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Indoor air quality of residential buildings and child welfare institutions in winter in Armenia

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The problem of indoor air is extremely urgent in Armenia, the country that due to several reasons, such as the destructive earthquake, transport and economical blockade by Turkey and Azerbaijan, the transfer to the market relations etc., is in a hard socioeconomic situation now.

In the last decade the industrial and agricultural production 5-6 times decreased. The entire system of services is ruined. For example, the central heating of residential and public buildings actually ceased in practice. Mass unemployment began. The increase of prices for the fuel and electricity, raw materials, as well as the cost of foodstuffs, goods of every day use and services have brought to abrupt decrease of the incomes of the government and the population, the vast majority being beyond the level of poverty.

The social tension especially increases in a period of long lasting winter (4-6 months), when there is the necessity to warm the apartments, production areas, offices, institutions and enterprises. Due to the high cost, the overwhelming part of population (80%), as well as many state institutions (schools, hospitals, places of entertainment, enterprises, etc.) cannot pay for heating of the indoor air. The use of local heating appliances functioning with the help of liquid fuel (kerosene, diesel fuel, gasoline, etc.) in residential and office areas, classrooms at schools, hospital wards and so on without stumps or ventilation hoods is hygienically unavailable, as the toxic products of burning remain in the indoor air. When the stoves for burning solid fuel are used, the removal of by-products outdoors is of low efficiency, as the smoke, gases and dust blown outdoors penetrate backwards through the untight cracks in the upper stairs of the buildings, polluting additionally the indoor air. As the use of both liquid and solid fuels is of low availability due to the high cost, the warming of the indoor air with the use of local heaters is usually done in one or two rooms. This brings to the high "density" of people in small area, creating favorable conditions for respiratory diseases. Besides, the number of smokers has extremely increased in the recent period, bringing to high tobacco smoke level in passive smokers. In these small rooms the meals are also prepared, the fact increasing the air humidity. The economically unprovided families (20-25%) have no means enough to purchase the fuel for warming their homes and to pay electricity bills and are forced to burn all flammable materials: wood treated by chemicals, paper, cartoon, tires, domestic and industrial wastes, polymers, plastics, worn old shoes and clothes, organic solvents, cables, transformer and technical oils. The releasing by-products of these types of fuel may be presented by rather harmful substances (dioxins, PCBs, lead, nitrogen and sulfur oxides, etc.). Thus the transition from central heating to the local with the use of liquid and solid materials as fuels creates conditions for pollution of the indoor air of residential and public buildings by toxic substances. In such conditions the normal microclimate is not achieved. In many cases the air temperature does not achieve the optimal level. The air humidity in unventilated rooms is increased.

Low temperature, high humidity and air dust content, the presence of chemical and biological harmful factors in the air, as well as the droplet infections penetrating from the outdoors, have brought forth the increase of respiratory and cold-related diseases and worsening of the indices of the health status. As an example, we can compare data on morbidity due to acute respiratory diseases in the inhabitants of the earthquake zone, who reside mainly in half-ruined and self-destroying houses with the similar information from the region of Vayots Dzor, where the central heating has been preserved. The indices in the earthquake zone were 2 times higher than those in Vayots Dzor as it is demonstrated in fig. 1.

Our researches on the indoor air evaluation were car-

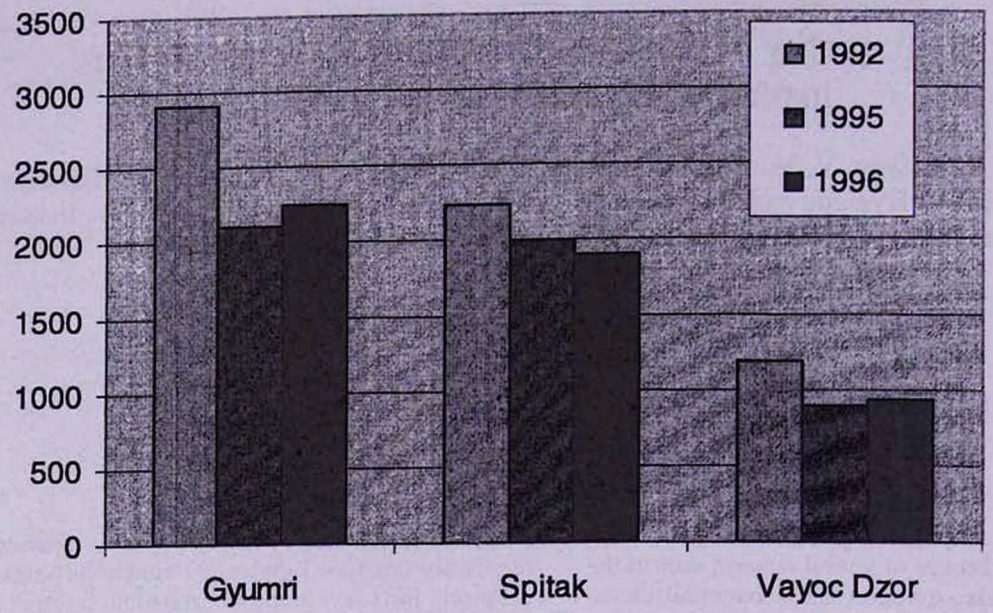

Fig. 1. Respiratory diseases morbidity indices in winter 1992, 1995, 1996 (per 10.000 people)

ried out in winter 1994, in a period of extreme crisis of electricity supplies, when the population and institutions were totally deprived or supplied with electrical energy only 2 hours a day. Then we continued the study in 1998, when the energy production was normalized, and the Armenian Nuclear Power Plant was restarted, that is in the conditions, when there was no deficiency of electricity. The study was held in towns of the earthquake zone, where 25 thousand families still live in temporary metallic or wooden dwellings, as well as in 2 other towns not suffering the destructions of the earthquake. Besides the measurements of temperature and humidity, the determination of the contents of air dust, carbon monoxide, nitrogen oxides, lead, streptococci, mold and yeast fungi was performed.

We analyzed the data on morbidity due to respiratory diseases in inhabitants residing during the whole winter in conditions of cold and polluted indoor air in 1996.

The results of the study are the following: data presented in table 1 and 2, summarizing the results of 240 measurements, demonstrate that the air temperature was not optimal in all the examined residential and public buildings. Low temperature level varied from 7°C to 10° C, while the upper levels were 11–15°C. In rare cases it reached 17°C.

Table 1

Air temperature and relative humidity in residential houses in winter

Index	December 1994		February 1998			
	Yerevan	Byureghavan	Yerevan	Byureghavan	Gyumri	Spitak
Air Temperature	7-12,6	8-11,5	10-16	8-13	7,5-12	9-13,5
Relative Humidity	71-78	66-72	63-73	66-74	69-75	71-80

Table 2

Air temperature (^{0}C) in public and governmental buildings

Buildings	December 1994		February 1998			
	Yerevan	Byureghavan	Yerevan	Byureghavan	Gyumri	Spitak
Kindergarten	12,6-17	12-15-5	14-17	13-15	12-15	11-14
Schools	10-14	11-15	9-13	11-14	12-15	11-13
Hospitals, Clinics	9-13,5	10-11,6	12-15	11-13	12-16	11-13
Governmental buildings	12-14	–	11-17	–	–	–

The relative air humidity varied in all the examined rooms, and was higher than that of the outdoor air. In the temporary houses the humidity exceeded the level of the outdoor air to 18-20%, reaching the level of 75–80%.

Air temperature was a little higher in the kindergartens, at schools, in medical and state institutions, but it was still significantly (by 2-3°C) lower than the optimal one. Thus, in spite of the local heater's type and the fuel used, the unfavorable cool microclimate was created in the residential buildings.

The results of 100 samples analyzed for air dust content are presented in fig. 2. Data obtained demonstrate that dust air concentration significantly (up to 4 times) exceeds the permissible level, especially in residential buildings, kindergartens and schools.

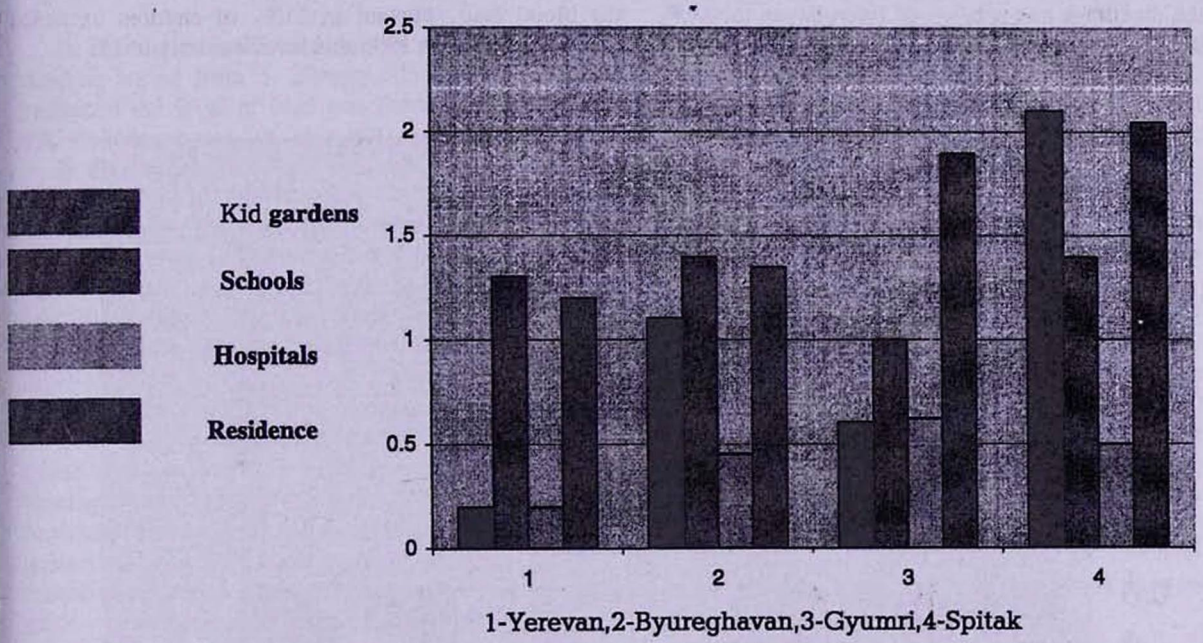

Fig. 2 Average dust content in the air of residential and public buildings

The results of our study on the carbon monoxide and nitrogen oxides are summarized in fig. 3. While the carbon monoxide content was mainly almost normal, the concentration of nitrogen oxides exceeded in some cases the allowable level.

In the earthquake zone (Gyumri, Spitak), as well as in Byureghavan town lead was found in the air and settled dust on the inner surfaces of residential and school buildings.

The sources of lead in the earthquake zone, probably, were the crumbled chips of the lead containing paints that, despite the prohibition, were used for painting inner surfaces.

The analyses of 26 samples of paint chips from these buildings showed that in the main the lead content was 1.3-2.4%, while in Yerevan (64 samples) the lead content varied from 0.3 to 0.5%. Another source of lead in the earthquake zone temporary dwellings was the ethylated benzene frequently used as fuel for heating by means of Primus stoves.

In other towns of Armenia the presence of lead in the indoor air and settled dust samples was mostly connected with the outdoor air polluted by lead from the transport-related and industrial emissions. For example, in Bureghavan the lead penetrated from the large crystal plant situated near the inhabited area and school.

In 26 samples of settled dust wipes from the inner surfaces of the dwellings and schools of Bureghavan the average lead content, determined by Atomic Absorption Spectrometry, varied from 420 to 1050 *mcg/m*^{2}. In 8 air samples from the dwellings near the crystal plant the average lead content was 0.8 *mcg/m*^{3}. In the air samples from the classrooms the lead content was 415-462*mcg/m*^{3}. In the school dining room it varied from 360 to 760 *mcg/m*^{2} in surface wipe samples. In the bedrooms it was in the range of 380-1300 *mcg/m*^{2}, in the flats not far from the plant lead level – 800-1700, in the shops and at the polyclinic – 1100-1200 *mcg/m*^{2}.

In Yerevan, where there were no industrial and transport emissions in that period, in 46 samples the lead content in residential buildings, offices and hotels was 150-1100 *mcg/m*^{2}.

In 7 samples from the earthquake zone (towns Gyumri, Spitak, Akhuryan) the lead content in settled dust wipes was in the range of 200-700. But in this zone there were no industrial emissions, and the automobile releases were 2-3 times less.

In Yerevan the determination of blood lead content in children and adults residing in the conditions of lead polluted air revealed the following. In 1992, when the autotransport was not functioning in practice, and the city was not supplied with the electricity, all the buildings were heated with the use of liquid or solid fuels, the lead content in blood samples of children varied from 2 up to 18 *mcg/dl*. In 1995, when some buildings were heated by electricity, the lead content was somehow lower. In 1992 the blood lead content in 21% of children exceeded 10 *mcg/dl*, while in 1995 this level was only in 11.

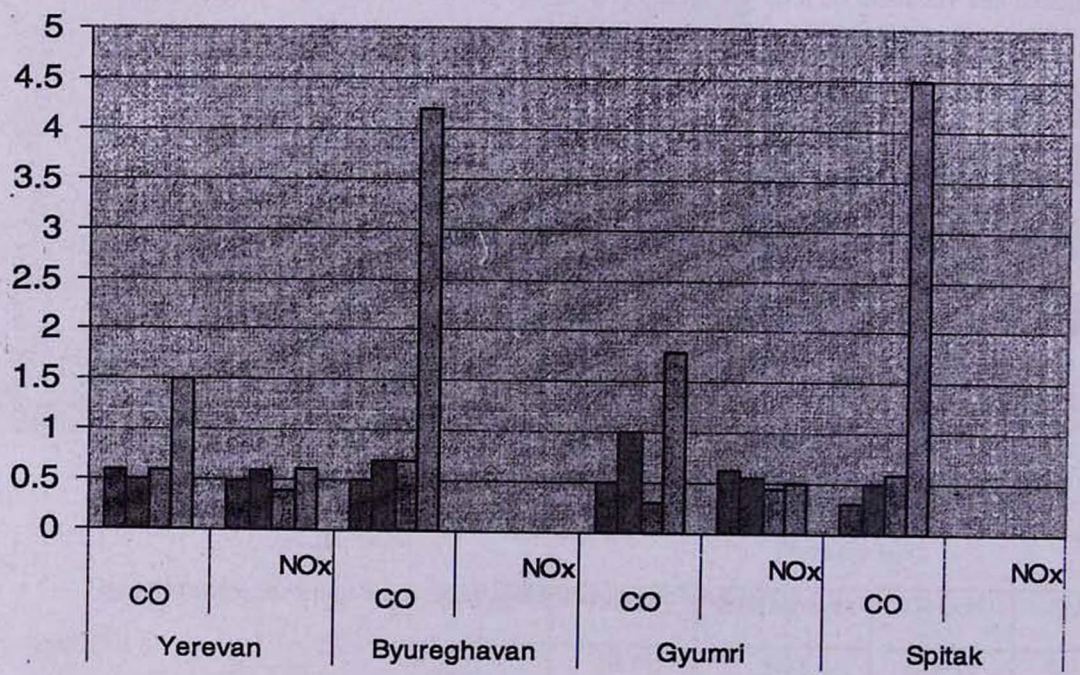

Fig. 3 Average content of toxic substances in the air (*mg/m*^{3})

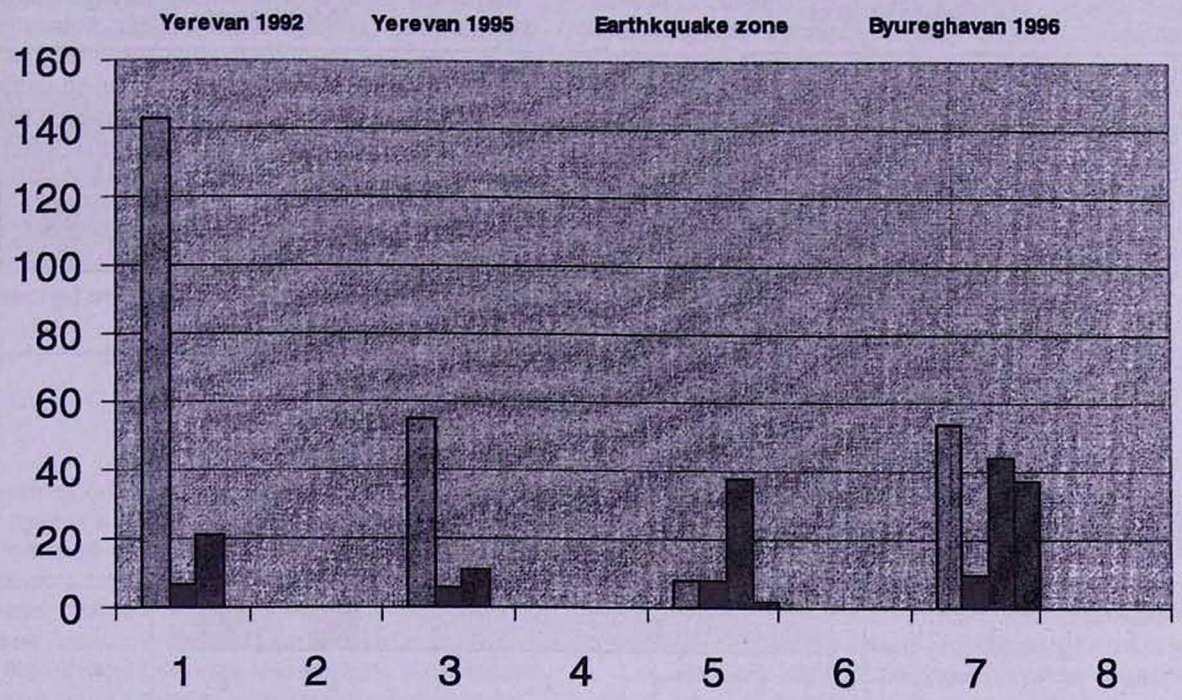

Fig. 4. Blood lead levels in children (*mcg/dl*)

In Byureghavan the lead content in blood samples of children varied from 3- 22mcg/dl.In the 44 % of those examined the level of lead was more than 10mcg/dl. In 4% the lead content was above 20 *mcg/dl* (fig.4).

In the earthquake zone in 2 out of 8 children the content of lead was above 20 *mcg/dl.*

And finally, the examination of 47 adults from Yerevan and Byureghavan revealed that the lead content was mainly up to 20 *mcg/dl.* In 12 individuals the lead content was 20-30 *mcg/dl.* Thus, these data demonstrate that the indoor air is polluted by lead in residential, school and other buildings. That is one of the significant sources for lead accumulation in the human organism.

Summarizing the findings obtained it should be mentioned that as a result of economy and complete energy blockade in 1990-1996 and due to present serious socio-economic problems there is a negative effect on the organization of heating in residential, public and state institutions in Armenia. The lack of national fuel resources has made Armenia pass from the central heating to the local one. Besides the traditional types of fuel (gas, oil, coal, wood) there was a wide use of different other types of fuel, bringing forth emissions dangerous for human health. The local heating was performed in high-storied buildings not intended for it (without chimneys, ventilation systems, etc.). This resulted in accumulation of toxic substances, dust and humidity, microorganisms and fungi in the heated rooms (fig. 5). As a result the aim to create normal temperature conditions was not achieved. The air temperature remained below the optimal one, while the quality of indoor air became worse. For example, the higher indices of morbidity by respiratory diseases and elevated blood lead levels signify the probable unfavorable effect on the health status in humans.

A very serious threat to the human health is presented by the use of different wastes and materials as fuel. The burning of these is fraught with the danger of formation of harmful substances, – sulfur oxides, dioxins, PCB, etc.

The most effective measures to prevent worsening of indoor air in winter in Armenia are the complete restoration of central heating and the refuse to use local heaters, despite the type of fuel. This will also favor the creation of normal microclimatic conditions.

The liquidation of temporary dwellings used also as schools and other public institutions will allow us to solve the problem of indoor air quality, the problem of heating and prevention of the harmful action of chemical and biological factors.

The real steps in this respect have been already successfully carried out. 25 thousand families and 40 thousand schoolchildren will be provided with new buildings and all modern conveniences in 2-3 years.

Besides the governmental support, the awareness of population about the danger of using the flammable domestic and industrial wastes is also of great importance. Without having information that some transformer oils

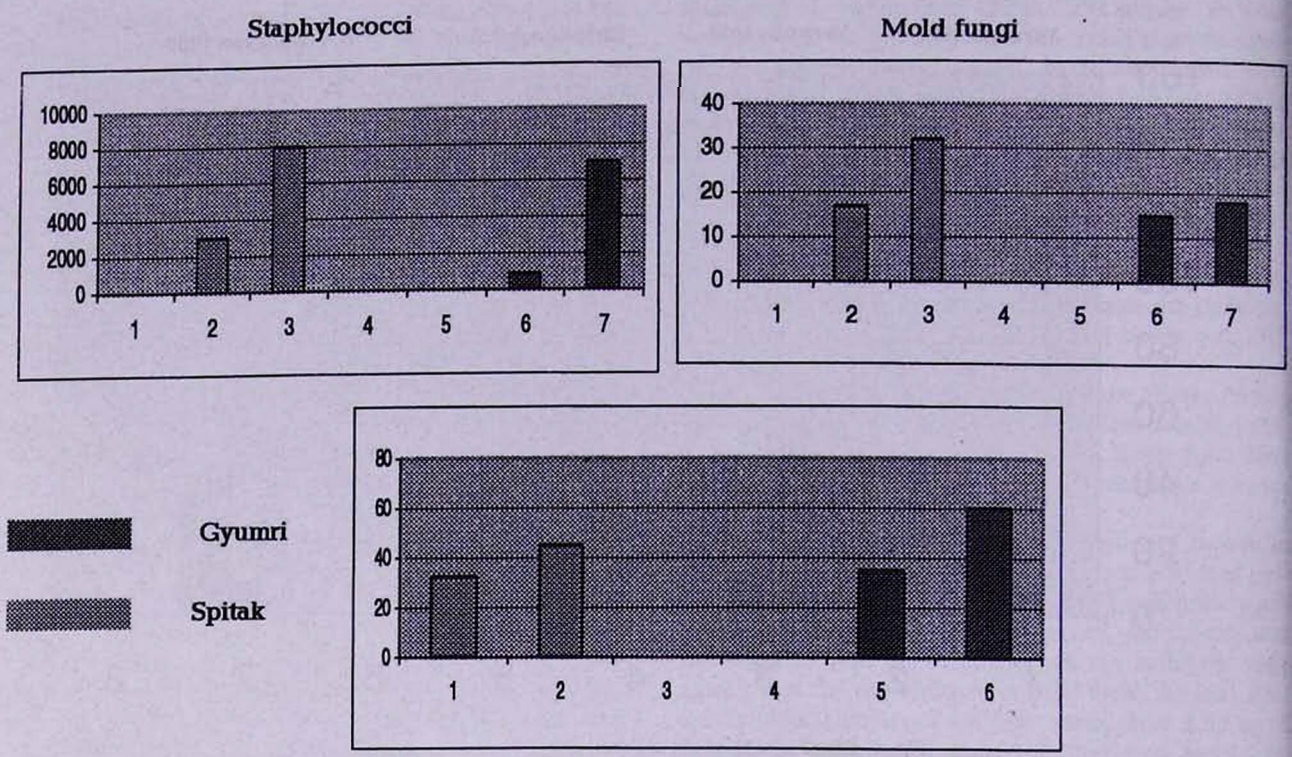

Fig. 5. Quantity of staphylococci and fungi in the residential air(in $1m^3$)

contain PCB, tons of this oil were burnt as a fuel for heating. People used the garbage as a fuel, being unaware that burning of domestic wastes is connected with the formation of highly dangerous chemical compounds.

A significant effect can be also achieved in result of fighting against smoking in offices, public institutions and residences. This problem remained unsolved for a long period of time. At last a National Program is established against such a dangerous habit as smoking. Now smoking is prohibited in offices and public institutions. A wide educational activity is dedicated to increase the awareness of general population.

Mass information on hygienic and ecological problems will facilitate the prevention of air pollution in general and the improvement of the indoor air quality, in particular.

Հայաստանում հասարակական և մանկական հիմնարկների շենքերի ներսի օդի որակը ձմռանը

Է. Բաբայան, Վ. Կաֆյան, Վ. Մադոյան, Լ. Մարյան, Ռ. Օհանյան, Ա. Հայրապետյան, Ս. Սկրտչյան

Վերջին տարիների տնտեսական և էներգետիկ ճգնաժամի հետևանքով կազմալուծվեց կենտրոնական ջեռուցման համակարգը, որի հետևանքով առաջացան լուրջ դժվարություններ բնակելի և հասարակական շենքերում օպտիմալ միկրոկլիմայական պայմանների պահպանման համար: Բնակարաններում, դպրոցների դասասենյակներում, մանկապարտեզների խաղասենյակներում և ննջասենյակներում, պետական հիմնարկներում օդի ջերմաստիճանը գտնվում է օպտիմալ մակարդակից 6-10^0C ցածր: Ջերմային ռեժիմի պահպանման համար օգտագործվում են տարբեր վառելանյութեր. նավ-

քամթերքներ, փայտ, քարածուխ, այրվող քիմիական նյութեր, ռետին, պոլիմերային նյութեր, կենցաղային աղբ, այրվող արտադրական թափոններ, ինչի հետևանքով նշված շենքերի ներսի օդը աղտոտվում է թունավոր նյութերով՝ ածխածնի օքսիդով, ազոտի և ծծմբի օքսիդներով այրված նյութերի փոշիներով և այլն: Ստեղծված անբարենպաստ իրավիճակը վտանգ է ներկայացնում բնակչության զգալի մասի առողջության համար, որը ծմռան շրջանում ենթարկվում է ցածր ջերմաստիճանների, թունավոր նյութերի և վտանգավոր կենսաբանական գործոնների՝ միկրոբների և սնկերի, երկարատև ազդեցությանը, ինչը բերում է շնչական օրգանների ախտահարումներով հիվանդացության բարձրացմանը:

Качество воздуха внутри зданий общественных и детских учреждений в Армении зимой

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Экологический и энергетический кризис последних лет привел к практическому парализу деятельности центральной отопительной системы, в результате чего возникли серьезные затруднения в обеспечении нормальных микроклиматических условий внутри помещений жилых и общественных зданий. В подавляемом большинстве случаев в квартирах, в классных комнатах школ, в игровых комнатах и спальнях детских садов, в помещениях государственных учреждений температура воздуха поддерживается на 6-10^{0}C ниже оптимального уровня.

Температурный режим внутри зданий общественных и детских учреждений поддерживается сжиганием горючих материалов: нефтепродуктов, древесины, угля, воспламеняющихся химических веществ, резины, полимерных материалов, бытового мусора, горючих промышленных отходов и пр., что приводит к загрязнению воздуха указанных помещений токсическими продуктами - окисью углерода, окисями азота и серы и пр., а также аэрозолью сгоревших материалов.

Создавшаяся неблагоприятная ситуация представляет угрозу для здоровья большой части населения, которая в зимний период подвергается длительному воздействию холодового фактора, токсических веществ и опасных биологических факторов, что приводит к повышению заболеваемости респираторными заболеваниями.

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