purification of drinking water from iron are established. It is established that in the range of zeolite, thermally activated at a temperature of 300 °C characterized by the highest adsorption capacity. It can be used to clean drinking water from iron ions. It has been established that natural zeolites can successfully replace activated carbon to purify drinking water. Chemical activation of the natural sorbent contributed to an increase in the rates of water purification. It is revealed method of activation with hydrochloric acid in the shuffle mode is the most effective according to the activity of the zeolite impact. 7% of HC1 is selected for optimal activation conditions, processing time is 2 hours. It is advisable to use hydrochloric acid for treatment of zeolite in the ratio of solid phase: liquid = 1: 2. Dynamical exchange capacity is the main indicator which characterizes the quality of water purification. In particular, the dynamic exchange capacity increased more than twice in clinoptilolite chemically activated with 7% hydrochloric acid.

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RADON DURING THE HEATING OF DWELLING HOUSES BY NATURAL GAS

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ABSTRACT

The equivalent equilibrium volumetric activity of radon in dwelling houses, located in permafrost regions, equipped with the heating boilers operating on natural gas and located inside the residential sector of houses are investigated. Allocation of radon from wooden walls, other constructions of houses and underground space is improbable. Hence, high variations of volumetric concentration of radon in different houses are caused, mainly, by burning of methane. It is established that in houses equipped with heating boilers with low efficiencies or having a bad thermal insulation of walls the equivalent equilibrium volumetric activity of radon may be close to permissible level of radon concentration for buildings under construction equal to 100 Bq/m^3.

Keywords: the radon, equivalent equilibrium volumetric activity, a heating boiler, natural gas, dose loading.

INTRODUCTION

It is known that uranium is mainly distributed in the Earth's crust and often accompanies hydrocarbon deposits, namely, oil and natural gas. In there are instructions that radon is isolated from natural gas, but there are no regular researches on measurement of radon isolated when heating with natural gas of dwelling premises [1], [2].

The presented work is devoted to an urgent theme of research of radon under conditions of a long-term permafrost. The urgency of research consists in the fact that radon measurements in dwelling houses provided with a network gas heating in Yakutia were not carried out.

The basis for this work is experimental researches done earlier by definition of VA of radon in unheated premises (26±12 Bq/m^3) and in a house with oven heating (18±8 Bq/m^3) that is, on the average, less by 3,4 times than indications in the investigated houses with a gas heating [3].

Materials and methods

The village of Oy is the center of Nemyuginsky settlement (nasleg) of Khangalassky district (uluus), it is located on the left coast of the river Lena, at a distant of 68 km above Yakutsk and at a distant of 7 km below the district's center of Pokrovsk. The area of village's territory is 1344,69 km^2, the population is 2247 persons [4]. The existing housing estate consists of wooden houses. All dwelling houses are gasified, during 30 years there operates Khangalassky Gazstroy JSC engaged in gasification.

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The climate of Khangalassky uluus is sharp-continental characterized by very low winter and high summer temperatures. The Khangalassky uluus is in a permafrost zone. The average monthly temperature of air in January is -40°C, in July – beginning from +19ºC. The duration of the period with negative temperatures is approximately 7-8 months. Annually precipitations fall out at the rate of about 200-350 mm [5]. The type of soil is sandy loam. The depth of summer thawing of the soil is from 80 to 150 cm [4].

Results of investigations of volume activity of radon in six premises equipped with the following popular models of gas boilers: KChM-5, AOGV, KSG-7, KSG-10, KSG-12,5 and Wolf are presented. All investigated premises are private one-storeyed dwelling wooden houses built of larch with cellars equipped with small ventilation windows to avoid formation of fungi in premises, without preservation of permafrost in the basis. One can assume that the radon allocated from a ground does not accumulate indoors because of ventilation under a floor of house. But because of winter extreme cold weather a house's cellar is not aired for the December to February period. In all investigated houses gas boilers are located in kitchens and have no separate extensions for boilers.

In the house located in 33, Khangalassky street measurements were carried out from 2012 to 2016 where from 2012 to 2014 the house was equipped with the universal gas KChM-5 boiler, then in 2015г the KChM-5 boiler was replaced with the gas KSG-12,5 boiler. In the house located in 77, the Reyevs brothers Street and equipped with the universal AOGV boiler, the measurements were carried out from 2012 to 2016. In the house located in 3, Victory street and equipped with the German gas boiler Wolf the measurements were carried out for the period from 2012 to 2016. From 2014 to 2016 the measurement were carried out in the house located in 29, Khangalassky street where the universal gas KChM-5 boiler was placed. In 2017 for the January to May period the measurement were carried out in private houses to the following addresses: 22, Lenin Street, 4 Gorky Street in which boilers of KSG-10 and KSG-7 are used, respectively.

Measurement results

In this paper the results of long-term measurements of volume activity (VA) of radon in dwelling houses with gas heating are presented.

The measurements were carried out with the device – a radiometer of radon Alpha Guard PQ2000 (manufacture of Germany) which was installed near boilers and it directly measured radon in the air of a premise. Continuous measurements were carried out during a heating season from September till May: 4 days a month in each investigated premise moving the device from one house to another one. Tables 1-3 present results of measurement of VA of radon for the whole investigated period.

Equivalent equilibrium volume activity (EEVA) of radon for a nonequilibrium mixture of short-time affiliated products of decay in the air is called a volume activity of radon. It is in balance with affiliated products of decay which has the same value of latent energy, as well as the given nonequilibrium mixture. It is calculated by the following formula [6]:

$$EEVA_{Rn} = VA_{Rn} \times F, \text{ Bq/m}^3 \quad (1)$$

where VA_{Rn} is a volume activity of radon, F is a balance factor between radon and products of its decay which can accept values from 0 to 1. In the absence of

experimental data about a mean value of this factor, it is accepted as F=0,5. The given value has been used in this work.

It must be considered in the design of new buildings of housing appointment that the level of EEVA of affiliated products of radon in air of premises is not more than 100 Bq/m^3, and in the dwelling houses is not more than 200 Bq/m^3 [7].

From 2012 to 2017 the measurement were carried out on the universal KSG-5 boiler and on the KSG-12,5, KSG-10, KSG-7 gas boilers. The data of the measurements are presented in Table 1.

Table 1 - Results of measurements of radon on the KChM-5, KSG-12,5, KSG-10, KSG - 7 gas boilers

Year	Type of gas boiler (address of the premises)	VA ^{222}Rn, Bq/m^3	Mean value of VA	Standard deviation	Temperature, °C	Pressure, mbar	Humidity, %
2012-2013	KCHM-5 (Khangalasskiy street, 33)	max:=95±29 min:=17±8	53,4	17,3	max:=22 min:=20	max:=999,0 min:=998,7	max:=15 min:=12
2013-2014	KCHM-5 (Khangalasskiy street, 33)	max:=80±25 min:=29±11	59,1	14,7	max:=21 min:=20	max:=1000,0 min:=999,8	max:=15 min:=14
2014-2015	KCHM-5 (Khangalasskiy street, 29)	max:=75±23 min:=17±8	57,8	12,9	max:=20,8 min:=19	max:=1001,5 min:=1000,2	max:=16 min:=12
2015-2016	KCHM-5 (Khangalasskiy street, 29)	max:=98±30 min:=18±8	76,6	16,1	max:=26 min:=23	max:=1008,4 min:=1008,1	max:=18 min:=7,4
2015-2016	KSG-12,5 (Khangalasskiy street, 33)	max:=47±16 min:=13±7	36,8	7,5	max:=21 min:=20	max:=1002 min:=1001,2	max:=15 min:=13
2016 (september-december)	KSG-12,5 (Khangalasskiy street, 33)	max:=47±16 min:=7±5	38,5	8,2	max:=21,5 min:=20,5	max:= 1000,1 min:= 998,5	max:=17,1 min:=12,4
2017 (january-may)	KSG-10 (Lenin street, 22)	max:=73±24 min:=17±8	50,6	15,7	max:=23,5 min:=22	max:= 1021,3 min:= 1020,1	max:=10,6 min:=1,7
2017 (january-may)	KSG-7 (Gorkiy street, 4)	max:=103±32 min:=21±10	67,2	20,9	max:=10,8 min:=10,3	max:= 1020,3 min:= 1018,2	max:= 2,3 min:= 1

Observation results of volume activity of radon are almost twice as high as for the KSG-7 gas boiler and the universal KChM-5boiler than for the KSG-12,5 have been obtained. From 2012 to 2016 the measurements were carried out on the universal AOGV boiler in the premises of 77, the Reyevs Brothers. The data of measurements performed are shown in Table 2.

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Table 2 - Results of measurements of radon on gas AOGV boiler

Year	Type of gas boiler	VA ^{222}Rn, Bq/m^3	Mean value of VA	Standard deviation	Temperature, °C	Pressure, mbar	Humidity, %
2012-2013	AOGV	max:=150±46 min:=66±21	91,1	14,1	max:=21 min:=20	max:=999,1 min:=998	max:=15 min:=14
2013-2014	AOGV	max:=166±49 min:=25±10	86,1	14,4	max:=22 min:=20	max:=1000,1 min:=999,5	max:=16 min:=14,5
2014-2015	AOGV	max:=229±53 min:=37±13	106,4	23,4	max:=21 min:=20,8	max:=1001,1 min:=999,8	max:=16 min:=15
2015-2016	AOGV	max:=197±51 min:=37±13	112,4	43,7	max:=21,2 min:=20,5	max:=999,8 min:=998,7	max:=14 min:=13,8
2016 (septe mer-decem ber)	AOGV	max:=117±32 min:=18±8	79,5	27,2	max:=21,5 min:=11,4	max:=1011,4 min:=1011,1	max:=12 min:=11

It is seen from observations that EEVA of radon is at the level of maximum permissible concentration of radon for new buildings, and below permissible level for exploited buildings. If we assume that the main source of radon indoors is burning of natural, then the following factors can be the reason of high values of radon VA radon in dwelling houses are:

1. Models of gas boilers, the low efficiency of a boiler leads to the increase of volumes of consumed gas that is connected with the corresponding increase of radon content indoors.

2. Bad heat insulation of a house because of the high leakage of heat leads to the increase of consumed gas volumes.

Since 2012 of measurement were carried out in premises equipped with German the Wolf gas boiler in premises located at the address: 3, Victory Street. The data of the measurements carried out are shown in Table 3.

Table 3 - Results of measurements of radon on the Wolf gas boiler

Year	Type of gas boiler	VA ^{222}Rn, Bq/m^3	Mean value of VA	Standard deviation	Temperature, °C	Pressure, mbar	Humidity, %
2012-2013	Wolf	max:=126±36 min:=66±21	83,3	10,3	max:=21 min:=20,8	max:=1010,0 min:=1009,2	max:=16 min:=15
2013-2014	Wolf	max:=56±20 min:=29±11	45,3	8,3	max:=20,9 min:=20,5	max:=999,3 min:=998,2	max:=15 min:=14,5
2014-2015	Wolf	max:=79±24 min:=33±13	58	11,1	max:=21 min:=20,6	max:=1002,3 min:=999,3	max:=15 min:=14,2
2015-2016	Wolf	max:=85±26 min:=29±11	59,4	18,4	max:=20,9 min:=20,3	max:=1000,6 min:=999,3	max:=16 min:=15,3
2016 (septe mer-decem ber)	Wolf	max:=95±29 min:=22±9	70	22,5	max:=21,1 min:=30,1	max:=1002,3 min:=1001,5	max:=12 min:=10

In Tables 1-3 the maximum results of radon VA have been obtained for the October to January period during the operation of automatic switch –on and switch-out of the boiler. By results of observations it is seen that EEVA of radon does not exceed the ultimate permissible concentration.

On schedules the average values of OAP by months by all kinds of the investigated coppers for the investigated period about 2012-2017 (figures 1-5) are visually presented.

Figure 1 - Results of radon measurements for 2012-2013.

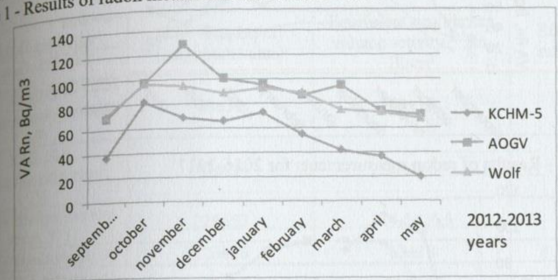

Figure 2 - Results of radon measurements for 2013-2014

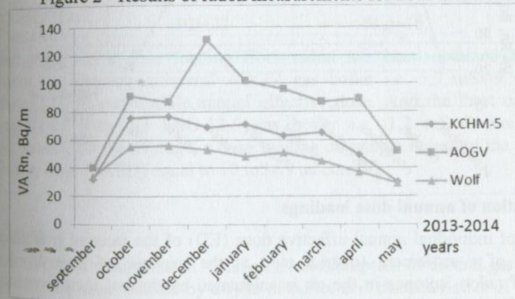

Figure 3 - Results of radon measurements for 2014-2015

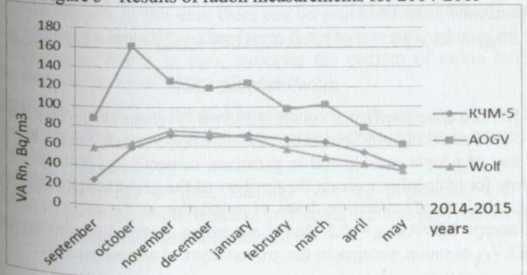

Figure 4 - Results of radon measurements for 2015-2016

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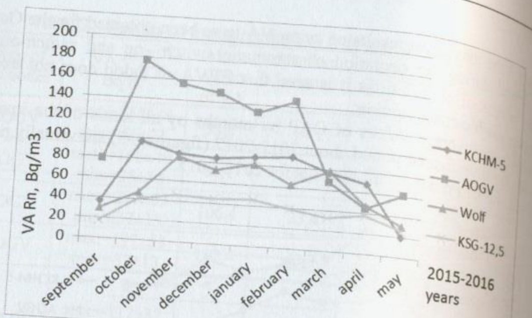
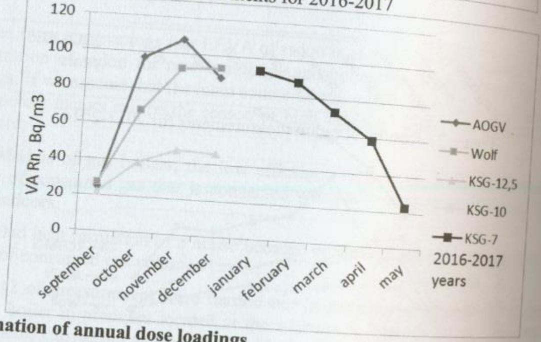


Figure 5 - Results of radon measurements for 2016-2017



Determination of annual dose loadings

The value of individual annual effective dose (ED) of the internal irradiation of adult inhabitants of a settlement (district etc.) at the expense of short-lived subsidiary products of radon isotopes in the air is calculated by data of measurements of radon isotope EEVA in the air of premises and atmospheric air on the territory of a settlement (district, etc.) by the formula [8]:

$$ED_{Rn} = 9.5 \times 10^{-6} \times 6552 \times (0.2 \times EEVA_{street} + 0.8 \times EEVA_{house}), \text{ mSv/9 months,} \quad (2)$$

where $9{,}5 \cdot 10^{-6}$ is a dose coefficient (in units (mSv·m^3) / (hour·Bq)); 6552 is a quantity of hours per a cold season (from September, 1st till May, 31st); 0,2 and 0,8 are a share of time of a stay of people outside and in premises, respectively; if there are no data on EEVA values for atmospheric air on the territory of the given settlement (district, etc.), then for calculations of irradiation doses of population at the expense of this factor it should be accept $EEVA_{street}$ = 6,5 Bq/m^3 according to the data about average world values of EEVA of radon isotopes in the ground layer of atmospheric air.

In a radiation hygiene it is customary to calculate doses by the greatest possible variants under real vital conditions. So, using data from Tables, we make calculations for the maximum volumetric concentrations of radon.

By means of the obtained data, the annual dose loadings in the given settlement have been calculated by the formula (2). Results of calculations are presented in Table 4.

Table 4 – Dose loadings in the investigated houses

Type of gas boiler (house addresses)	VA ^{222}Rn, Bq/m^3 (maximum value)	Equivalent equilibrium volume activity ^{222}Rn, Bq/m^3	Effective dose, mSv/9 months
KCHM-5 (Khangalasskiy street, 29)	98±30	49±15	2,5
KSG-12,5 (Khangalasskiy street, 33)	47±16	23,5±8	1,2
AOGV (Bratya Reevux street, 77)	229±53	114,5±26,5	5,7
Wolf (Pobeda street, 3)	126±36	63±18	3,2
KSG-10 (Lenin street, 22)	73±24	36,5±12	1,9
KSG-7 (Gorkiy street, 4)	103±32	51,5±16	2,6

The greatest result on a dose loading from radon has been obtained in premises equipped with the Russian universal AOGV gas boiler i.e. 5,7 mSv/9 months that accounts for a half of permissible annual effective dose. And the least one – in the premises equipped with the KSG-12,5 gas boiler i.e. 1,2 mSv/9 months. In all investigated houses, on the average, a dose loading on people is less of the permissible annual effective dose (PAED) equal to 10 mSv/9 months [9].

CONCLUSION

Based on the obtained data, one can assume that consumption of natural gas for heating of premises in some cases caused by a type of boiler and characteristics of the thermal insulation of houses can lead to the excess of permissible level of EEVA of radon for built houses (100 Bq/m^3). In this case there can be situations when consumers have the house with a bad thermal insulation that forces them to increase volumes of natural gas consumed on heating. Which in turn, increases the content of radon indoors up to comparable level with permissible one of radon.

Under condition of a sufficient thermal insulation of walls and use of economical gas boilers the level of radon activity can be decreased several times in comparison with permissible level.

Further complex researches of dose loadings onto the population with radon are necessary, when gasifying of rural districts in Yakutia for various types of gas heating boilers and heat insulant indicators of buildings.

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It is recommended for heating of apartment houses by natural gas to build separate boiler-houses for heat boilers. It is recommended to place gas stoves for cooking in a separate ventilated room for kitchen.

This work gives a validity of necessity for further more profound research on this theme for a lot of gas coppers, and also the additional measurements of VA of radon in apartment houses with oven and a central heating of buildings under the conditions of Yakutia are necessary.

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REDUCING THE IMPACT OF CIVIL AIRCRAFT ON THE ATMOSPHERE DUE TO FUEL EFFICIENCY IMPROVING

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ABSTRACT

The impact of civil aviation objects on the environment is characterized by a number of features related to the fact that this kind of anthropogenic activity is rapidly developing, taking on increasing importance in humanity`s life. Also, civil aviation is one of the most important connecting elements of international relations. Improving the efficiency of fuel resources applying, which is one of the priority directions for the country's economy development, increases the environmental safety of the investigated objects, including civil aviation facilities. Moreover, this improving leads to positive economic effect. To analyze the impact of civil aviation facilities on the atmosphere were used methods of scientific generalization, modeling, comparative analysis and the statistical method.

As a result of the research, the main fuel consumption objects and air pollutants were identified on the airport area. These objects include aircraft engines; special vehicles; motor transport; boiler rooms, etc. The average amount of main pollutants, which entering the airport's monitored area per day, has been established. It is noted that this amount of harmful substances under unfavorable meteorological conditions can lead to a significant excess of the maximum permissible concentrations of the pollutants in the airport`s work zone.

The main characteristic feature of the aircraft operation is an altitude of the flights, which is 8-13 km and causes the possible impact of emissions from the aviation fuel combustion on the climate system of the Earth. It was calculated the emission of the main greenhouse gas - carbon dioxide, which is released during the aircraft operations. The calculation was carried out using standard methods, which are approved in Russia. The processing of these data was the basis for modeling the dependencies of carbon dioxide emissions on fuel consumption by the aircraft engine for various phases of the takeoff and landing cycle. It was found that the greatest amount of emissions is released on the climb phase. The factors that contribute to reducing emissions of pollutants and the fuel efficiency improving of civil aviation were analyzed. Compliance with these factors will save a significant amount of fuel.

Keywords: impact on the atmosphere, civil aviation, pollutants, greenhouse gases, fuel efficiency

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