ANALYSIS OF INDOOR RADON CONCENTRATIONS IN HILLSBOROUGH COUNTY (FLORIDA) PUBLIC SCHOOL BUILDINGS

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ABSTRACT

Indoor radon concentrations have been measured and reported in Hillsborough County, Florida, public school buildings in response to the Florida mandatory radon testing program for public facilities. Testing of indoor radon was conducted in 1079 school buildings in 160 public schools belonging to the Hillsborough County School District. Testing was completed between 1989 and 1994 in compliance with the first five-year cycle of the Florida mandatory indoor radon testing program, covering 100% of the occupied spaces. Data were collected and organized into databases by the Florida Department of Health and Rehabilitative Services, the agency responsible for administering radon regulations in Florida. Analysis of reported results were performed to evaluate indoor radon concentrations in the county public schools with respect to other indoor radon concentrations in non-residential buildings in the county and statewide, and with non-residential buildings that are located in the same zip codes as the schools. The overall average indoor radon concentrations in the schools is 0.7 pCi/l, with 1.6% of the buildings exhibiting concentrations exceeding 4 pCi/l. The school's overall average is approximately 41.7%, 12.5%, and 0% less than the average indoor radon concentrations in non-residential buildings located in the same zip codes of the county, countywide, and statewide; respectively. The majority of school buildings exhibited maximum to average indoor radon concentration ratios equal to or less than two.

INTRODUCTION

Beginning in 1989, all of the following buildings have been required to be tested for indoor radon: all public and private school buildings or school sites housing students in Kindergarten through grade 12; all state-owned, state-operated, state-regulated, or state-licensed 24-hour care facilities such as hospitals, detention centers, and nursing homes; and all state-licensed day care centers for children or minors. The mandatory indoor radon testing program was established by a 1988 Florida Legislature action, and administered by the Florida Department of Health and Rehabilitative Services (HRS) through Chapter 10D-91 of the Florida Administrative Code (FAC), (FHRS 1994).

Chapter 10D-91 established periodic testing cycles of 5-year each. During the first testing, a facility is required to be test for 100%, 20%, and 10% of the occupied spaces on the first, second, and third floors; respectively. These spaces must be habitable and occupied on a regular basis. Occupied space testing coverage is then reduced to 20% for the next cycles if no location in the building exhibited indoor radon concentrations greater than 4 pCi/l. Although mandatory testing for indoor radon concentrations in residential buildings have been conducted following the United States Environmental Protection Agency (USEPA) short-term testing protocols, testing in non-residential buildings have been conducted following the FAC measurement procedures. The latter procedures were developed to provide uniform protocols for the purpose of the mandatory testing in Florida. Measurement procedures are similar to the USEPA short-term testing protocols, however, it addresses several issues that have a significant impact on indoor radon such as the heating, ventilating, and air-conditioning systems (FHRS 1994). In this work, results of the first-cycle indoor radon testing (1989-1994) for the Hillsborough County public school buildings, reported to the Florida HRS through the mandatory testing program, are presented and analyzed.

APPROACH

Testing of Hillsborough County School District (HCSD) public school buildings was performed by GLE Associates, Inc., for the School Board using activated charcoal adsorption devices. The devices were deployed for a minimum period of 48 hours, approximately 3 to 5 feet above the floor and a minimum of 1.5 feet from any wall, and as much near the center of the room as possible. One test device was placed in each room, and where rooms are greater than 2000 square feet, additional devices were placed. Duplicates and blanks were used for the quality control requirements of the measurement procedures. One blank devise, not exposed at the site, is randomly selected from every 20 devices and analyzed to indicate background in the devices and to monitor for other potential problems that might be generated as a result of shipping, storage, or processing of the measurement devices. A duplicate device is used with every 10 devices used at a site for the purpose of comparing the measurement results.

Plumbing, electrical conduit and ventilation penetrations through the floor into each room and ventilating fans and chases carrying plumbing or other conduits, which are visible, were noted and identified prior to the testing. Building floor plans were used to identify test device locations according to the testing protocols outlined in Chapter 10D-91 of the FAC. Tests were conducted in each building by trained technicians. Results of HCSD school buildings reported between 1989 and 1994 were organized into databases by the Florida HRS. Related indoor radon concentrations for other non-residential buildings reported to HRS under the mandatory testing program, using the same measurement procedures, and mostly conducted by trained technicians, were organized into databases based on the zip codes in the county in which the county's public schools are located for the purpose of comparison. Other non-residential indoor radon testing data for Hillsborough county and for the state of Florida, were also organized and used in the analysis.

RESULTS AND DISCUSSION

There are 160 schools in HCSD that were tested for indoor radon concentrations during the first cycle of the Florida radon mandatory testing program. These schools compromise 1079 non-residential buildings, bringing the average number of buildings per school to approximately 6.7. Most of these buildings are one story structures, however; their shape, complexity, size, and slab and foundation details varied greatly. The number of devices used to measure indoor radon concentrations in each building ranged from one to 269 devices, at an average of 12.3 testing devices per building.

Since data used in this analysis are collected only from the first testing cycle results, testing was performed to cover 100% of the occupied spaces. The schools are located in geographical areas spanning 44 zip codes in the county. Indoor radon measurements performed in other non-residential buildings, under the mandatory testing program, were collected and organized for buildings located in the same zip codes set where the schools are located. Table 1 summarizes results obtained from the schools along with results obtained from other buildings in the zip codes set, the Hillsborough County, and the State of Florida.

As seen in Table 1, buildings belonging to the HCSD have an overall average indoor radon concentration of approximately 0.7 pCi/l with only 1.6% of the buildings exceeding 4 pCi/l. This average is approximately 41.7% less than the overall average indoor radon concentration collectively obtained from reported non-residential buildings in the same zip code areas where HCSD buildings are located. This significant difference is attributed to an extra measure undertaken by the Hillsborough County School Board to reduce indoor radon concentrations in their school buildings by employing different mitigation techniques. The latter were gradually installed in some school buildings during the past five years. It is expected that calculations of the overall average indoor radon concentration exhibited in HCSD buildings based on the second five-year cycle reporting requirements will result in further reductions, compared to the non-residential buildings in the area, as more radon mitigation systems are further utilized and installed.

Table 1: Summary of indoor radon measurement results and the percentage of buildings exhibiting concentrations greater than 4 pCi/l for HCSD school buildings with respect to other relevant data.

Item	Average Indoor Rn (pCi/l)	Maximum Indoor Rn (pCi/l)	Buildings Exceeding 4 pCi/l (%)
Hillsborough County School District	0.7	31.6	1.6
Non-Residential Buildings in HCSD zip code areas	1.2	32.9	4.8
Non-Residential Buildings in Hillsborough County	0.8	34	5.1
Non-Residential Buildings in Florida	0.7	86.1	6

Using indoor radon concentration data reported under the Florida mandatory testing program in Hillsborough County, and in the State of Florida, Al-Ahmady et. al. calculated the overall average indoor radon concentrations as 0.8 and 0.7 pCi/l for countywide and statewide, respectively (Al-Ahmady et. al. 1996). These figures are in very good agreement with the current estimate of the indoor radon concentrations in the HCSD buildings. The latter is still 12.5% smaller than the estimate of the average indoor radon concentration countywide. While the average concentration in the HCSD equals the statewide average indoor radon concentration in non-residential buildings (0.7 pCi/l), the percentage of school buildings exhibiting concentrations greater than 4 pCi/l is significantly less at 1.6% compared to the statewide estimate of 6%. Further, the number of HCSD buildings exceeding 4 pCi/l are only 33% and 31% of the non-residential buildings with indoor radon concentrations exceeding 4 pCi/l in the same set of zip code area where schools are located and in the entire county, respectively. This is also attributed to the efforts undertaken by the Hillsborough County School Board to control radon exposure in their school buildings.

Figure 1 shows the distribution of reported indoor radon concentrations in HCSD school buildings and in non-residential buildings located in the same zip codes where schools are located, plotted as a percentage relative to the range of average indoor radon concentrations. As seen in the figure, over 60% of school buildings exhibiting concentrations less than one pCi/l. The number of school buildings sharply drops as the range of average concentration increases to about 3.5 pCi/l, and almost became negligible when the range increases to over 4 pCi/l. The corresponding percentage of non-residential buildings located in the same zip codes, where schools are located, is less by more than 10% for the range of average indoor radon concentrations less than one pCi/l. However, the number of buildings located in the same zip codes as the schools and exhibiting concentrations in ranges greater than 1.5 pCi/l are systematically larger. Yet, the general trend of these buildings show a sharp decrease as the average indoor radon concentrations exceed 0.5 pCi/l, similar to the trend of the school buildings.

Figure 2 shows the distribution of the percentage of buildings versus ranges of reported maximum indoor radon concentrations. These concentrations are comparable to each other with levels of 31.6, 32.9, and 34 pCi/l for the HCSD school buildings, non-residential buildings located in the same zip codes, and non-residential buildings countywide; respectively. However, they are at least 60% less than the maximum indoor radon concentration in non-residential buildings statewide, reported at 86.1 pCi/l (Al-Ahamdy et. al. 1996). Over 80% of HCSD schools have maximum indoor radon concentrations less than or equal to 2.5 pCi/l. This is significantly larger than the percentage of non-residential buildings countywide, which is less than 30%. The percentage of school buildings decrease as the range of maximum indoor radon concentrations increase, and exhibited sharp drop when ranges exceed 2.5 pCi/l. This trend is similar to the trend observed with ranges of average indoor radon concentration. However, unlike the school buildings trend with average indoor radon, their trend with maximum indoor radon noticeably differs from the trend of non-residential buildings countywide. Although, a decrease in the latter can be easily observed when ranges

of maximum indoor radon concentration exceed 5 pCi/l, neither the peak percentage value nor the trend at higher concentrations is similar to the HCSD school buildings.

Figure 3 illustrates the relationship between the range of maximum to average indoor radon concentrations in HCSD buildings and the count of the school buildings. The highest number of buildings is shown to have maximum indoor radon concentrations that are twice the average concentrations exhibited in these buildings. Further, the number of school buildings that exhibited maximum to average indoor radon concentrations less than or equal to 2, exceeds the rest of buildings that exhibited ratios greater than 2. It is also interesting to notice that the number of school buildings exhibiting maximum to average indoor radon concentration ratios that are whole numbers, systematically exceeds the number of buildings in that range of maximum to average concentration. This phenomenon is likely to be an artificial effect that is generated from the tendency to round up indoor radon measurement results during processing and reporting.

CONCLUSIONS

Results of indoor radon testing performed at 1079 public school buildings belonging to 160 public schools in Hillsborough County, Florida, reported in this study indicate that these schools exhibiting average indoor radon concentrations significantly less than concentrations obtained from non-residential buildings located in the same zip code area where the school are located. Furthermore, the number of HCSD school buildings that reported with average indoor radon concentrations exceeding 4 pCi/l is significantly less than the number of non-residential buildings located in the same zip codes as the schools, across the county, and statewide. This is attributed to extra measures undertaken by the county school board to reduce indoor radon concentrations in their school buildings by installing radon mitigation systems. The maximum indoor radon concentrations in the schools were observed to be similar to concentrations exhibited in non-residential buildings located in the same zip code areas, where the schools area located, and in the entire county. However, all maximum concentrations reported were at least 60% less than the value of the statewide non-residential maximum indoor radon concentration. It has been observed that similar trends exist as the percentage of reported buildings sharply decrease as the average indoor radon increases to a specific level for both school buildings and other non-residential buildings in the county. Although, a very sharp decrease in the percentage of HCSD buildings occurs when maximum indoor radon concentrations, measured in these buildings, exceed a specific level; a different trend is observed for other non-residential buildings in the county. It has been shown that a possible artificial effect may occur when indoor radon measurement data are reported or processed. The latter phenomenon was remarkably noticed as the maximum number of buildings systematically occurred at maximum to average indoor radon concentration ratios forming whole numbers for each range of the ratios.

REFERENCES

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Florida Department of Health and Rehabilitative Services (HRS) "Control of Radiation Hazard Regulations- Radon", Florida Administrative Code, Chapter 10D-91; 1994

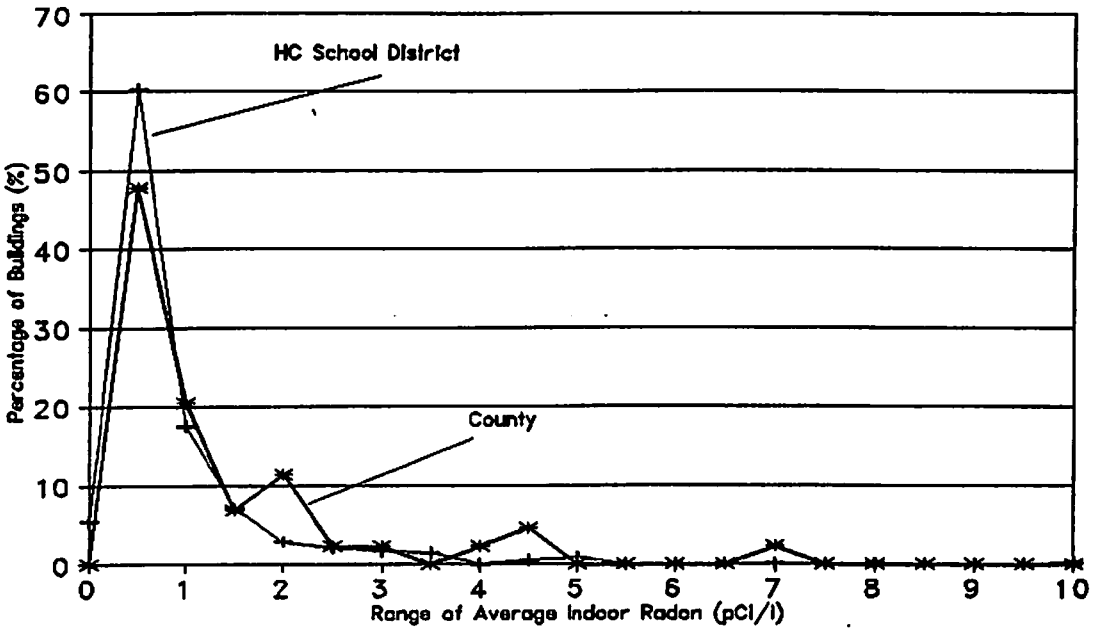

Figure 1: The perçentage of HCSD school buildings and non-residential buildings in Hillsborough County as a function to their average indoor radon concentrations.

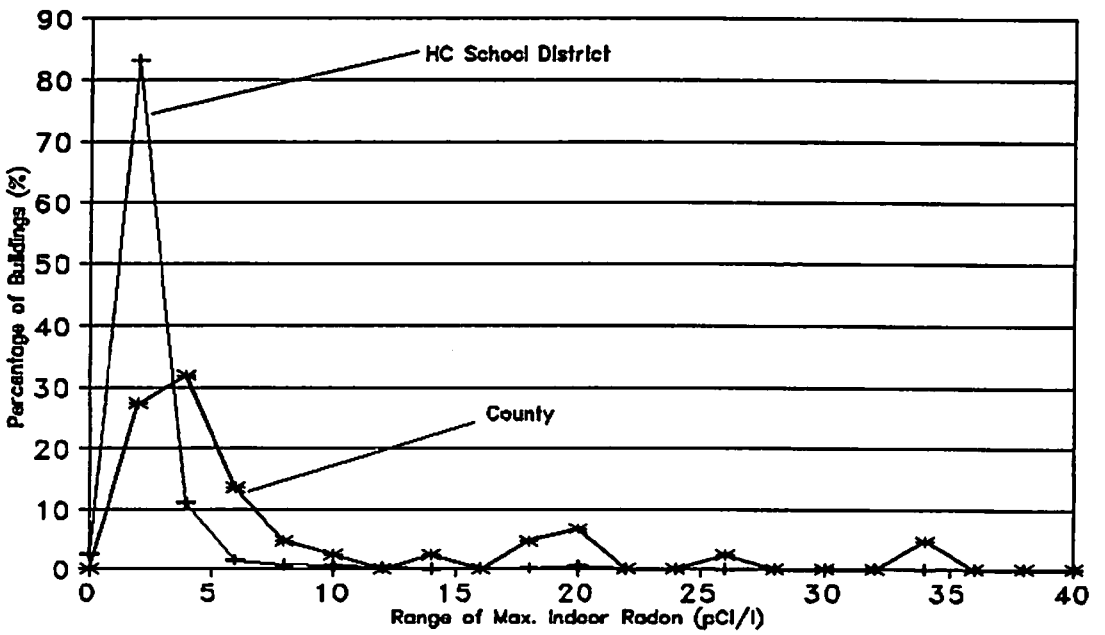

Figure 2: The percentage of HCSD school buildings and non-residential buildings in Hillsborough County as a function of their maximum indoor radon concentrations.

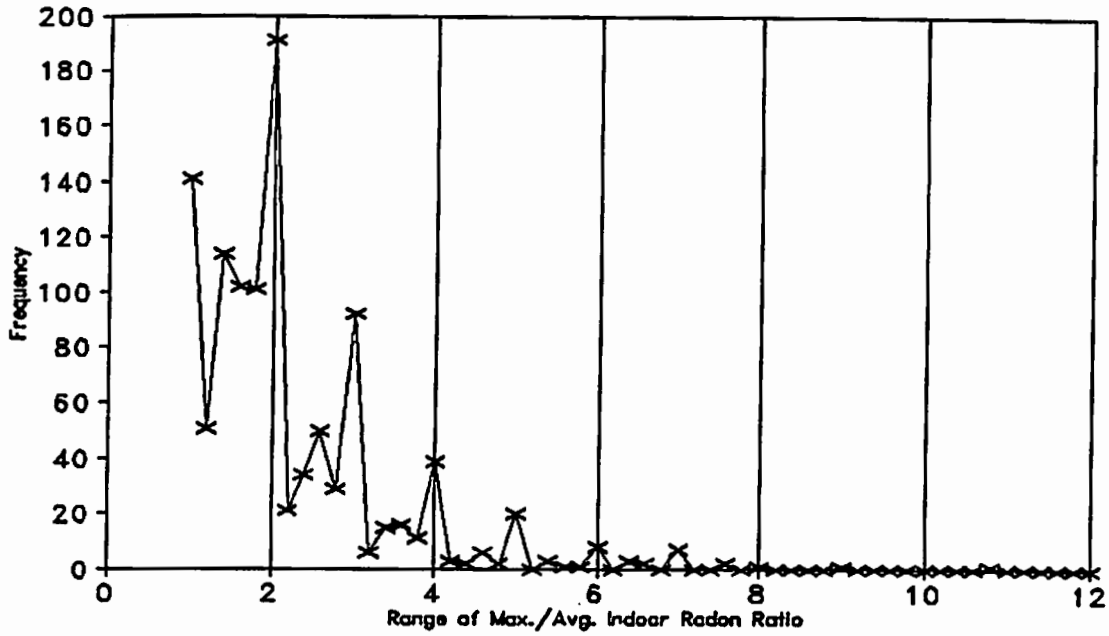

Figure 3: The frequency of occurrence of HCSD school buildings as a function to their reported maximum to average indoor radon concentrations.