2003_05

Proceedings of the 2003 International Radon Symposium – Volume II
American Association of Radon Scientists and Technologists, Inc.
October 5 – 8, 2003

MONITORING OF RADON IN UKRAINE

Komov, I.L.

Komov I. L. Institute of Environmental geochemistry. City Kyiv, Country UKRAINE

Abstract. National data on indoor radon, radon in water, and geologic radon potential indicate systematic differences in the distribution of radon across the Ukraine. Radon gas is found in homes all over the Ukraine. Its maximum percentage is detected in uranium deposits (up to 30000 Bq/m^3). In indoor air from the penetration of soil gas into homes, so only very high concentrations of radon in water will make an important contribution to the airborne concentration. Parameters that can be used to examine the possibilities of the appearance of hazard radon areas in the geologic medium in the Kiev area have been determined. The map was developed using five factors to determine radon potential: indoor radon measurements; geology; aerial radioactivity; soil permeability; and, foundation type. We have proposed and are developing equipment of new type for complex investigation of movement and transformation of radon, thoron and their derivatives. A number of methods can be used to reduce elevated radon levels in a home. These methods fall into two categories: (1) preventing radon from entering the house, and (2) removing radon after entry. Some actions may be taken immediately, and can be done quickly at minimal expense.

Introduction. Three natural isotopes of radon are widely distributed: actinon (^{219}Rn), thoron (^{220}Rn), radon (^{222}Rn). All of them are the members of the natural radioactive series (^{219}Rn is from ^{235}U family, ^{220}Rn is from ^{232}Th family, ^{222}Rn is from ^{238}U family) and they are the daughter decay products (DDP) of radium. Radon is the inert radioactive gas, dissociating with α-radiation, forms the series of radioactive DDP with α-radiation and β-radiation: ^{218}Po, ^{214}Pb, ^{214}Bi, ^{214}Po. Arriving in organs of breathing of a person, radon and in the greater measure its DDP subject they to radioactive exposure. For want of stay of the person in a location with 1 Bq/m^3 volumetric activity of radon its upper respiratory paths receive an effective dose of an exposure about 50 mSv/year. At present, it is universally recognized that natural sources of ionizing radiation introduce the main contribution (60-90%) in the population exposure dose. Radon and its decay products are the largest danger for population.

Safeguarding of the human radiation security and reduction of the radioactive irradiation level in dwelling houses is very actually. The population of industrially developed countries spends in dwelling and public buildings about 80% of its time. The radon concentration on ground floors and basements can considerable raise the radon concentration in outdoor air, and its activity can reach several thousands of Bq/m^3. Radon and its daughter decay products (DDP) enter in human breathing organs and influence on lungs.

The domestic portable radiometer RGA-11 was recently created and for the first time it became possible fulfillment the mass measurements of equivalent equilibrium volumetric activity (EEVA) of ^{222}Rn and its DDP. The RGA-11 radiometer allows to measure ^{222}Rn EEVA in an air in a diapason of 5-10 000 Bq/m^3, ^{220}Rn (thoron) EEVA - from 0,5 up to 1000 Bq/m^3, and volumetric activity (VA) of ^{222}Rn DDP (^{218}Po, ^{214}Pb, ^{214}Bi) and ^{220}Rn (^{212}Pb) in a diapason of 5-10 000 Bq/m^3. The relative error of radon EEVA determination (on Markov-Terent'ev's method) for want of P=0,95 makes less than 30 %. The gear work is based on a preliminary sedimentation of radioactive aerosols on AFA-RSP-20 filter for want of selection the air sample with the help of small-sized pump, mounted in the gear, such as MP-20. Then alpha-radiation of radionuclides on a filter is measured with the help of semi conducting detector with use of a difference in a life time of radon DDP. The time of one measurement is 15 minutes. VA of DDP of ^{222}Rn, EEVA of ^{222}Rn and ^{220}Rn (thoron) is determined as a result of indirect measurements on the Markov's formula.

Radon in Ukraine. National data on indoor radon, radon in water, and geologic radon potential indicate systematic differences in the distribution of radon across the Ukraine. Its maximum percentage is detected in uranium deposits (up to 30000 Bq/m^3). In one-store buildings situated in the region of crystal shield, concentration of ^{222}Rn is about 100 Bq/m^3, with half that much out of it. About 23 per cent of homes in Ukraine are estimated to have radon levels above 100 Bq/m^3 and 1,0 percent of homes above 200 Bq/m^3, with big differences between the oblasts. Most radon enters homes via migration of soil gas. Our studies investigate indoor ^{222}Rn concentrations and also the radioactivity of building material and drinking water.

In the Ukraine were about 20 underground mines. At that time radon concentrations were less than 400 Bq/m^3 in about 50% of all the measured places of work in the mines. Concentration exceeded 2000 Bq/m^3 in about 20% of the measurements. The highest detected concentration in a working area was about 37 KBq/m^3. Even higher concentrations were detected in some poorly ventilated unused areas of the mines. In the city of Yellow Waters for want of fulfillment of works on a radiation inspection of schools, Liceum, grammar school, children's shelter of the Yellow Waters city were used equipment passed through the State Metrological Control. From 50 inspected locations of schools and children's gardens in 64 % of locations average annual values of radon EEVA exceed an allowed level (200 Bq/m^3) and in these locations the obligatory fulfillment of anti radon measures is necessary.

Typically radon concentrations in surface waters are less than 4,000 Bq/m^3. Water from ground water systems can have relatively high levels of dissolved radon, however. Concentrations of 10,000 kBq/m^3 or more are known to exist in public water supplies. Ukraine is extremely rich Rn by waters, which is territorial are connected to the Ukrainian crystalline shield area. The contents

^{222}Rn in sources of water - supply should not exceed 100 Bq/m^3, and ^{226}Ra - no more than 1 Bq/l. The largest share in radiation of waters of the occupied items, as well as waters of deposits, introduces Rn.

The building materials and radon. Natural radioactive nuclides, containing in mineral resources for the building materials, are regarded as the important sources of outer gamma-irradiation and the human's lung tissues irradiation by the radon and thoron decay products. The problem of radioactivity in the building materials can be examined from the two inter-dependence points of view: radiation - hygienic and technological ones. If the first one establishes the possible radioactivity regulations on various building materials and ensures a control system, but the technological approach requires such a constructive decisions under which these regulations will be kept, and radiation doses will be turned out as poor (below of the normative dose), as this is reachable with due regard for acceptable technical-economical indices.

The highest specific activities of natural radionuclides are typical for intrusive and volcanic rocks (granite, tuff, pumice), but the lowest ones are characteristic for carbonaceous rocks (marble, limestone). Sand and gravel, as a rule, has a low specific activity of natural radionuclides. Moderately heightened specific activity of radoinuclides is typical for clay.

The crystalline rocks with different levels of natural radioactivity are the main providers of raw materials for the building materials in Ukraine. A gamma-spectrometric analysis of activity value of long-living natural radionuclides in rocks shows that specific activity of radioinuclides in potassium-40, radium-226, thorium-232 depends on deposit's age, structure and density of rocks. We had generalized facts on natural radioactivity (NR) of the raw materials for building materials production on the base of data investigation and had picked out four groups of deposits.

To the deposits of the first group (all types of constructions) we have attributed the objects in which the NR level is no more than 370 Bq/kg and 20 mkr/hour. To the second group (industrial and road buildings within the territories of populated areas and zones of long-term buildings; outward decoration of dwelling and public buildings) deposits with the NR level from 350 to 740 Bq/kg and 40 mkr/hour are attributed. The third group (industrial and road buildings outside populated areas) contains deposits with the NR level from 750 to 1350 Bq/kg and 73 mkr/hour. The deposits in which rock blocks have the NR level more than 1350 Bq/kg and more than 73 mkr/hour are included in the fourth group. It is impossible to use in dwelling and cultural-domestic construction all other classes of the building materials in which the NRN concentration exceeds mentioned indices. Maximum permissible radon concentration in buildings within Ukraine is 100 and 200 Bq/m^3 for houses newly being built and ones, which were already built accordingly [3].

At present in many countries of the world, wide scale investigations on study and standardization of radiation parameters of mineral raw materials, building materials for dwelling and public constructions are carrying out. In Poland, for example, raw materials and finished building material are estimated according two qualification coefficients [5].

$F_1=0{,}00027S_K+0{,}0027S_{Ra}+0{,}0043S_{Th}$ (1);

$F_2=S_{Ra}$ (2)

S_K, S_{Ra}, S_{Th} are potassium, radium and thorium concentrations in given material correspondingly. The building material can be used for dwelling building if qualification coefficients answer at the same time to next conditions:

F_1=1 (3),

F_2=5 nCi/g (4)

The condition (3) limits outer irradiation by gamma-radiation, and the condition (4)- limits possible radium concentration in the material, which determines the concentration level of free radon in indoor air.

In Austria the condition $C_K/9620+C_{Ra}(1+0{,}1\varepsilon\rho d)/740+C_{Th}/520<1$ (5), is the criterion of radiation safety of the building materials, where C_K is concentration of proper isotope (K, Ra, Th), Bq/kg; ε – the value without scale, that less is than 1; d – the thickness of a wall; m, ρ – wall density, kg/m^3. The idiom in round brackets of the second number of the condition takes into account radiation on radon, the source of which is radium containing in the building materials. When one or some parameters describing radioactivity on radon are unknown, it must be taken: ρ = 2000 kg/m^3; ε = 0,1; d = 0,3 m. If material don't answer the condition (5) then it is necessary to examine the condition (6): $(\rho d)/250\{C_K/9620+C_{Ra}/740(1+25\ \varepsilon)+C_{Th}/520\}<11$ (6).

Specific effective activity of natural radionuclides A_{sea} are calculated in according with the formula: $A_{sea}=A_{Ra}+1{,}31A_{Th}+0{,}85A_K$ (7),

A_{Ra}, A_{Th}, A_K is specific activities of radium, thorium and potassium, Bq/kg.

The value of A_{sea} in a considerable degree determines gamma-background and so forms the dose of outer human radiation in buildings. Clay raw materials and ceramic materials: ceramsite (168 Bq/kg) and brick (171 Bq/kg) have the largest quantity of A_{sea} of the NRN. The average value of A_{sea} of these materials is somewhat more than A_{sea} of raw materials such as clay and loam (159 Bq/kg). These are caused by some enrichment with natural radionuclides of ceramic materials in result of baking. The least value of the NRN specific effective activity is fixed in silicate brick (59,7 Bq/kg), building solution (79,9 Bq/kg) and Portland cement (101 Bq/kg). Lowly active lime and carbonaceous raw materials as it is known are in composition of these materials. Gravel, rock debris, sand and sand-gravel mixture (131 Bq/kg), using as fillings, has some higher values of A_{sea} in comparison with concretes (107-109 Bq/kg).

The main mineral astringents: cement, gypsum, lime and materials on their base have average values of radium specific activity of radium in limits of 30-40 Bq/kg. This index is more than 50 Bq/kg in kilning materials (ceramic bricks and Portland cement). As a result, of the kilning process the enrichment of these materials with natural radionuclides occurs under chemically bound water removal from clay minerals. Low ^{40}K concentration in Portland cement is explained by prevalence of lime (80%) in charge composition and by high kilning temperature. Reduction of alkaline elements happens in the kilning process.

In building industry the carbonaceous rocks of Ukraine from which lime for silicate bricks are produced, are used too. Under the technological cycle of the production of lime the dust from precipitation chamber are returned into adjustable stove that leads to increasing of ^{226}Ra activity in lime. Radium is a source of radioactive radon gas exhalation: ($^{226}Ra \rightarrow {}^{222}Rn + {}^{4}He$). There are small amount of ^{226}Ra in initial chalk. Under heating it is occurs $CaCO_3$ dissociation with generation of supersaturated solution and increasing ^{226}Ra content on 27%. Radiation monitoring of the production on every section of radiation measuring showed that the final product – lime has the largest total effective activity.

On some plants it is possible the generation of the zones of intensive radioactive gases migration, which can create the radiation risk for the workers of enterprises and also for the population living on the territories adjacent to them. Such zones of intensive migration of radioactive gases are the followings: quarries, premises for raw materials stores, thermal treatment and cooling, sections for the moldings and drying. Within Yantsevskiy and Kamenskiy quarries (Zaporozhskiy district) gamma-activity of granites reaches 150 γ (it is the third class of danger – more than 1350 Bq/kg according to standards of Ukrainian Ministry of Public Health). Radioactive dust connected with granites under explosions and loading of rock debris when wind is blowing, covers the city of Zaporozh'e (the south-east regions) by compact cloud, sharply deteriorating ecologic situation in this town.

In fireproof industry, there are plants on serial production of firebricks from local kaolin clay rocks. But firebricks received from kaolines, as a rule, have radionuclide content higher than working standards on radiation security. To such types of firebricks ceramsite, shaleceramsite, porous rock debris, foamceralite, agloporite, etc. are attributed. From Chasov'yar clays having specific activity of natural radionuclides (Bq/kg) ^{40}K-453, ^{226}Ra – 60, ^{232}Th – 47, it is possible to receive ceramic with A_{sea}=233. Their use must be limited.

Industrial wastes are used for the building materials too. Such practice promotes the preservation of nature resources and it reduces working expenses on the building materials production too. Wastes in some cases have sufficiently high specific activity of natural materials. The highest contents of natural radionuclides are fixed in cement with gravel additions. Coal slag which was used in old building construction, can be a cause of higher level of gamma-radiation within apartments. All types of building control are directed on achievement of the maximum its quality and human security. Radiation control of building materials also can be considered as form of quality control of building industry, providing radiation security of man, which is a user of this production. The objects of control may be both building raw materials and separate constructions and completed buildings.

Radon in City Kyiv. In a geological structure of the territory of Kiev two structural floors are selected: the lower one is the base, built with dislocated crystalline Precambrian formations of the Ukrainian Shield (USh), and the upper floor is the slope of the USh, built by weakly dislocated sedimentary Phanerozoic formations. In this study, geologic factors (types of rock, fault zones) are quantified and used to produce a radon-hazard-potential map of the Kyiv city area. The radon activity in sections directed perpendicularly to active breaking segments was measured that ensured deriving information about modern geochemical tectonic activity of fault zone. The map helps radon testing and evaluation of the need for radon-resistant construction. The area Kyiv city is structural filled with sediments derived intrusive rocks (granite) and contains the uranium also high levels of faults. Ground water depth is greater then 10 feet. High faults concentrations, rocks with uranium, deep ground water, and highly permeable soils combine to a high radon-hazard potential in much of the area. South and west of the city of Kyiv, contribute to a hazard potential. In this study, geologic factors (types of rock, fault zones) are quantified and used to produce a radon-hazard potential map of the Kyiv city area (Fig). The three radon-hazard-potential categories are: 1. Low (L): areas where no geologic factors contribute to indoor-radon hazards; 2. Moderate (M): areas where some geologic factors contribute to indoor-radon hazards; and 3. High (H): areas where all geologic factors contribute to indoor-radon hazards. Areas with low hazard potential have expected indoor-radon concentrations less than 50 Bq/m^3. Areas with high hazard potential have expected concentrations greater than 100 Bq/m^3. Fault zone and along the extensively faulted center of city, localized areas of high radon concentration may occur. Series of electronic vector maps of the territory of Kyiv such as the map of Neotectonic of Kyiv, the map of the Prequaternary sediments, the map of crystalline rocks, the map-scheme of the territory of Kyiv were made in MapInfo programmer for generalization of the results of volumetric activity (VA) of radon in soil, water and in an air for the purpose to reveal correlation dependence and risk zones. On the base of these maps the generalized map was made, in which structure and quantities parameters of soils were shown and various levels of radon dangers were shown too. Such information is a basis for prognosis of radon content in an indoor air.

Following factors contribute to elevated indoor-radon levels: 1. Type of rocks, concenrationn of fault zones, uranium levels in the rocks, on which a structure lies, 2. Type of soil, uranium levels, their porous, concentration of clay and sand, 3. Ground-water conditions that do not restrict the movement of radon, 3. Type of building materials or foundation openings near or below the ground surface, and types of construction of houses, 4. Conditions of atmospheric pressure inside a building than outside, 5. Variable and fluctuates the weather. Geologic factors influencing indoor-radon levels by controlling the local concentration and transport of radon.

The concentrations of soil-gas radon in pores and the permeability of the soil for transport (geologic factors) affect indoor-radon levels. Soil-gas-radon and faults concentrations broadly correlate with indoor-radon and hazard potential. When assessing an area for radon-hazard potential, the soil must be considered because radon gas must migrate through it. Comparisons of average soil-gas-radon concentrations in other studies show a good correlation despite radon being highly mobile in soil and concentration of radon indoor. The mean concentration of seven indoor-radon samples from the city of Kyiv is 20 kBq/m^3, with all samples greater than 100 Bq/m^3. All samples came from areas of high hazard potential.

The highest concentration of uranium, radium and radon are observed in ground waters, area of which feed are the massifs of granitites, relating to a class of rocks most enriched with uranium and thorium. The water supply of the city based on use of both surface (Desna and Dnieper rivers) and underground waters. On a level of Dnieper's and Desna's water collectors the underground waters of Cenomanian (Cretaceous) and Bajocian (Jurassic water-bearing horizons are actively exploited. The average contents of radon-222 in different types of spring are the followings: springs and mineralized sources - 7 Bk/l, wells – 5Bk/l, artesian boreholes - 4 Bk/l and surface waters - 4 Bk/l.

As a whole within region in sections of beds the distribution of fluorine is characterized by considerable irregularity and in main it is inspected by the content and structure of an inorganic part of rocks. The content of fluorine varies from 1,7 mg/l up to 0,19 mg/l.

For revealing correlation dependences between parameters of contents of underground waters of Kiev the correlation analysis was executed with the help of STATISTICA 6,0 software package. For extract from 50 analyses on four components (^{226}Ra, ^{232}Th, ^{235}U and ^{222}Rn) the significant positive correlation connection under of 5% -s' level of significance value is established only between radon and uranium (r = 0,3 under critical significance r05 = 0,28). Between three parameters of water content (pH, F and 222Rn) of underground sources of Kiev (under n =11 for all three parameters) positive correlative connection is established between the contents of radon and fluorine (r = 0,87 under critical value r = 0,6). For extract of the contents of radon and fluorine from 16 values the coefficient of double correlation between these parameters is lower (r = 0,55), however remains significant, since r = 0,5.

Research of radon distribution (of EEVA – equivalent equilibrium volumetric activity of ^{222}Rn) within surface and underground stations of the Kiev's metro were conducted. The analysis of the results of an inspection shows, that essential exceeding in relation to a level of a radiation background on a surface both on stations, and in tunnels of the underground is not revealed. Their absolute values are comparable to a level of a radiation background on an open area. Doze loads in connection with a small response time of the passengers in the underground and low values of the Rn concentration, which are in allowed norms.

The undergrounds of large cities of the World including Kiev deserve special attention in the plan of radioecological performance of radon accumulation by virtue of the above-stated notes. In connection with a diverse relief of the territory of Kiev, the underground are characterized by various depth of an underlay. In most raised relief of right bank parts of the city with a complicated relief the tunnels of the underground lines pass on various depths, sometimes rather significant, in mares and clays of the Kiev's suite of the upper Eocene. The part of the underground lines was built in subsurface friable of the Quaternary sediments and on a surface (the left bank part of the Svjatoshinsko-Brovarskaya line). Measurement of VA of ^{222}Rn DDP and the following calculation of ^{222}Rn EEVA was executed for the air of the underground offices located at three level: 1) cash hall (cash departments, studies, rooms of eat period etc.); 2) technical floor (workshops, machine rooms etc.); 3) platforms (rooms for workers on duty on station, drainage pipes, etc.). The research of radon EEVA immediately in inter-station transport tunnels was not made yet.

In total during the spring-summer season of 2002 130 locations on all 40 acting stations of the Kiev's underground were inspected. The outcomes of calculation of ^{222}Rn EEVA in the air of inspected locations of three lines of the underground were generalized in the table, and the average values for locations of a different level of separate stations were indicated on a histogram (Fig.2). On data of a measurement ^{222}Rn EEVA in the air of offices of three lines of the underground essentially do not differ among themselves. In majority of the locations ^{222}Rn EEVA is insignificant and it is within the limits of 5-36 Bq/m^3, that does not exceed an permissible level of average year significance for being built and renovated buildings and structures with constant people stay (50 Bq/m^3), and the more so it is lower than threshold significance for exploited buildings of similar purpose (100 Bq/m^3) and industrial locations (300 Bq/m^3).

In a number of cases the increased significances of the radon contents were marked. It concerns to such stations as "Vokzalnaya", "Dvoretz sporta" and "Vidubichy". The maximum significances of ^{222}Rn EEVA on the "Vokzalnaya" station are marked in locations at the level of the cash hall (till 90-94 Bq/m^3). The samplings conducted in these locations after airing, have shown noticeable reduction of a radon level. On the " Dvoretz sporta " station, in several locations of subsurface level ^{222}Rn EEVA significances for want of repeated measurements is stable in the limits of 31-105 Bq/m^3. On the "Vidubichy" station maximum significances of ^{222}Rn EEVA achieved 47-61 Bq/m^3 in subsurface locations at the level of the cash hall.

As a whole the lowest significances of ^{222}Rn EEVA are established for locations at the level of a platform, that is stipulated, probable, at the expense of good air exchange for want of trains movement. The increased radon level was marked in a room of the attendant on the" Tarasa Shevchenko" station, where ^{222}Rn EEVA is from 17 up to 26 Bq/m^3.

The level measurement of radon radio-activity in locations of the Kiev's underground allows to assume, that major factors, defining process of radon load forming, are: 1 - ability of grounds to produce radon, depending from concentration of radium-226 in them; 2 - features of a geological section (a thickness of stratums of grounds of a various type, an order and depth of their bedding, contents in them U and Th, generating radon, their water- and gas penetrating, a level and dynamics of ground waters etc.); 3 – availability of long living, including and nowadays, tectonic zones in the crystalline base and sediments, overlapping it; 4 - the depth of a underlay of stations and transport tunnels of the underground; 5 - kind of facing materials used for decoration of the underground, contents of radioactive elements in them, porosity etc.

With the purpose of elucidation of a source of the high radon content in separate locations of the stations of the underground the surface profile emanation survey of the regions, adjacent to these stations was conducted. The survey was conducted on a net of 50 x 50 m with use of a gear RGA-01 named "Glisinia". Essential advantage of this method is it velocity and technical simplicity. In an outcome of realization of the survey the increased content of radon and thoron (the total significance of EEVA is more than 20 κBq/m^3) is established in a soil air near the "Vokzalnaya", "Polytechnic institute", "Dvoretz Ukraine", "Libedskaya", "Dvoretz sporta " stations. The analysis of distribution of these anomalies with use of the tectonic map has allowed making a conclusion about their connection with neotectonic movements of long living faults.

Taking into account presence on the Kiev's territory a number of anomalies with rather high radon content, including content above the underground lines, rather low radon amounts in the locations of the Kiev's underground are stipulated first of all by high-power and reliable isolation from a gas and water stream from containing grounds, and also their intensive cooling with an atmospheric air. The rather increased radon content in some objects of the underground indicate son unsuccessful condition of the above-stated protective factors, less often it is stipulated by availability of facing materials with an increased radio-activity (granites, granite-gneisses).

The analysis of outcomes of the executed researches has shown, that the Kiev's underground on a level of the radon contents does not represent danger to passengers. In connection with a small response time of the passengers in the underground and low significances of radon concentration a common load dose per capita don't exceed 0,05 mSv /year.

Investigation of air ions and radon. Ions play a significant role in our environment there are two kinds of ions, positive and negative. Almost all "+" natural ions come from radioactivity. About 40% of natural air ions come from radioactive minerals in the ground. Each time a radioactive atom decays near the air, it produces 50,000 - 500,000 air ion pairs. Another 40% comes from radon in the air (which produces about 250,000 ion pairs for each radon atom), and 20% comes from cosmic rays (high-energy protons from distant supernovas). Normal fair-weather ion concentrations are 200 to 800 negative and 250 to 1500 positive ions per cubic centimeter. Indoor levels are usually lower. Because a large concentration of + ions can attract - ions, high concentrations of + and - ions are often found together. Typically, a high concentration (1000 or more) of both may be found in one area outdoors while low concentration (300 or less) is found typically one city block away.

Indoors, near ground level (basement), most "+" ions come from radon, and a reading of 1000 "+" ions/cm^3 means about 150 Bq/m^3 of radon. A higher concentration of + ions near cracks in the concrete foundation or near corners indicate the radon is coming in there.

If the average "+" ion count is low (for example, less than 100), then there is essentially no radon present. Aeroion regime in the accomodations deteriorates as a result of the entering of air exhaled by man, work of different instruments and equipment, during the combustion of consumer gas and other. Unbalance of positive and negative ions established in this case can lead to the negative consequences for human health. Thus, the positively ionized air causes worsening in the health of the people: headache, insomnia, tiredness, reduction in the fitness for work. Thus, the importantly not only study of the state of the aeroion atmosphere in the closed accomodations, but also planning and the realization of measures for the restoration of optimum for the health of the man of aeroionization of air.

The field of aeroions is studied in the computer class, the laboratories and the audiences Institute of Environmental geochemistry in City Kyiv with the aid of instrument MAS-01. In this case are measured the concentrations of both background light and heavy positive and negative aeroions and concentration of such aeroions after switching on and work of computers, radiating equipment, stay of worker during 2 - 3 h in one and the same audience.

The measurements of a quantity of light and heavy aeroions were accompanied by the synchronous measurements of the power of exposure dose. The background concentrations of aeroions are measured in the audiences without any ionizing sources and to the visit by worker. It turned out that the average contents of light aeroions in the limits from ~100 to 700 ions/cm^3, and heavy from ~$0,3 \cdot 10^4$ to $1,3 \cdot 10^4$, the average values respectively of ~250 and ~$0,57 \cdot 10^4$ of ions/cm^3. The work of seven computers and the presence of seven students in the aired computer class for 5 h lead to the significant changes in the concentrations of aeroions. X-ray and electronic emissions from the X-ray spectral installation and the electron microscope did not cause noticeable changes in the concentration of aeroions. In the weakly aired accomodation in the winter period in the presence of 7 workers the concentration of light aeroions did decrease approximately into 3- 4 times, and heavy it grew approximately 3. Thus, the basic factor, which influences the concentration of aeroions in the closed accomodations this the people: aeroion climate deteriorates due to reduction in the concentration of light negative aeroions and growth of heavy positive aeroions. Important criterion of evaluation of ambient effect on human health - the content of light and heavy, negative and positive aeroions. It is experimentally established that in the weakly aired urban accomodations the background concentration of light negative aeroions into shchey 5-10 of times is lower than the concentrations of similar aeroions in the forest and maritime air. The presence of people in such accomodations in the winter period increases this relationship even several times, which leads to the apathy, the rapid fatigue and, as a result, to worsening in the perception.

Protection against radon radiation. The choice of measurements for protection dwelling houses from radon are determined first of all with intensity of main sources of radon existing in soil air as well as in the presence of fractures and cracks within building constructions. The second source of radon penetration in dwelling houses is the building materials, containing sources of radioactive irradiation in its structure. It is necessary to exclude direct radon penetration radon in human organism with drinking water. In living and public buildings, it is necessary to provide its full hermetization, hydro isolation and effective ventilation. Considering the building materials as potential sources of ionizing irradiations, it is necessary to take into account their screening role.

For protection from unhealthy natural radioactive radiation and, first of all, from radon, it is recommended to use new building material, conditionally, named "light" concrete [5]. This ecologically pure material is capable completely protect the population from radon (because of gas impenetrability) and from other natural radiation. Gravel (rock debris), containing radioactive elements is absent as the fullness in this concrete. Under little density (500...900 kg/m^3) concrete have compression strength to 15 MPa and answer the all present requires of heat - and sound –isolation. From them it is possible to make guarding constructions, which has one bed and don't need decoration work (internal and external ones). The cost of 1 m^3 of light concrete guarding constructions is in two times lower than the cost of brick walls.

It is necessary to determine possible velocity of leaching of radionuclides from a cement matrix. Tests on leaching must be fulfilled with samples of lime solutions containing ash additions or without such additions. The building materials with cement matrix and additions as a rule leach small amount of heavy metals and therefore they don't be dangerous for soil and ground waters. Cement base of materials are investigated on gamma-radiation with calculation of a radon emanation coefficient.

Wide application of decoration materials on polymeric base leads to exhalation of chemical substances in indoor air in living houses and industrial constructions that badly influence on human organism. These changes in decoration materials occur under influence of different factors in result of various physic and chemical processes. Quality of air space environment can become worse as a result of work of domestic apparatuses, as well as sources of water and gas supply, use of furniture, made from polymeric materials, etc. Total load on air environment of buildings are raised also in a result of entering anthropogenic pollutions through ventilation systems of buildings. Chemical substances under influence of free radicals permanently generating in air environment of closed building, can be transformed with formation of more toxic compounds with change class of their danger. For estimation of degree of their influence on human organism it is necessary to make permanent control of the content of these chemical matters in indoor air of dwelling and industrial constructions with determination of local sources of their exhalation, as well as zones of their negative influence and diffusion. Such control permit to fulfill the plan measures on the certification of living and industrial buildings and their expert estimation with due regard for ecological risk factors. Kuznetsov A.G., P.N Snitko and V. A Ugarov, 1996 had proposed the method for reduction of radon danger of dwelling, public, domestic and industrial premises. They had recommended to use the generator with soft emission of electrons, which creates electrostatic field in buildings [2]. Experimental and field investigations on estimation of effective generator work show that during the first 0,5-1,0 hours after device engaging Rn reduction under real meaning of 1000-2000 Bq/m^3 occurs to background levels, don't exceeded PDK for living and working premises. Effect of the radon concentration reduction is connected mainly with depolarization of DDP aerosols with following precipitation in inner surface of constructions. Reduction of the equivalent equilibrium volumetric activity of radon isotopes in houses can be carried out by the way of remove short-living DDP from air environment with help of the generators with cold electrons emissions [2]. Use of these generators of electrons permits to reduce radon level in dwelling and official buildings to utmost possible level, when the level of the equivalent equilibrium volumetric radon activity reaches 1000 Bq/m^3 and more. Creation in living house the concentration of light negative oxygen air ions on the level of 1-50 thousand of electrons 3 ap/cm^3, together with reduction of level of radiation of air environment, have beneficial medical-prophylactic influence on a man. Electro energetic expenditures under continuous of twenty-four-hour exploitation of such generator don't exceed 20-30 kw/hour in month. Practically the question about possibility to use those or other materials for dwelling buildings, if there no houses, built from them can be solve by experimental way. From given materials a model of a wall or an overhead cover must be built. They must be covered with proper plaster, oil paint or white washing and then specific radon exhalation must be measured. Don't exclude, in particular, that building material will be possible to use only under painting them with oil paint or other cover materials. Treatment of data of accompanying measurements will permit to clear up the question about the levels of radon exhalation by different build materials and about radon sources (radon exhalation from walls and radon diffusion from soil through a floor). Such researches will permit to work out measures, providing levels of radon concentration in dwelling houses don't exceeding maximum permissible level.

Application of sufficiently economical methods of protective measures and their wide introduction will allow sharply reduce the doze which depend on daughter radon products. Criteria of necessity of protection measures must be used for determination of the priority order of measures in different buildings.

Financial support was provided of the European Union by the project STCU # 2431.

REFERENCES

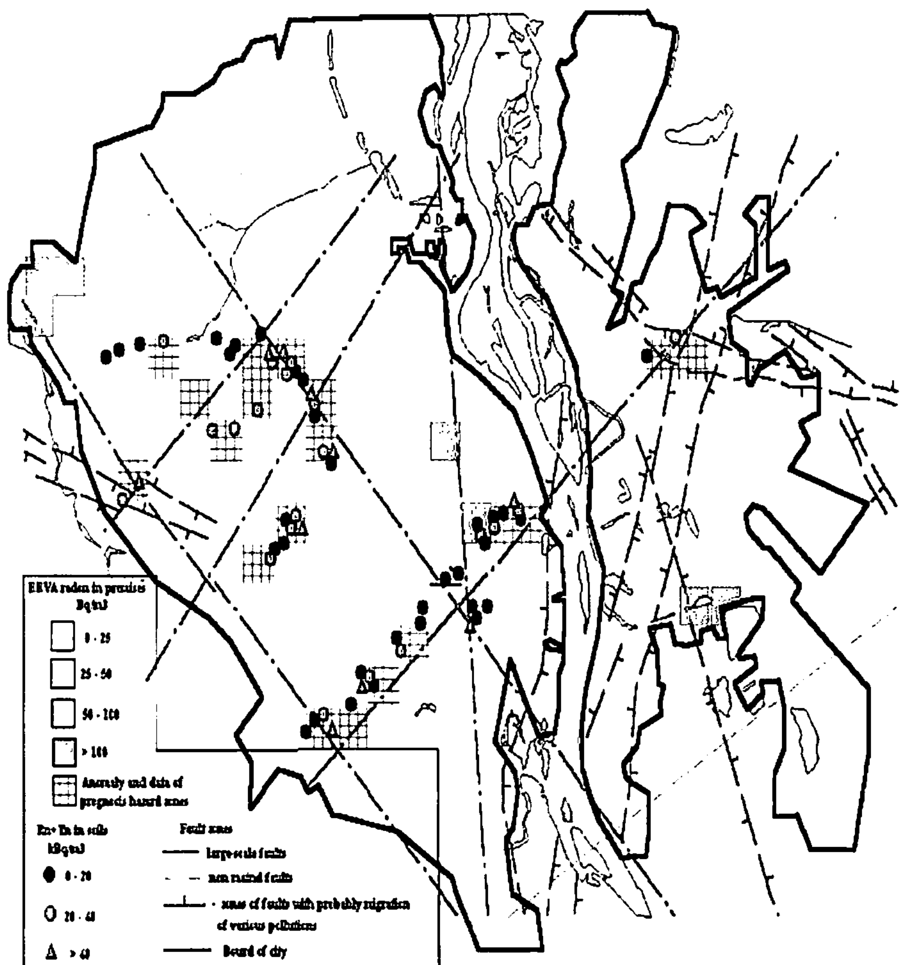
1. Krisjuk A.M., Ivanov S.I, 2000. Priority problems of maintenance of radiation safety. J. ANRI, №3: 54-64.

2. Kuznetsov A.G., P.N Snitko and V. A. Ugarov, 1996. Hazard reduction of the radon of locations with the help of generators with cold issue of electrons. J. ANRI, 2: 18-22.

3. Pavlenko T. A., P.I. Los and N.V. Aksenov, 1996. Indoor radon and irradiation doses in the territory of the Ukraine. Radiation Measurements. 26: 585-591

4. Recommendations for the implementation of Title VII of the European Basic Safety Standards Directive (BSS) concerning significant increase in exposure to natural radiation sources. Radiation Protection No 88, European Commission, Luxembourg, 1997. 3

5. Shnitkovskjy A.F, 2000. Safety of residential buildings for want of of increased concentration Rn in locations. J. Seismic stability construction, 2: 36-37.



National Estimate of soil and Indoor radon concentration in city Kyiv

Figure. Radon in City Kyiv