The concentration of indoor radon depends on the geology of the ground upon which the building is constructed, construction details, and habits of the inhabitants of a dwelling [7]. Radon becomes dangerous indoor by producing a chain of radioactive isotopes called radon daughters [3]. Short live radon progeny can attach to surfaces in dwellings and accumulate into long live progeny [8]. Indoor radon exposure accounts for about 5% to 10% of lung cancer death [9]. In view of this, the United Kingdom government recommends that any home found to be above 200Bq/m3 should take mitigation measures to reduce the exposure [10].

Background Study

Investigation into domestic exposure of radon began in the 1970s and 1980s and this included mapping and surveying to know the level of radon problem [11]. The mapping of radon affected areas was done based on the geology of the area [7]. Loughborough is classified as low risk radon area although radon gas above action level (200Bq/m3) have been found in dwellings in the west, northwest and south west of Loughborough [12]. This is due to sand and gravel extraction carried out in the south and quarrying activities in the western part of Loughborough [13].

This study is of key importance because the World Health Organisation listed radon as the second cause of lung cancer asides smoking with indoor risk exposure from 100Bq/m3 [14]. Secondly, the largest radiation dose of radon is found in domestic dwellings because more time is spent in living abode and smokers are at twenty five times more risk of radon exposure than non-smokers [15]. Thirdly, radon levels vary with each house; although geologically radon had been predicted in some areas, high levels of radon have been discovered in areas that were not predicted [11].

The data recently made available by the Health Protection Agency for Charnwood for Loughborough area showed that 150 out of 68000 homes was measured, with results as high as 1000Bq/m3, and two dwellings above action level [16]. The cost of testing for radon by the Health Protection Agency is about $\pounds 49.80$ and the result sent to home owners [17].

Also, based on a survey carried by NRPB on randomly selected 400,000 houses for radon out of which 100000 were affected and 40,000 had concentration above action level; majority of the owners of affected houses are reluctant to act even when aware of the risk and benefits associated with

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remediation as only 10% took remediation action [18]. It is the duty of the Local Authority to ensure that there is increased public awareness of the risk of indoor radon exposure without creating panic among the members of the public [19]. They should also promote a positive response to the measurement programme, introduce radon preventive measures in new buildings, and encourage remedial actions to be carried out in existing buildings [19]. This study aims to critically evaluate the level of awareness of Loughborough dwellers to radon contamination in the home and its effect on health. The objectives are to critically evaluate the level of Loughborough dwellers awareness of the following:

1. radon contamination in the home

2. the health effect of elevated radon concentration in the home.

3. the cost of monitoring radon and what proportion have had their home tested for radon or taken remediation action.

Methodology

This study was carried out using online and paper designed questionnaire as survey instrument between March and April, 2013. The questionnaire was distributed to 200 interested participants living within the targeted pollution. The participants' duration of residing in Loughborough ranged from two years to sixty years. Three hypotheses were formulated to address the aim and objectives of this study. Hypothesis 1(H1) assumed a significant difference in the level of awareness of radon in dwellings among Loughborough population using their postcodes with the dependent variable being the level of awareness, while the independent variable are the postcodes.

H1 was analysed using one- way analysis of Variance. Hypothesis 2 (H2) predicted a relationship between the awareness of radon health implications amongst smokers or non-smokers within the various postcodes. The independent variable were the Loughborough dwellers aware of health implication of indoor radon, while the dependent variable were participants who smoked or do not smoke. Hypothesis 2 was analysed using descriptive statistics.

Also, Hypothesis 3 (H3) stated a significant relationship exist between Loughborough dwellers perception to cost of monitoring, and testing for radon in the home. The latter was the independent variable, while perception to cost of monitoring was used as the dependent variable. H3 was analysed using percentage, and analysis of variance. SPSS was used to analyse the data obtained from the questionnaire survey.

Results and Discussions

Radon Awareness Level within the LE11 Postcodes

The gathered data from the sampled population showed that 33 out of 200 survey participants are aware of radon in dwellings. The breakdown across each postcode is shown in Table 1a.

From Table 1a, there is a wide gap between participants not aware of indoor radon than those aware of indoor radon contamination in the home across the postcodes. Also, the percentage A, of radon in the dwelling awareness amongst participants is calculated as follows: A=

 $\frac{\text{Number of Yes within a postcode}}{\text{Total number of participants within a postcode}} X 100\%$

The percentage of people who were not aware was deduced by subtracting the percentage of those who showed awareness from 100 as shown in Table 1b.

The result shows that the percentage of voluntary participants aware of radon is the home is between 15% and 25%, while that of participants not aware of indoor radon contamination is between 75% and 86.6% with LE11 4 and LE 12 having the same percentage of level of awareness.

This establishes similarity and not difference in the level of awareness within the postcodes. This also shows that although the number of participants varied within the postcodes, there is no sharp difference in the level of awareness of radon within the postcodes. In addition to this, the depth of individual awareness was analysed as shown in Table 2.

Table 2 shows that 167 out of 200 survey participants are not at all aware of radon contamination in dwellings, also the majority of those aware within the postcodes are slightly aware with none of the survey participants extremely aware. The percentage of participants who have never heard of radon in the home across the LE11 postcodes is reported earlier in Table 1b. Furthermore, the possibility of a statistical significance in the level of awareness within each postcode was analysed using post hoc test as shown in Table 3.

From Table 3, it can be seen that the p > 0.05 in each postcodes, with all the lower bound being negative while the upper bounds are positive. This condition presents the probability of having no statistically significant difference in level of awareness within the LE 11 postcodes. In order to verify this assertion, one way analysis of variance was used as shown in Table 4.

Table 4, shows no statistical significant effect in the presentation condition (F (5, 194) =1.062, P = 0.383> 0.05.

Where df = degrees of freedom

F = F- ratio for the source of variance

Sig = P value

Since P > 0.05, it can be affirmed that there is no statistical difference in the level of awareness of radon in dwellings amongst Loughborough population. Based on the descriptive and inferential statistics above, H1 is therefore rejected.

Secondly, the awareness of smokers and non-smokers to health implication of indoor radon (HIIR) was analysed. The result of the survey showed that 174 participants are nonsmokers while 26 participants smoke cigarette. The breakdown further reveals that only 4 out of the 26 participants who smoke are aware of the health implications of indoor radon (HIIR), while 142 out of 174 participants who do not smoke are not at all aware of radon health Implication.

The percentage of smokers aware of (HIIR) = Total number of smokers aware of HIIR X 100%

Total smoking population

 $\frac{4}{26} \times 100\%$ =15.4%. The result of the radon awareness rating

is shown in Table 5.

Table 5 shows that those that non-smoking participants are more aware of the health radon health implication than those that smoke. The total number of health implication awareness between smokers and non-smokers is 4 and 32, which is in the ratio 1: 8. This shows that survey participants who are nonsmokers are eight times more aware of the health implications of radon than that smoke. Therefore, based on this descriptive statistics, H2 is accepted. Thirdly, the Loughborough dwellers perception to cost of monitoring radon in the home shows that out of 200 voluntary participants, a total of 29 participants had an idea of the cost of monitoring radon while 171 participants have no idea of the cost of monitoring as shown in Table 6.

From Table 6, it is evident that majority of the survey participants do not have an idea of the cost of monitoring radon in the home. Furthermore, the number of participants that have tested for radon in their homes is shown in Table 7.

| Table 1(a) : Level of Awareness within the LE 11 Postcodes | | | | | | | | | | |
|--|------------|--------|--------|--------|--------|--------|--|--|--|--|
| | Post Codes | | | | | | | | | |
| | LE11 1 | LE11 2 | LE11 3 | LE11 4 | LE11 5 | LE11 9 | | | | |
| | Count | Count | Count | Count | Count | Count | | | | |
| Radon Contamination at Home Awareness Yes | 6 | 5 | 9 | 4 | 8 | 1 | | | | |
| No | 34 | 15 | 59 | 24 | 29 | 6 | | | | |

Table 1(a) : Level of Awareness within the LE 11 Postcodes

Table 1 (b): Level of Awareness and Non-Awareness of radon and lack of it, within the Postcodes

| Postcodes | LE111 | LE112 | L113 | LE114 | LE115 | LE119 |
|--------------------|-------|-------|------|-------|-------|-------|
| Aware (A%) | 15 | 25.0 | 13.4 | 14.3 | 21.6 | 14.3 |
| Not aware (100-A)% | 85 | 75 | 86.6 | 85.7 | 78.4 | 85.7 |

Table 2: Level of Awareness Rating of Radon in Loughborough

| | | Post C | Codes | | | | | |
|---|------------------|--------|--------|--------|--------|--------|-------|-------|
| | | LE1 1 | LE1 12 | LE1 13 | LE11 4 | LE1 15 | LE119 | |
| | | Count | Count | Count | Count | Count | Count | Total |
| Level of Awareness of Radon Contamination at Home | Not at all | 34 | 15 | 59 | 24 | 29 | 6 | 167 |
| | Slightly Aware | 3 | 1 | 6 | 4 | 5 | 0 | 19 |
| | Moderately Aware | 2 | 2 | 1 | 0 | 2 | 0 | 7 |
| | Very Aware | 1 | 2 | 2 | 0 | 1 | 1 | 7 |
| | Extremely Aware | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Total | 40 | 20 | 68 | 28 | 37 | 7 | 200 |

Table 3: Post Hoc Test (Multiple Comparism) Showing the Level of Awareness of Radon Contamination in the home.

| | | | | | 95% Confidence Interva | | |
|-------------|------------------|-----------------------|------------|-------|------------------------|-------------|--|
| (I) Post Co | ode(J) Post Code | Mean Difference (I-J) | Std. Error | Sig. | Lower Bound | Upper Bound | |
| LE11 1 | LE11 2 | 300 | .189 | .611 | 85 | .25 | |
| | LE11 3 | .041 | .138 | 1.000 | 36 | .44 | |
| | LE114 | .107 | .170 | .989 | 38 | .60 | |
| | LE11 5 | 066 | .157 | .998 | 52 | .39 | |
| | LE119 | 179 | .283 | .989 | 99 | .64 | |
| LE11 2 | LE11 1 | .300 | .189 | .611 | 25 | .85 | |
| | LE11 3 | .341 | .176 | .384 | 17 | .85 | |
| | LE114 | .407 | .203 | .341 | 18 | .99 | |
| | LE11 5 | .234 | .191 | .824 | 32 | .78 | |
| | LE119 | .121 | .304 | .999 | 75 | 1.00 | |
| LE11 3 | LE11 1 | 041 | .138 | 1.000 | 44 | .36 | |
| | LE11 2 | 341 | .176 | .384 | 85 | .17 | |
| | LE114 | .066 | .156 | .998 | 38 | .51 | |
| | LE11 5 | 107 | .141 | .974 | 51 | .30 | |
| | LE119 | 220 | .275 | .967 | -1.01 | .57 | |
| LE114 | LE11 1 | 107 | .170 | .989 | 60 | .38 | |
| | LE11 2 | 407 | .203 | .341 | 99 | .18 | |
| | LE11 3 | 066 | .156 | .998 | 51 | .38 | |
| | LE11 5 | 173 | .172 | .916 | 67 | .32 | |
| | LE119 | 286 | .292 | .925 | -1.13 | .56 | |
| LE11 5 | LE11 1 | .066 | .157 | .998 | 39 | .52 | |
| | LE11 2 | 234 | .191 | .824 | 78 | .32 | |
| | LE11 3 | .107 | .141 | .974 | 30 | .51 | |
| | LE114 | .173 | .172 | .916 | 32 | .67 | |
| | LE119 | 113 | .285 | .999 | 93 | .71 | |
| LE119 | LE11 1 | .179 | .283 | .989 | 64 | .99 | |
| | LE11 2 | 121 | .304 | .999 | -1.00 | .75 | |
| | LE11 3 | .220 | .275 | .967 | 57 | 1.01 | |
| | LE114 | .286 | .292 | .925 | 56 | 1.13 | |
| | LE11 5 | .113 | .285 | .999 | 71 | .93 | |

Table 4: One Way Analysis of Variance of the Level of Awareness of Radon Contamination in Loughborough Dwellings.

| | Sum of Squares | df | Mean Square | F | Sig. |
|----------------|----------------|-----|-------------|-------|------|
| Between Groups | 2.542 | 5 | .508 | 1.062 | .383 |
| Within Groups | 92.878 | 194 | .479 | | |
| Total | 95.420 | 199 | | | |

Table 5 : Awareness Ratings of Radon Health Implications in the Home

| | | Cigarette | | |
|--|------------------|-----------|-----|-------|
| | | Yes | No | Total |
| Awareness Ratings of RHI in Loughborough | Not at all | 22 | 142 | 164 |
| dwellings | Slightly Aware | 0 | 11 | 11 |
| | Moderately Aware | 4 | 9 | 13 |
| | Very Aware | 0 | 11 | 11 |
| | Extremely Aware | 0 | 1 | 1 |
| Total | | 26 | 174 | 200 |

Table 6: Cost of Monitoring Rating from Questionnaire Response within the Postcodes

| Cost of Monitoring Rating | Mean | Ν | Std. Deviation |
|---------------------------|------|-----|----------------|
| No Idea | 1.91 | 171 | .292 |
| Very Cheap | 1.57 | 7 | .535 |
| Cheap | 1.77 | 13 | .439 |
| Moderate | 1.86 | 7 | .378 |
| Expensive | 2.00 | 2 | .000 |
| Total | 1.89 | 200 | .320 |

Table 7: Radon Testing within the Loughborough Postcodes

| Testing Radon in the Home | Mean | Ν | Std. Deviation |
|---------------------------|------|-----|----------------|
| Yes | 1.52 | 23 | .898 |
| No | 1.28 | 177 | .811 |
| Total | 1.31 | 200 | .823 |

Table 8: The Relationship between Radon Testing and Cost of Monitoring Radon in the Home.

| Analysis of Variance | Sum of Squares | df | Mean Square | F | Sig. |
|---|----------------|-----|-------------|-------|------|
| Testing Radon in the Home * Cost of Monitoring RatingBetween Groups(Combined) | .973 | 4 | .243 | 2.447 | .048 |
| Within Groups | 19.382 | 195 | .099 | | |
| Total | 20.355 | 199 | | | |

From Table 7, 177 out of 200 participants have not tested for radon in the home. This establishes a direct relationship between perception to cost of monitoring radon and radon testing in the home. Furthermore, analysis of variance was used to determine the statistical significance as shown in Table 8.

Table 8 shows that a statistical significant effect in the presentation condition (F (4, 195) = 2.447, p< 0.05. Where df = degrees of freedom, F = F- ratio for the source of variance and Sig = P value. Therefore, based on the inferential statistics above, H3 is therefore accepted although it is marginal as 0.048 is very close to 0.05.

Furthermore, the perception of landlords and tenants towards remediation action was analysed in the event of the need for remediation action, 147 volunteer participants stated they were tenants while 52 are landlords. Only 1 out of the 52 landlords stated he would take remediation action. In addition to this, majorly of the tenants have never tested for radon in the home and therefore are not aware if their homes would require remediation action. This implies that renting or owning a home does not influence taken remediation action, therefore, hypothesis 4 is accepted.

Conclusion

The findings from the survey reveal the need for more awareness on indoor radon contamination in dwellings. Also, based on the descriptive and inferential statistics of the data collected from 200 voluntary participants:

>75% of the participants in this study have never heard of radon contamination in the home.

> The majority of those who are aware of radon in the home are slightly aware and therefore no in depth knowledge of its health implication.

> Only 15.4% of those who smoke cigarette are aware of radon health implication.

>85% of the study's participants have no idea of the cost of monitoring radon in the home and this accounts for the minute number that have taken remediation action.

Recommendations

The local authority should create more awareness to Loughborough dwellers on radon contamination in the home and its health implications since the low risk of occurrence does not equal to no risk in form of voluntary testing while emphasizing that it is affordable. Also, future research can focus on assessing the level of public awareness to radon in the home, their perception to cost of monitoring, and the awareness of the health implication of radon amongst smokers.

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