ISSN 0142-0843

ҚАРАҒАНДЫ УНИВЕРСИТЕТІНІҢ ХАБАРШЫСЫ

ВЕСТНИК КАРАГАНДИНСКОГО УНИВЕРСИТЕТА

БИОЛОГИЯ. МЕДИЦИНА. ГЕОГРАФИЯ сериясы

№ 2(66)/2012

Серия БИОЛОГИЯ. МЕДИЦИНА. ГЕОГРАФИЯ

Сәуір–мамыр–маусым
1996 жылдан бастап шығады
Жылына 4 рет шығады

Апрель–май–июнь
Издается с 1996 года
Выходит 4 раза в год

Собственник РГКП **Карагандинский государственный университет имени Е.А.Букетова**

Адрес редакции: 100028, г. Караганда, ул. Университетская, 28
Тел.: (7212) 77-03-69 (внутр. 1026); факс: (7212) 77-03-84.
E-mail: vestnick_kargu@ksu.kz. Сайт: http://www.ksu.kz

Редакторы *Ж.Т.Нұрмұханова*
Редактор *И.Д.Рожнова*
Техн. редактор *В.В.Бутяйкин*

Издательство Карагандинского государственного университета им. Е.А.Букетова
100012, г. Караганда, ул. Гоголя, 38,
тел.: (7212) 51-38-20
e-mail: izd_kargu@mail.ru

Басуға 26.06.2012 ж. қол қойылды.
Пішімі 60×84 1/8.
Офсеттік қағазы.
Көлемі 10,12 б.т.
Таралымы 300 дана.
Бағасы келісім бойынша.
Тапсырыс № 789.

Подписано в печать 26.06.2012 г.
Формат 60×84 1/8.
Бумага офсетная.
Объем 10,12 п.л. Тираж 300 экз.
Цена договорная. Заказ № 789.

Отпечатано в типографии издательства КарГУ им. Е.А.Букетова

Зарегистрирован Министерством культуры, информации и общественного согласия Республики Казахстан.
Регистрационное свидетельство № 1131–Ж от 10.03.2000 г.

МАЗМҰНЫ

Смағұлов Н.К. Редактордың сөзі 4

ТІРШІЛІКТАНУ

Ыбыраев С.С., Отаров Е.Ж. Өндірістік фактордың әсеріндегі жұмыстың ықтимал өтілі хризотил-асбестті бақылап қолдану көрсеткіші ретінде 6

Аманбекова А.Ұ., Ыбыраева Л.Қ., Әжиметова Г.Н., Жұмабекова Г.С. Хризотил-асбест өндірісі жұмысшыларында индукцияланған мутагенезді хромосомдық аберрацияны есептеу әдісімен анықтау 12

Пылев Л.Н., Васильева Л.А., Смирнова О.В., Агафонова М.В., Везенцев А.И., Гудкова Е.А. Хризотилдың кальцийленген талшығында канцерогенді белсенділікті төмендету мәселесі жайында 16

МЕДИЦИНА

Измеров Н.Ф. Хризотил-асбест және денсаулық 21

Кашанский С.В., Гринберг Л.М., Берзин С.А. Кәсіби қызметтің ісік мезотелиоманың дамуына әсері 26

Кочелаев В.А. Хризотилдың қолдануына қатысты асбест туралы ең жаңа халықаралық медициналық зерттеулер 31

Плюхин А.Е., Бурмистрова Т.Б. Асбест өндірісінде істейтін жұмыскерлердің асбестке байланысты болған өкпе аурулардың алдын алу және айықтыру жолдарын жетілдіру...................... 36

Кашанский С.В., Берзин С.А. Свердлов облысы Асбест қаласындағы ер адамдардың өкпе ісік ауруларының динамикасы.................................. 40

Кундиев Ю.И., Чернюк В.И., Каракашян А.Н., Кучерюк Т.К., Мартиновская Т.Ю., Демецкая А.В., Сальникова Н.А., Чуй Т.С., Пятница-Горпинченко Н.К. Украина асбестцементті өндірісіндегі негізгі кәсіби мамандардың еңбек әрекетінің гигиеналық сипаттамасы 44

Демецкая А.В., Леоненко О.Б., Ткаченко Т.Ю., Мошковский В.Е., Мовчан В.А. Украина хризотил-асбесттің бақылау қолдануы........................ 49

Аманжол І.А., Мұқашева М.А., Суржиков Д.В., Ыбыраева Л.К. Халыққа асбест тозаңның әсерінен туындайтын канцерогенді тәуекелді бағалау 52

Дүзбаева Н.М. «Қостанай минералдары» АҚ хризотил-асбест өндірісіндегі жұмысшылардың жоғарғы тыныс алу жолдарындағы шырышты қабықшасының морфофункционалдық жағдайы... 56

СОДЕРЖАНИЕ

Smagulov N.K. Word of the editor 4

БИОЛОГИЯ

Ibraev S.S., Otarov E.Zh. Acceptable work experience as an indicator of controllable chrysotile-asbestos usage in conditions of production factors influence 6

Amanbekova A.U., Ibrayeva L.K., Azhimetova G.N., Zhumabekova G.S. Identification of induced mutagenesis by method of accounting of chromosomal aberrations at the workers of chrysotile asbestos production.............................. 12

Pylev L.N., Vasilyeva L.A., Smirnova O.V., Agafonova M.V., Vezentsev A.I., Goudkova E.A. On decreasing the carcinogenic activity of calcified chrysotile fibers 16

МЕДИЦИНА

Izmerov N.F. Chrysotile asbestos and health......... 21

Kashanskiy S.V., Grinberg L.M., Berzin S.A. Impact of occupational activity on development risk of malignant mesothelioma 26

Kochelayev V.A. Recent international medical research on asbestos concerning the use of chrysotile.. 31

Plukhin A.E., Bourmistrova T.B. Features of prevention and rehabilitation of asbestos-related bronchopulmonary diseases in workers exposed to chrysotile 36

Kashansky S.V., Berzin S.A. The dynamics of lung cancer incidence rates for the male population of the town of Asbest, Sverdlovsk region 40

Kundiyev Yu.I., Chernyuk V.I., Karakashyan A.N., Kucheruk T.K., Martynovskaya T.Yu., Demetskaya A.V., Salnikova N.A., Chuy T.S., Pyatnitsa-Gorpinchenko N.K. Hygienic characteristics of labor conditions for main occupations in the asbestos cement industry of the Ukraine 44

Demetskaya O.V., Leonenko O.B., Tkachenko T.Y., Moshkovsky V.E., Movchan V.A. The controlled use of chrysotile asbestos in Ukraine 49

Amanzhol I.A., Mukasheva M.A., Surzhikov D.V., Ibrayeva L.K. The evaluation of carcinogenic risk when exposed to asbestos dust on the population . 52

Duzbaeva N.M. The morphofunctional state of the mucous membrane of the upper respiratory ways among workers of chrysotile-asbestine production of JSC «Kostanaisky minerals»................ 56

Аманбекова А.Ұ., Әжиметова Г.Н., Ғазизов О.М., Бекпан А.Ж. Хризотил-асбест өндірісіндегі жұмысшылардың иммундік жүйесінің сипаттамасы 61

Amanbekova A.U., Azhimetova G.N., Gazizov O.M., Bekpan A.Zh. Characteristics of the immune system of the organism of workers in chrysotile-asbestos production 61

ГЕОГРАФИЯ

Нейман С.М., Попов К.Н., Межов А.Г. Хризотилцементтен жасалған әр түрлі мерзім қолданылған жамылғы табақтардың қасиеттерін зерттеу 66

ГЕОГРАФИЯ

Neumann S.M., Popov K.N., Mezhov A.G. Investigation of the chrysotile cement roofing sheets properties of various operation term...................... 66

«ҒАЛАМДЫҚ ӘЛЕМДЕГІ УНИВЕРСИТЕТ: ӨЗАРА ӘРЕКЕТ ЖОЛДАРЫ МЕН ТҮРЛЕРІ» ХАЛЫҚАРАЛЫҚ ФОРУМЫНАН МАТЕРИАЛДАР

Есполов Т.И., Ұмбаталиев Н.А., Садықов Ж.С., Әлпейісов Ш.А. Күріш жинау кезінде дәнің сапасын белсенді басқару 70

Тойлыбаев М.С., Садықов Ж.С., Әлпейісов Ш.А., Тойлыбаев Н.С. Астықты жинайтын комбайнның жетілдірілген көлбеу қондырғы камерасын зерттеу нәтижелері 73

АВТОРЛАР ТУРАЛЫ МӘЛІМЕТТЕР.......... 77

МАТЕРИАЛЫ С МЕЖДУНАРОДНОГО ФОРУМА «УНИВЕРСИТЕТ В ГЛОБАЛЬНОМ МИРЕ: ПУТИ И ФОРМЫ ВЗАИМОДЕЙСТВИЯ

Есполов Т.И., Умбаталиев Н.А., Садыков Ж.С., Альпейсов Ш.А. Активное управление качеством зерна риса при уборке................................. 70

Тойлыбаев М.С., Садыков Ж.С., Альпейсов Ш.А., Тойлыбаев Н.С. Результаты исследования усовершенствованной наклонной камеры зерноуборочного комбайна.................................... 73

СВЕДЕНИЯ ОБ АВТОРАХ............................ 77

Dear readers!

The present collection is devoted to an actual issue — asbestos. What is asbestos and why is it paid so careful attention?

Asbestos is a natural material which name means «fireproof yarn» from Greek. Asbestos another name is «mountain flax». All types of asbestos are easily split into very thin elastic and strong fibers which really resemble flax. These fibers constitute asbestos. Its main advantage is flexibility and fire-resistance; ability to crumple and to fluff into fine-fiber material which is similar to flax or cotton and could be used for fire-proof fabrics manufacturing. The fibers start to destroy at temperatures higher than 600–700 ºC and start to melt only at t = 1500 ºC.

Asbestos is known from the ancient times. Even 1300 years BC in Ancient China and India priests had fire-proof clothes made from asbestos. Wearing these clothes, they had been entering into the fire and had been coming out alive which created worshiping of them. In Ancient Rome and Greece people knew how to make yarn from the asbestos fibers and used it as material for fire-proof wicks of lamps. Medieval Arabs made outwear from asbestos fabric for soldiers fighting with enemy by wildfire — ancient napalm. It is said that Emperor Karl V, the most powerful monarch of Europe in 16 century, had a tablecloth made from fine asbestos fibers which he usually threw in the fire after feasts for guests' amusement. All organic remains were burned but the cloth remained. The same trick Nikita Demidov demonstrated to Peter the First; his tablecloth was made from long-fibered asbestos from Ural.

Asbestos is a collective name of minerals which could be found in nature as bunches of fibers and are highly resistant for tension. There are six types of asbestos: chrysotile (white asbestos), amosite (brown asbestos), also known in industry as amphibole, crocidolite (blue asbestos) and less common tremolite, anthophyllite and actinolite.

Chrysotile is highly resistant for alkalis but is has low acid resistance; minerals of amphibole groups are sparingly soluble or insoluble in acids.

The largest deposits of chrysotile asbestos are in Russia and Kazakhstan. Abroad the largest deposits are in Canada, South Africa, USA, Italy, Yugoslavia, Finland, France, Japan, Brasil, Australia and China.

In the recent years the attitude to asbestos becomes more and more watchful. What is the danger of this well-known material? Even in the first century Pliny paid attention to the fact that workers who had been mining asbestos fibers and had been making the protective asbestos fabric often were ill and died early. The number of ill significantly increased in the period of industrial revolution since asbestos was widely used for steam engines production. At the beginning of century the link between asbestos and pulmonary fibrosis, a disease caused by asbestos fibers penetrated into the lungs, was found («fibra» is a fiber in Latin).

In the present time the exact mechanism of unfavourable influence of fibers on the human organism is not studied fully yet. At the same time it is known that intensity of pathologic process is defined by the ability of fibers to stay in lungs for the long period which length is defined by the fibers quantity (dose), dimensions and resistance to biological environment impact.

It is known that chrysotile is dissolved in acid and under the impact of subacid environment of lungs its fibers are quickly resolved. Amphibole fibers are highly resistant for acid environment that is why it is impossible to remove them from lungs by means of dissolving. This is one of the main reasons of longer presence of amphibole in lungs which defines the difference in risks evaluation.

Because all types of asbestos were used incorrectly in the past, chrysotile and amphibole were classified as 1st category carcinogen (tested carcinogenic agents) such as cadmium, chromium, vinyl chloride, tobacco and others. The classification of World Health Organization (WHO) stated the danger of the material but not the risk. Because the material is classified into the 1st group, its usage should not be prohibited, but its application should be strictly controlled.

The discussion on the subject of unique material chrysotile asbestos usage has been continuing for more than ten years. Opinion of the one arguing party is based on the scientific researches devoted to the safety of materials and goods containing chrysotile asbestos. Another party declares the worldwide prohibition for their application grounding by the predictable data based on the cases of asbestos-caused diseases provoked by serious violations of safety regulations in 1960–1970s.

The scientific understanding of asbestos danger has been evolved from the danger of all asbestos till the specific danger of special types of this material. As a result, amphibole asbestos was widely accepted as very hazardous and was prohibited worldwide. But the impact of chrysotile on the disease especially in low doses was not finally clarified and the scientific society is focused on the influence of chrysotile asbestos on the human health.

The application of amphibole is prohibited in the majority of the countries in the world. About chrysotile there was not the same opinion. There is not the same opinion concerning the fibers which are offered as its substitutes as well.

The present collection gathered various opinions on this subject. We offer our readers to find their own position in the discussion concerning pros and cons of chrysotile asbestos application as well as application of chrysotile containing materials and goods.

N.K.Smagulov, *Production Editor*
of Journal «Bulletin KarSU. Biology,
Medicine, and Geography Series», professor

UDC 616–057:622.874

Acceptable work experience as an indicator of controllable chrysotile-asbestos usage in conditions of production factors influence

Өндірістік фактордың әсеріндегі жұмыстың ықтимал өтілі хризотил-асбестті бақылап қолдану көрсеткіші ретінде

Ibraev S.S., Otarov E.Zh.

Karaganda State Medical University MH RK (E-mail: ibraev_kgmu@mail.ru)

Өндірістегі шу, діріл және шаңдану факторларының кәсіби аурушаңдылықтың дамуына әсері зерттелді. Қауіпсіз жұмыс өтілін есептеу үшін байыту кешенінің құрамында хризотилі бар шаңның орташа ауысымдық концентрациясы мен шудың эквиваленттi деңгейлерi қолданылды. Алынған мәліметтер негізінде хризотил-асбест өндірісінің өндірістік орта факторларының әсері жағдайындағы қауіпсіз жұмыс өтілі есептелінді. Тыныс алу мен ЛОР ағзаларының кәсіби аурушаңдылығы шаң мен шудың жоғарғы деңгейінде жылдам дамитыны анықталды.

В статье было изучено влияние производственных факторов, таких как шум и запыленность, на сроки развития профессиональной патологии. Для расчета безопасного стажа работы были использованы среднесменные концентрации хризотилсодержащей пыли в воздухе рабочей зоны и эквивалентные уровни шума обогатительного комплекса. На основе полученных данных авторами рассчитан безопасный стаж работы в условиях воздействия факторов производственной среды хризотил-асбестовой промышленности. Выявлено, что профессиональная патология органов дыхания и ЛОР-органов может развиваться быстрее при высоких уровнях запыленности и шума.

The problem of safety with the use of asbestos in last years is paid intent attention of specialists and departments, which are responsible for population health protection. Many international organizations and WHO, ILO, IARC first of all pay attention to this problem [1, 2].

The problem of asbestos established lungs diseases till present time stays enough actual, through this question was devoted many number of researches [3–5].

The noise accompanies human with first day of his life and is one of most widespread hostilities of production and natural environment. Long influence of noise is increased than hygienic norms, lead to professional diseases development of acoustic organ — double-sized sensorineural deafness. The human with lower hearing significantly most difficult adapts in society, is restricted in choice of education and professional activity, faces with specific difficulties in interpersonal society not only in family, but and I labor staff. This is one of basic reasons (besides fear of working place lost as a result of professional diseases and slower lower hearing subjective sensation development) unwillingness of timely visit for medical aid in the process of hearing disorder, that in turn lead to incomplete an later detection of sensory deafness of professional etiology [6].

Professional contact is possible with natural and artificial inorganic fibres consisting of industrial dust, also and for account of special material extensive use and it contain in many branches at the present time. Practically all kinds of industrial inorganic fibres in that or other degree can render the negative influence on human health. Most widespread usage had six kinds of natural inorganic fibres, which are combined under commercial name «asbestos». It is five fibres of amphibolic group and one mineral of serpentine group (chrysotile) [7].

Full exclusion of production environment of hostilities is impossible in connection with technologic, economic and other difficulties. Therefore principle of level and time limitation of hostilities influence is implementating in practice, i.e. «protection by time». The term «protection by time» means the deleterious effect decrease of working environment and labor process hostilities on workers [8, 9]. Calculation of acceptable work experience is conducted in unfavorable conditions of production environment for estimation of work continuousness possibilities in hygienic researches. The calculation of acceptable experience permits to definite the preventive arranges which direct to the decrease of harmful industrial factors influence on worker organism.

Purpose of work is a calculation of acceptable work experience in conditions of noise and dustiness influence for workers of chrysotile asbestos industry.

Research materials and methods. Objects of research are leading professions, which work on industrial subdivisions of mining enterprise JC «Kostanay minerals». Research of acoustic atmosphere and dustiness level was conducted on work places of basic professions of concentration workshops and ore concentration of concentrating complex.

Noise measurement was conducted on work places in typical conditions of equipment exploitation. The purpose of these measurements is hygienic noise estimation as harmful factor of production environment and definition of calculated safe work experience.

Acoustic apparatus of firm «SVAN» was used for measurement of noise parameters. Measurement and estimation of noise parameters conducted according to requirements of sanitary norms and rules № 139 «Hygienic normative of noise level on work place». Also general noise level on scale dBA registered and identified their intensity on frequencies from 31,5 till 8000 Hz.

Identification of acceptable (safe) work experience in terms of noise influence was identified according to Standard ISO — 1999.2 «Acoustics. Identification of professional noise level influence and hearing disorder estimation is provoked by noise». Standard is devoted to estimated probability questions of specific hearing disorder in depend on exposition and permits to prognosis the probability of professional diseases origin and estimates effectiveness of prophylactic measures [10].

Information about average shift concentration (ASC) of dust in work place air, which presented by laboratory staff of JC «Kostanay minerals» were used in the base of calculations of acceptable (safe) work experience in conditions of dustiness for professions of concentration workshops and ore concentration of concentrating complex on work places.

On the basis of measurement protocols ASC of dust, we calculated and identified acceptable (safe) work experience in professions of concentrating complex.

Research results. Basic risk factors of worker's professional sensory deafness development of basic professions of ore concentration workshop (ore accepter, driver of crushing and grinding sorting machine, driver of ventilation and aspiratory installations, operator) and concentration workshop (driver of crushing and grinding sorting machine, traffic-controller, and crusher-operator) are intensive noise. It is known that production noise causes on hearing disorder function development, as well as influence on all organism and promotes to the development of untimely fatigue which leads to attention concentration decrease, labor capacity and exactness of worker functional duties execution of dangerous noise professions.

We calculated the noise doses, which the workers got during work time period, on base of chronometric researches of worker labor activity of concentrating complex in the process of work with technological equipments. That is, noise dose is an integrated quantity, taking into account the acoustic energy, which influence on human organism during definite work time period.

Considering that hearing loss of I degree with big possibility can develop and without noise influence in the result of age changes, presents the unreasonable to use I degree of hearing impairment for safe work experience estimation. In connection with it in table № 1 presents computed values of work experience during f which can develop the hearing disorder of II and III degree in depend on noise level I work places.

Technological equipment concentration in workshops and plots in the process of professional activity leads to noise influence on work places of leading professions, which are worked by crushing and concentration of chrysotile-asbestos ore.

Research results showed that the noise level on work places of or concentration workshop is 68–93 dBA, at acceptable norms 80 dBA. As we can see from Table № 1, we calculated and identified parameters of safe work experience on work places of ore concentration workshop with such noise level from 40 till 35 years old.

According to our researches, the highest noise level was registered in work zone CSC 1–5 (conical secondary crushing). It general level was 93 dBA and exceeded a maximum permissible level on 13 dBA. The calculation indicator (criteria till 20dB) of acceptable work experience of 10 % of workers is 25 years old, but 25 % of workers — 39 years old. The probability of hearing loss on level of criteria meaning till 30dB is 44 years old of work experience.

According to the presented table (table 1), most level of acoustic energy in concentration workshop noticed on section by mark + 20. The measurement of noise level on mark +20 showed the excess of normative sizes on 26 dBA at the rate of 80 dBA.

Analysis results of noise level on work places f concentrating workshop showed that the excess of normative values observes on all sections of work zone, besides work places on sections of pile-forming machine hydraulic actuator (PFM), work places of packing, sewing, sack tare transportation and on mark + 10. The levels of noise are especially high on sections of work places with marks +6, +34, 52 and 55, in the dry ore depot (DOD), skip of hatch wastes and in 4 stages of crushing and exceeds acceptable sizes from 5 till 9 dBA.

Research of noise level is presented in Table 1 to show, that level of acoustic vibrations on sections with mark +25, +30, +44; +46 and hoisting plant (HP 3) exceed the normative values on 2–3 dBA. The results of conducted calculation of acceptable work experience on work places PFM and packing, sewing, sack tare transportation and on mark + 10 (table 1) show that acceptable work experience on these work places is more than 45 years, t.i. noise level is found with the scope of sanitary norms requirements.

Table 1

Calculated worker acceptable work experience of concentrating complex JC «Kostanay minerals» in terms of production noise influence (at 8 hours influence)

Work places (section of work zone)	Factual noise level, dBA	Work experience (years) at noise level (dBA)	
		Till 20 dB	Till 30 dB
Workshop of ore concentration			
Receiving hopper № 1, 2.	68	–	–
Conveyor –1	84	39	–
Conveyor –2	90	35	
Crash	88	35	–
Conveyor –16, 19, 26, electric filters	81	40	–
Conveyor –15, 17, Cyclone -1–20.	83	40	–
Conveyor –14, 20	85	39	–
Conveyor –201, К–202	82	40	–
Evacuated chamber, filter	85	39	–
CPV 1–2; Feeder 1–2	87	39	–
CSC 1–5; Feeder 1–2	93	25 years — 10 % 39 years — 25 %	44
Crash 1–5; К 8–12	86	39	–
Mark –3; –6	78	–	–
Mark +1	82	40	–
Workshop of concentration			
Hydraulic actuator PFM	76	–	–
Mark +6	85	39	–
Mark +10	80	40	–
Mark +20	106	3 years–10 % 5 years –25 % 18 years –50 %	8 years –10 % 16 years–25 % 35 years –50 %
Mark +25	82	40	–
Mark +30	83	39	–
Mark +34	89	35	–
Mark +52, +55	87	35	–
Mark +44, +46	82	40	–
HP-3	83	39	–
DOD	85	39	–
Skip of hatch wastes	86	39	–
VAS	85	39	–
Packing, sewing, sack tare transportation	79	–	–
4th stage of crushing	85	39	–

Note. Dash means that the work experience is more than 45 years.

By factual noise level (80–82 dBA) the calculated acceptable experience on work places (mark +10; +25 and +44, 46) is 40 years of work experience, that is on level of criteria till 20 dB. On the scope of same criteria — till 20 dB the safe work experience on level of 39 years was calculated for professions in work zone «Mark» + 39; HP-3, DOD, skip of hatch wastes, ventilative and aspiratory section (VAS) and 4th stage of crushing. But marks +34 и +52, +55 on sections are the acceptable work experience — 35 years. The origin of hearing loss reasons on mark +20 from 10 % possibility from influence of industrial noise is on the scope of 3 years; with 25 % possibility of professional pathology development of respiratory organs observes in 5 years. The half of basic separators professions, risk of professional hearing loss development with probability 50 % can develop through 18 years.

Received information permits to prognosis the possibility of specific hearing disorders on level of criteria till 30dB of workers on section with mark +20. Representatives of basic professions, who work on mark + 20 have the hearing function disorder, 10 % could get the development of hearing disorder only after 8 years, and 25 % and 50 % of workers — through 16 and 35 years of work experience.

Thereby, generalized results of hygienic probability estimation of professional hearing loss development under the influence of noise, we can to prognosis, that hearing function loss with big probability from influence of industrial noise in ore concentration workshop of concentrating complex is 25–44 yeas of work experience. Hearing lower with big probability (contact with noise must be during 8 hour working shift) can develop by 10 % and 25 % of basic professions workers through 3 and 5 years of work experience. 50 % of workers who works on mark + 20, hearing loss development till 20 dB could observe through 18 years of work. The hearing loss of 3rd level (till 30 dB) for workers of mark +20 with big probability can develop through 8 and 16 years of 10 % and 25 % of workers. The half (50 %) of workers has the probability of hearing function loss through 35 years.

Table 2

Estimation of predictable acceptable work experience in terms of dust influence of concentration workshop of concentrating complex JC «Kostanay minerals»

Work places (section of work zone)	ASC, мг/м^3	MAC, мг/м^3	T, years
1	2	3	4
Workshop of ore concentration			
Receiving hopper	1,4	2	35,7
+19; +27,4	0,9	2	–
+29,4	3,6	2	13,9
+31; +24	2,3	2	21,7
+0,0	1,6	2	31,2
–3,4	1,1	2	–
D–31	2,3	2	21,7
+15	1,6	2	31,2
Settler D–1	3,0	2	16,7
VAS	0,8	2	–
–3,8	2,6	2	19,2
+10,8	2,0	2	25,0
+5,4	1,7	2	29,4
+0	1,0	2	–
Workshop of concentration			
– 3,2	3,1	2	16,1
±0	2,0	2	25,0
+6	1,7	2	29,4
+10	1,7	2	29,4
+15,6	2,8	2	17,8
+20	1,6	2	31,2
+25	2,3	2	21,7
+30	3,0	2	16,7
+34,8	1,6	2	31,2
+39,6	1,7	2	29,4
+52+55	2,2	2	22,7

1	2	3	4
+44+48	1,6	2	31,2
ПУ–3	1,0	2	–
ССР	2,2	2	22,7
ВАУ	1,7	2	29,4
+6	1,2	2	41,7
IV stage of crushing	2,6	2	19,2
«Signoda»	0,7	2	–
+0	0,4	2	–

Note. Dash means that the work experience is more than 45 years.

The usage of highly mechanized equipment with one side significantly makes the worker labor easier, with other side — all process of ore concentration is accompanied by significant dust discharge.

High dust concentrations notice at the transportation, crushing and sifting of ore concentration.

The elaboration of acceptable wok experience permits to prognosis the probability of professional diseases origin and estimates the effectiveness of prophylactic measures.

Results of predictable lungs pathology development from of chrysotile-asbestos dust influence in workshops of ore concentration and concentration of concentrating complex are presented in the Table 2.

Following values for work experience were got in the process of risk estimation of dust pathology development on work places in the ore concentration workshop in the contact with dust, whereby predicts development of professional disease from observed sections of work zone: more than 45 years of work on sections of ore concentration workshop +19; 27,4; –3,4; VAS; + 0 mark. In this workshop for work zone of receiving hopper, marks 0; +15; +10,8; 5,4 predictable period of respiratory tracts pathology development composed 35, 7–25 years of work, at average shift concentration 1,4–2 мг/м^3. By average shift of dust concentration on level 2,3–3,6 мг/м^3 the predictable work experience duration whereby can develop professional disease is 21,7–13,9 years of work experience.

Conducted hygienic researches in concentration workshop showed that industrial environment at concentrations of chrysotile-asbestos ores is not enough optimally. So, average shift concentration of chrysotile-asbestos dust on sections — 3,2; +15,6; +25; +30; +52, +55 и IV stage of crushing is found in the scope of 3,1–2,2 mg/m^3, if the norm is 2 mg/m^3. Conducted calculation of acceptable work experience on these marks showed that predictable safe work experience duration under influence of chrysotile-asbestos dust is found in the scope of 16,1–22,7 years of work experience.

The conducted analysis for periods of lungs pathology formation from influence of chrysotile-asbestos dust permits to separate sections (mark ±0; +6; +10; +20; +34,8; +39,6; +44 and +48; VAS and +6) where periods of professional diseases development is from 25 till 41,7 years of work experience. The level of average daily concentration is from 2 mg/m^3 till 1,2 mg/m^3 on these sections. The content of average shift dust concentration from 1 till 0,4 mg/m^3 on work places of sections HP-3, PFM «Signoda» and mark +0 didn't exceed normative values. Received information permits to propose, that these numbers of average shift concentration is that concentration, for which, as a rule, doesn't happen the formation of professional pathology.

Therefore, analysis of lung pathology formation periods from influence of chrysotile-asbestos dust permits to detect that safe work experience in ore concentration workshop on different marks is for appropriate professions in the scope of 13,9–35,7 years of work experience. The predictable safe work experience is more than 45 years on marks +19; –3,4; +0 and VAS, i.e. the level of average shift concentration doesn't exceed the acceptable dustiness levels.

The predictable safe work experience is more than 45 years of work experience at the rate of ASC 1–0,4 mg/m^3 on production sections HP-3, PFM «Signoda» and on mark +0 of concentration workshop.

Conclusions

1. Hearing loss with big probability from industrial noises influence in ore concentration workshop happens at the work experience from 25–44 years.

2. Hearing loss with big probability for workers on marks + 20 (contact with noise must be during 8 hour working shift) can develop by 10 % and 25 % of basic professions workers through 3 and 5 years of work experience. 50 % of workers who works on mark + 20, hearing loss development till 20 dB could observe through 18 years of work. The hearing loss of 3rd level (till 30 dB) for workers of mark +20 with big

probability can develop through 8 and 16 years of 10 % and 25 % of workers. The half (50 %) of workers has the probability of hearing function loss through 35 years.

3. Safe work experience in ore concentration workshop on different marks is for appropriate professions in the scope of 13,9–35,7 years of work experience. The predictable safe work experience is more than 45 years on marks +19; –3,4; +0 and VAS, i.e. the level of average shift concentration doesn't exceed the acceptable dustiness levels.

4. The predictable safe work experience is more than 45 years of work experience at the rate of ASC 1–0,4 mg/m^3 on production sections HP-3, PFM «Signoda» and on mark +0 of concentration workshop.

References

1. *Izmerov N.F.* Elaboration of national program on asbestos established diseases elimination // Labor medicine and industrial ecology. — 2011. — № 5. — P. 1–16.
2. *Izmerov N.F., Kovalevskiy E.V.* Basics of national program elaboration on asbestos established diseases elimination // Labor medicine: Realization of Global action plan on health of workers for 2008–2017: Mater. All-Russia conference — Moscow, 2008. — P. 116–118.
3. *Pluhin A.E., Burmistrova T.B., Postnikova L.V.* Modernization of prophylactics and rehabilitation system principles of asbestos established diseases of bronchopulmonary worker system // Labor medicine and industrial ecology. — 2011. — № 5. — P. 37–44.
4. *Kosyachenko G.E., Suvorova I.V., Tishkevich G.I.* Hygienic aspects of asbestos circulation and worker labor terms of asbestos processing organizations of Belorussia // Profession and health: Mater. All-Russia Congress — Moscow, 2011. — P. 249–251.
5. *Salnikova N.A., Demetskay A.V., Moshkovskiy V.E.* Chrysotile-asbestos dust control in air of work zone: Ukraine Experience // Profession and health: Mater. All-Russia Congress — Moscow, 2011. — P. 438–439.
6. *Ilkaeva E.N.* Professional deafness — psychosocial side of problem // Profession and health: Mater. All-Russia congress — Moscow, 2010. — P. 221–223.
7. *Kovalevskiy E.V., Kashanskiy S.V.* Correction of maximum permissible dust concentration in the air of work zone, which contain natural and artificial inorganic fibres // Profession and health: Mater. All-Russia congress — Moscow, 2011. — P. 229–231.
8. *Ibraev S.A., Zhusupov K.K. et al.* Prognostication of professional deafness under influence of production noise of chrysotile-asbestos production workers // Modern technologies in labor medicine: Mater. International scientific conference — Donetsk, 2009. — P. 52–54.
9. *Ibraev S.A., Zhusupov K.K. et al.* Calculation of acceptable work experience I the contact with chrysotile contain dust in professions of mining and transport enterprise // Ural medical journal. — 2008. — № 11. — P. 32–34.
10. *Izmerov N.F., Suvorov G.A.* Physical factors of production and natural environment. Hygienic estimation and control. — Moscow: Medicine, 2003. — 555 p.

UDC 616–091.8:553.676

Identification of induced mutagenesis by method of accounting of chromosomal aberrations at the workers of chrysotile asbestos production

Хризотил-асбест өндірісі жұмысшыларында индукцияланған мутагенезді хромосомдық аберрацияны есептеу әдісімен анықтау

Amanbekova A.U.[1], Ibrayeva L.K.[1], Azhimetova G.N.[1], Zhumabekova G.S.[2]

[1]*National center for occupational hygiene and occupational diseases MH RK, Karaganda;*
[2]*Station of the emergency help, Karaganda (E-mail: ncgtpz@gmail.com)*

Мақалада хризотил-асбест өндірісіндегі жұмысшылардың цитогенетикалық зерттеуі берілген. Негізгі цехтағы жұмысшылардың перифериялық қанындағы хромосомды аберрациялар есептеліп, хромосомдық аберрациялар деңгейінің дәлелденген түрде артқаны анықталды. Хросомалардың құрылымдық бұзылуы хросомдық және хроматидтік түріндегі аберрациямен көрсетілген, бұл химиялық мутагенездің орын алғанын дәлелдейді. Индукцияланған мутагенездің жоғарғы көрсеткіші хризотил-асбест байыту цехының жұмыскерлерінде және 25 жылдан астам еңбек өтілімі бар кісілерде анықталды. Перифериялық қан лимфоциттеріндегі хромосомдық аберрациясы бар жасушалар саны бақылау тобымен салыстырғанда негізгі топта 2,4 рет есе артық екені тіркелді.

В статье приведены данные цитогенетического исследования рабочих хризотил-асбестового производства. Проведен учет хромосомных аберраций в периферической крови рабочих основных цехов, где выявлено достоверное увеличение уровня хромосомных аберраций. При этом структурные нарушения хромосом были представлены аберрациями хромосомного и хроматидного типов, что может свидетельствовать в пользу химического мутагенеза. Авторами установлено, что более высокие показатели индуцированного мутагенеза наблюдались у рабочих цеха обогащения хризотил-асбеста и у лиц со стажем работы более 25 лет. Частота клеток с хромосомными аберрациями в лимфоцитах периферической крови основной группы достоверно превышала контрольные показатели в 2,4 раза.

Actuality. To date, assessment of the effects of the mutagen-induced production factors and the effects of environmental factors is carried out by detecting chromosomal damage by analysis of chromosomal aberrations and sister chromatid exchanges in peripheral blood lymphocytes. To evaluate the mutational event is necessary to use method of accounting for chromosomal aberrations, which is a highly sensitive methods of biological indication of human exposure to mutagens and production of environmental factors. In the molecules of DNA genetic information is encoded, mutagenic, acting on the cell, leading to breaks and rearrangements of chromosome structure [1]. In the formation of chromosomal aberrations important stage of the mitotic cell cycle, which occurred at the time of the impact of the mutagen.

Damage to the genetic apparatus of cells forms the basis of violations of biological reactions. According to N.P.Bochkov and A.N.Chebotarev, chromosomal aberrations are an early indicator of adverse effects on the body before they will develop pathological processes. In some countries, accounting cytogenetic analysis of chromosomal aberrations is used as a control method of mutagens and raises the question of restricting professionals on genetic grounds. As a result of works by American authors found that the mutagenic effects at low doses is important in assessing the carcinogenicity of substances has been investigated with 134 substances listed in the National Toxicology Program USA [2–5]. Studies on the structural variation of chromosomes in lymphocytes, provides an opportunity not only quantitative, but also qualitative account the need for objectivity and accuracy of test results. Studies of the spontaneous level of chromosomal aberrations in human peripheral blood lymphocytes in the last 30 years have shown that the level of chromosomal aberrations increased by 1.5–2 times to the present time, 1.56–2.78 % [5, 6].

A team of researchers found mutagenic activity of heavy metal salts, which contacted the workers of cobalt and tungsten in the production of plants at steel mills, manifested a significant increase in the level of chromosomal aberrations in lymphocytes of the workers at these plants compared with the control group by 2.5–3 times [7].

According to some authors, the workers of lead refineries traced the growth of disease, based on considerable importance is the accumulation of adverse genetic load. The frequency of chromosomal aberrations in workers of lead production exceeds spontaneous level [8], other researchers have noted that the metal ions possess mutagenic activity due to destruction or binding of natural antimutagens cells [9].

At the present time particularly relevant in the diagnosis of prenosological is to study the role of individual human sensitivity to adverse environmental factors. Polymorphism of enzymes responsible for metabolism of mutagens, determines the ability of an organism to mutations [10–12].

Thus, all of the above confirms that the study of the chemical nature of mutagens, scientists are paying great attention, which confirms the need to further examine the state of the genetic status of persons employed in manufacturing. Analysis of the literature has shown promising use of micronucleus test and the method of accounting for chromosomal aberrations in peripheral blood lymphocytes to detect cytogenetic damage from exposure to factors of production.

The aim of investigation: to study the cytogenetic status of the workers of chrysotile asbestos production by method of accounting of chromosomal aberrations in peripheral blood.

Materials and methods. A retrospective cohort study of workers of main shops of JSC «Kostanai minerals is carried out.» In order to study the cytogenetic status of the accounting method of chromosomal aberrations in peripheral blood of 50 men studied male, working on chrysotile asbestos production: 20 out of the shop enrichment (SE) and 15 of the ore preparation plant (OPP) and mining-transport workshop (MTW). In the SE (group 1) — the average age was examined 47,8 ± 1,3 years, the average length — 27,4 ± 0,82 years. In group 2 (OPP) — the average age of workers was 48,2 ± 1,05 years, the average length of service — 23,2 ± 0,65 years. In group 3 (MTW) — the average age of surveyed — 45,1 ± 0,93 years, average length — 25,0 ± 0,06 years. The control group consisted of 12 male workers in non-manufacturing sector, whose average age was 42,8 ± 2,01 years, the average length of service — 24,8 ± 0,96 years (Table 1).

Table 1

Number of persons examined for chromosomal aberrations account for the group, depending on length of service

Main groups	Experience 15–25 years		Experience 25–35 years	
	Subdivisions	Number of persons	Subdivisions	Number of persons
SE	1	5	2	15
OPP	3	10	4	5
MTW	5	9	6	6
Control	7	6	8	6

Each of the surveyed groups was divided into two subgroups depending on the length from 15 to 25 years and 25 to 35 years and above. All respondents at the time of blood sampling did not take chemotherapy and hormone therapy, and were not subjected to X-ray examination the past 3 months.

Statistical analysis was carried out with material of PP «STATISTICA 5.5», with the calculation of average performance (M ± m), t — the Student for comparisons between groups.

To account for the frequency and types of chromosome aberrations in human peripheral blood lymphocytes using a modified method of cultivation of peripheral blood lymphocytes of Hungerford DA et al. [13]. Consideration of chromosomal aberrations was performed using a microscope «NiKon Eclips 400» (Japan, 2005) and the system of karyotypes LUCIA Cytogenetics KARYO. Criteria for selection of metaphases corresponded to the generally accepted guidelines (N.P.Bochkov, 1989) [1]. From each individual were analyzed in 200 metaphases. All the results of cytogenetic analysis of the aberrations introduced into the uniform modeled on protocols approved by the Local Ethics Committee (Protocol № 4 of 16.05.2008)

Results and discussion. The results of cytogenetic studies by taking into account the status of chromosome aberrations (Table 2) demonstrated in peripheral blood lymphocytes of workers of major groups of chrysotile asbestos production significantly increased frequency of chromosome aberrations by 2.4 times (2,87 ± 0,16 %) compared with those of the individuals the control group (1,16 ± 0,21 %).

At the same time structural changes of chromosomes in the study group presented chromosome aberrations and chromatid types (Fig. 1).

The frequency of chromosome type aberrations in the exposed group was 1,19 ± 0,10 %, chromatid — 1,68 ± 0,12 %. In the control group, respectively — 0,58 ± 0,15 % and 0,58 ± 0,15 %, the difference is reliable indicators at $p < 0.01$. Aberrations of chromosome type were 41.5 % of the total chromosomal abnormalities in the major groups and, respectively, 58.5 % were chromatid-type. This ratio of types of chromosomal aberrations speaks in favor of chemical mutagenesis [5–7].

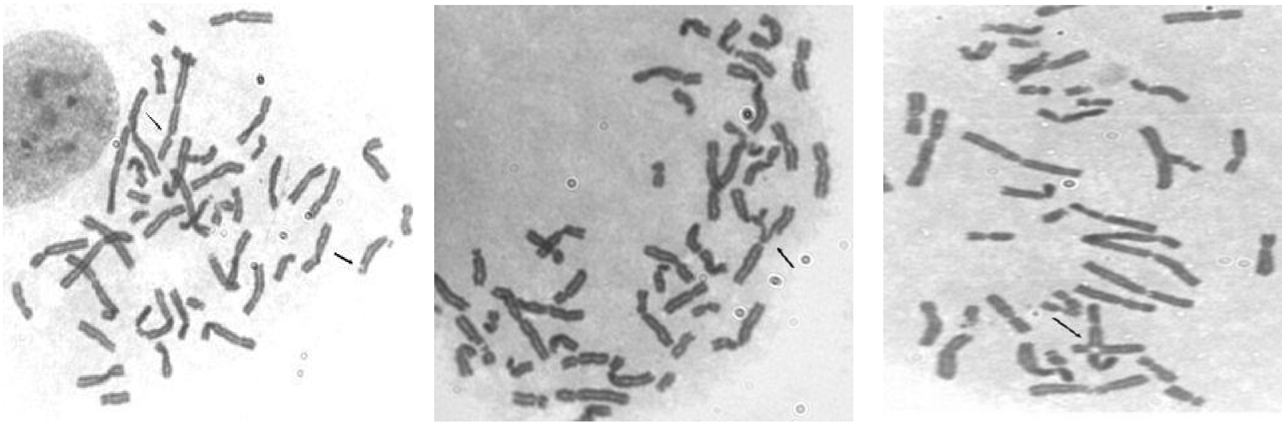
When analyzing the frequency and types of chromosomal aberrations in the examined individuals, depending on the place of work (shop) and work experience revealed that the highest level of chromosomal aberrations was observed in the second group of plant concentration and it reached 4,26 ± 0,36 %, which compared with the control group is 3.4 times higher (p <0.01) (Fig. 2).

Table 2

The frequency and types of chromosomal aberrations (CA) in patients and control group (M ± m)

Groups	Total metaphases	Total ChA		Frequency ChA (types)			
				chromosomal		chromatid	
	abs.	abs.	M±m	abs.	M±m	abs.	M±m
Main	10000	287	2,87±0,16*	119	1,19±0,10*	168	1,68±0,12*
Control	2400	28	1,16±0,21	14	0,58±0,15	14	0,58±0,15

Note. * — reliability of differences compared with the control group, p <0.01.



a) b) c)

Fig. 1. The chromatid gap and pair fragment (*a*), the strand exchange (*b*), chromosome exchanges in peripheral blood lymphocytes of chrysotile asbestos worker production. The increase 1,25×100

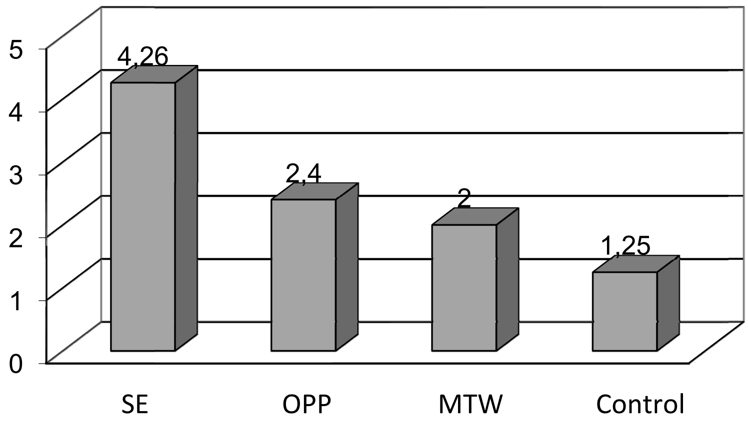


Fig. 2. The level of chromosomal aberrations in workers with experience of 25–35 years and above, %

This group belonged to a group of people with experience of 25–35 years and above. Considering the group in a given period of probation may be noted as an increased level of chromosomal aberrations induced in the shop ore preparation (group 4) but not in such large numbers as in the enrichment of the shop — 2,40 ± 0,48 %, which exceeded the benchmark by 1.9 times (p < 0.05). In the mining-transport workshop marked the lowest level of chromosomal aberrations compared with the previous two major groups — the SE and OPP. This figure was established at the level of 2,0 ± 0,40 %, which exceeds the reference level of 1.6.

Considering the frequency of chromosomal aberrations in the groups surveyed, those with experience of 15–25 years, it may be noted that the highest level observed in the SE (Group 1) — 2,9 ± 0,53 %, that compared with the control group higher in the 2 6-fold (p <0.01).

The shop ore dressing (group 3), this figure was established at the level of 2,25 ± 0,33 %, which is also higher than the control level in 2-fold (p <0.05). In the fifth group — the MTW, the level of chromosomal aberrations is 2,05 ± 1,33 %, which is also higher than the value of the control group in the probation period by 1.9 times (Fig. 3).

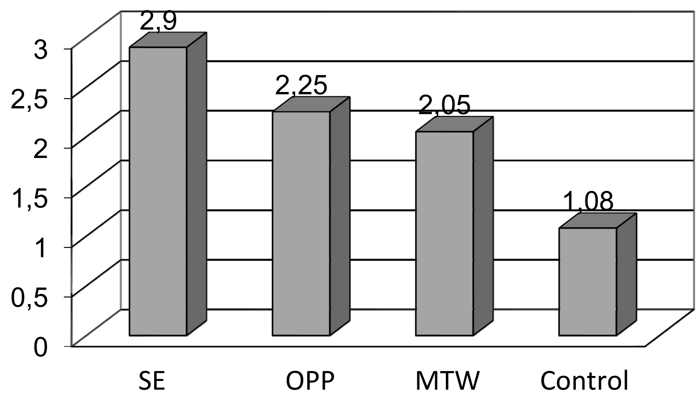


Fig. 3. The level of chromosomal aberrations in workers with experience of 15–25 years,%

Analyzing the types of chromosomal aberrations may be noted that the failure of the chromosomes are of two types: chromosome and chromatid. Breakage of the chromosome type are paired fragments and discontinuities of the centromere, chromatid-type — deletions, fragments and single chromatid breaks. Paired fragments in the main groups were 33.1 % (95 cases) of the total chromosome type aberrations, and the remaining 8.4 % (24 cases) belonged to the rupture of the centromere. In the control group chromosome type breakage are also paired fragments (9 cases), which accounted for 32.1 % of the total number of chromosomal aberrations in the control group and the discontinuities of the centromere — 5 cases (17.8 %).

Chromatid type aberrations in the main groups were as follows: deletion of 11.9 % (20 cases), single pieces — 21.4 % (36 cases) and chromatid breaks — 56.5 % (112 cases), breaks — 9 cases (32.1 %). In the control group are broken chromatid-type aberrations and similar types were as follows: deletion (1 case) — 3.6 %, single pieces — 4 cases (14.3 %).

Thus, the results of the studies showed that elevated levels of chromosomal aberrations in enriching chrysotile asbestos ore, have been observed among workers in the shop and the enrichment of the persons working in the shop of ore dressing. With higher rates are found among workers with experience of more than 25 years. In the mining-transport workshop performance level of chromosomal aberrations in workers slightly higher than in the control and almost fit into the framework of spontaneous mutagenesis. When comparing the trained groups of plant indicators of the frequency and types of chromosomal aberrations did not differ.

Conclusions. A significant increase in chromosomal aberrations in individuals working in the chrysotile asbestos industry, while structural changes of chromosomes were represented by chromatid aberrations and chromosome types, which may testify in favor of chemical mutagenesis.

Higher rates were observed in induced mutagenesis operating enrichment plant of chrysotile asbestos and in those with experience of over 25 years.

The results of cytogenetic studies have shown that the frequency of cells with chromosome aberrations in peripheral blood lymphocytes of the main group significantly exceeded targets by 2.4 times.

Aberrations of chromosome type constitute 41.5 % of the total number of chromosomal breakage in the main group and 58.5 %, respectively, constitute the failure of chromatid type.

Elevated levels of chromosomal aberrations in the production and enrichment of chrysotile asbestos ore occur in working in the shop enrichment. With higher rates are found among workers who have been working for over 25 years. Individuals working in the shop ore preparation also noted increased levels of chromosomal aberrations compared with the control group, and there is a direct relationship with the experience of work: higher rates (2.9 %) were detected at a higher work experience (over 25 years).

References

1. *Bochkov N.P., Tchebotaryov A.N.* Heredity of the person and environment mutagens. — M.: Medicine, 1989. — 270 p.
2. *Bochkov N.P.* Ecological genetics of the person // Medicine of work and industrial ecology. — 2004. — № 1. — P. 1–6.
3. *Tchebotaryov A.N.* Regularities of chromosomal variability of somatic cages of the person // The Messenger of the Russian Academy of Medical Science. — 2001. — № 10. — P. 64–69.
4. *Dotan Y., Lichtenberg D., Pinchuk I.* Lipid peroxidation cannot be used as a universal criterion of oxidative stress // Prog Lipid Res. — 2004. — № 43. — P. 200–227.
5. *Bochkov N.P., Tchebotaryov A.N. et al.* A database for the analysis of quantitative characteristics of frequency of chromosomal aberrations in culture of lymphocytes of peripheral blood of the person // Genetics. — 2001. — Vol. 37 — № 4. — P. 549–557.
6. *Druzhinin V.G., Minina V.I., Mokrushina N.V.* Cytogenetic violations at workers of coke-chemical production // Medicine of work and industrial ecology. — 2000. — № 10. — P. 22–24.
7. *Bobyleva L.A., Chopikashvili E.Z. et al.* Revealing of groups of the raised risk among the workers contacting to heavy metals, on the basis of the analysis of chromosomal aberrations and nursing chromatid exchanges // Cytology and genetics. — 1991. — Vol. 25. — № 3. — P. 18–23.
8. *Shushkevich N.I.* Cytogenetic instability at long impact of lead on an organism of workers of lead production // Medicine of work and industrial ecology. — 2007. — № 8. — P. 10–14.
9. *Koshkina V.S., Antipanova N.A., Kotljar N.N.* Monitoring of prevalence of chemical carcinogens in objects of environment and biological environments at residents with the developed branch of ferrous metallurgy // Hygiene and sanitary. — 2006. — № 1. — P. 12–13.
10. *Kulkybaev G.A., Bajmanova A.M. et al.* Cytogenetic inspection of working coal mines and polymetallic mines // The medical magazine of Astana. — 2003. — № 4. — P. 36–39.
11. *Bajanova M.F., Kulkybaev G.K. et al.* Cytogenetic instability at workers of titano-magnesium production depending on working conditions // Medicine of work and industrial ecology. — 2004. — № 11. — P. 16–20.
12. *Greim I.I., Borm P. et al.* Toxicity of fibers and particles — report of the workshop held in Munich, Germany // Inhal Toxicol. — 2001. — Vol. 13. — № 9. — P. 737–754.
13. *Hunderford D.A.* Leukocytes cultured from small inoculate of whole blood and the preparation of metaphase chromosomes by treatment with hypotonic KCl // Stain Technology. — 1965. — Vol. 40. — № 6. — P. 333–338.

UDC 616–091.8:553.676

On decreasing the carcinogenic activity of calcified chrysotile fibers

Хризотилдың кальцийленген талшығында канцерогенді белсенділікті төмендету мәселесі жайында

Pylev L.N.[1], Vasilyeva L.A.[1], Smirnova O.V.[1], Agafonova M.V.[1], Vezentsev A.I.[1], Goudkova E.A.[2]

[1]RAMS Research Institute for Carcinogenesis named after N.N.Blokhin, Moscow;
[2]Belgorod State University, Russia (E-mail: pylev@crc.umos.ru)

Хризотил талшығын Mg портландцементмен өңдеген кезде жарым-жартылай Ca айнала бастаған. Осының нәтижесінде олар көп қабатты портландит $Ca(OH)_2$ жабылған, сонымен бірге қышқылдылығы, белсенді орталық мөлшері мен биологиялық белсенділігі өзгерді (мутагенділігі жойылған, макрофагтармен оттегінің белсенді формаларының туындауы анағұрлым төмен максимуммен және нативті хризотилмен салыстырғанда анағұрлым ұзақ фонға ие болды).

В статье рассмотрены результаты исследований, когда при обработке портландцементом волокон хризотила Mg частично заменялся на Ca, в результате чего они покрыты монослоем портландита $Ca(OH)_2$. При этом менялись кислотная сила, количество активных центров и биологическая активность (отсутствовала мутагенность, генерация активных форм кислорода макрофагами характеризовалась более низким максимумом и более длительным достижением фона по сравнению с нативным хризотилом).

Discovering carcinogenic properties of asbestos in cancer epidemiology and experimental studies resulted in a tough struggle between opponents and supporters of its continued industrial use. In some cases this struggle (and opposition in the first place) gets farther away from the reality and scientific facts and often acquires a commercial and political format.

The notion of asbestos is collective; it covers different fibrous minerals including crocidolite, amphibole asbestos banned long ago due to its high carcinogenicity, and chrysotile, the extent of carcinogenicity of which for humans is still debated. It is sufficient to recall findings of the recent Multicentre European study of the International Agency for Research on Cancer (IARC) that, on the whole, showed no risk for occupationally exposed persons [1]. The asbestos cement industry consuming about 80 % of all chrysotile has no unambiguous data either [2]. Risks for the population with environmental exposure to chrysotile are even less clear. Amphiboles can, as a rule, be traced in the studies showing a high carcinogenic risk. In general, there is no scientific evidence convincing enough to ban chrysotile whereas safety of its substitutes requires further investigation [1]. Meanwhile they believe that the denial of chrysotile has already led to negative consequences such as an increase in the number of car accidents in Western Europe and, probably, significantly accelerated the collapse of towers of the World Trade Center during the terrorist attack in the USA, September 11, 2001. At the same time the asbestos-free roofing material Onduline, widely promoted as «safe and environmentally friendly», contains high concentrations of benzo(a)pyrene [3] which is a Group 1 carcinogen according to IARC classification, i.e. the agent carcinogenic to humans, and is an indicator of the presence of other polycyclic hydrocarbons including blastomogenic ones.

Our previous studies showed [4] that chrysotile fibers treated with Portland cement were significantly different from natural fibers, had a different structure of the crystal lattice where Mg was partially substituted by Ca, and were covered with a monolayer of portlandite — $Ca(OH)_2$. The suggestion was made about the formation in this case of a new fibrous mineral possibly with new chemical, physical and biological properties [11]. The decreased cytotoxicity, mutagenicity and carcinogenicity of chrysotile fibers treated by acids and heat under pressure, which we found, may serve as an indirect confirmation of the latter; i.e. the effect on the crystal lattice of the fiber changes its properties [5, 6].

On the surface of curved and tubular fibers of chrysotile asbestos there are positively (prevailing) and negatively charged active centers [5] where biologically active molecules can be adsorbed and generated; other carcinogens such as polycyclic aromatic hydrocarbons (PAH) may also metabolize there [7, 8]. The former primarily include active oxygen radicals and NO-radicals with high biological aggressiveness. As mentioned above, when the chrysotile fiber is treated with hydration products of Portland cement a chemisorption of Ca ions takes place and a surface layer of portlandite forms [9]. Further studies showed that in this case the acid strength shifted to the right and the alkaline active centers prevailed whereas the native asbestos contains more acid centers. The evaluation of the acid strength and active centers on the «asbestos-cement» fiber yielded a hypothesis about a weaker biological aggressiveness of the latter as compared to natural asbestos [10]. The study of mutagenic activity in the micronuclear test of the bone marrow of mice confirmed this hypothesis. Chrysotile fibers covered with hydration products of Portland cement showed no mutagenic activity whereas untreated fibers did [10].

Fiber carcinogenesis, including the asbestos one, is considered by most researchers to be non-genotoxic, i.e. cell transformation is not induced directly by the fiber but indirectly, through biologically active compounds generated by the fiber which affect the genetic apparatus of the target cell and cause mutation. However, in some cases a direct, «mechanical» effect of fibers on chromosomes and spindle during cell mitosis, which can also lead to mutation, are not excluded. It is regarded that asbestos has both inducing (causing mutation) and promoting effects; in particular it promotes the increase in the pool of mutated cells [7, 11–16].

In the organism of mammals both synthesis and destruction of active free radicals constantly occur. These free radicals include molecules or their fragments having one or more unpaired electrons on the outer orbital. They can be both neutral and positively or negatively charged. Because of their structure they are highly reactive. Active radicals include, in the first place, oxygen and NO-radicals. Generation of oxygen radicals is as follows:

I $O_2 + \bar{e} \rightarrow O_2^-$ (superoxide anion)

II $O_2^- + +2H^+ + \bar{e} \rightarrow H_2O_2$

III $H_2O_2 + \bar{e} \rightarrow OH^- + OH^-$ (hydroxyl radical)

Iron in its active form (Fe^{2+}) acts as a catalyst of these processes; it is also formed by means of the reaction of Fe^{3+} with an active oxygen radical superoxide anion (O_2^-)

I $Fe^{3+} + O_2^- \rightarrow Fe^{2+} + O_2$.

The hydroxyl radical is formed in the Fe^{2+}-dependent reaction (Fenton reaction).

II $H_2O_2 + Fe^{2+} \rightarrow Fe^{3+} + OH^- + OH^{\cdot}$.

Destruction of the hydroxyl radical ($OH^{\cdot}$) occurs in the reaction with Fe^{2+}

III $OH^{\cdot} + Fe^{2+} \rightarrow Fe^{3+} + OH^{-}$,

And superoxide anion — with Fe^{3+} (IV).

Apart from oxygen and NO-radicals a Fe-dependent peroxidation of lipids on cell membranes and in liposomes takes place in the organism, thus forming biologically active alkoxyl radicals. Active radicals play an important role in initiation and damage of many intracellular signal paths, secretion of different growth mediators, cytokines, in cell proliferation and apoptosis. They induce the DNA damage, its completeness and reparation as well as point mutations. A specific circulation of active radicals, particularly oxygen radicals, in the organism may, therefore, lead to both positive (protective) and negative consequences. It is probable that the law of «dose – time – effect» works here, too.

Nowadays active oxygen radicals, and the OH-radical in the first place, are thought to play the major role in the mechanism of the carcinogenic effect of asbestos [7, 12, 13, 17–22]. They are mainly formed from macrophages, but they can be also generated on the surface and inside target cells. Iron, the catalyst of these processes, can be a part of the crystal lattice of the fiber (amphibole) or be present in the form of admixtures on its surface (chrysotile).

When fibers affect cells, the latter experience an oxygen burst that leads to a sharp increase in the number of active radicals of oxygen [7, 21, 24], which cause an «oxidative stress» in target cells (here, lung epithelium and mesothelium) leading also to the damage of their genetic apparatus [7, 14, 21, 23, 24].

In contrast to long-living peroxides of lipids (alkoxyl radicals), the excess formation of which may be also caused by asbestos fibers, oxygen radicals live a very short life lasting nanoseconds. The radius of their effect is very small. For instance, the radius of effect of the OH-radical is about 100 nm, i.e. it affects only neighboring target cells. Here, naturally, it is both the number of cells and the number of oxygen radicals that matter. When discussing the role of active radicals, one should not forget about a complex effect of fibers on the target cell, about the importance of fibers' sticking to it (for this the presence of specific proteins such as fibro- and vitronectin, intergrins, and of their receptors on the cell membrane is necessary [25]), about the ability of activated macrophages to secrete a large number of various compounds that can activate and inhibit carcinogenesis [26, 27].

Taking into account all mentioned above, the evaluation of the ability of asbestos to generate formation of active oxygen radicals by a cell may serve as an indicator of one of the types of its biological activity. Using the acknowledged experimental model and method [28] we studied the available samples [10]. As it has been expected [29], native chrysotile activated macrophages rather quickly (the peak was observed in 4 minutes) and increased the number of active oxygen radicals (maximum 26×10^{3} impulses) generated (when luminol was used — of OH-radicals), which, however, quickly (in 19 minutes) dropped to background values. The fibers taken from asbestos-cement were significantly less active, and the increase in the number of impulses was smooth. The peak was observed in 15–17 minutes, the maximum was 17×10^{3} impulses, and the drop to background values lasted longer (27 minutes).

Thus, in this particular case also we found proof of our hypothesis [10] based on physical and chemical studies that properties of the surface of a fiber play an important role in its ability to induce a biological effect. «Screening» the surface of a chrysotile fibril with hydration products of Portland cement «eliminates» its mutagenicity and significantly reduces the potency to activated macrophages and generate biologically active molecules (in this case — active oxygen radicals). It was demonstrated [30] that asbestos also activated the generation of these compounds in the mesothelium, which is a known target for this type of carcinogenesis (mesothelioma). This does not happen when fibroblasts are affected. Moreover, if asbestos fibers cause damage of some signal paths and of the cell cycle in fibroblasts killing them, then the same was not observed in mesothelial cells. This might partially explain the «riddle» of the absence of connective tissue neoplasms in people and experimental animals exposed to asbestos.

The obtained results have a large scientific and practical importance. They broaden our knowledge and capabilities in studying the mechanism of fibrous carcinogenesis and show that the investigated biological aggressiveness of the fiber from asbestos-cement is much lower than that of asbestos, which is important since, as it has been mentioned, the major part of all asbestos mined is used for the production of asbestos-cement. These data confirm the hypothesis [27] that the crystal lattice of the fiber treated with Portland cement is changed so much that one can speak about a new fibrous mineral with new properties.

A weaker but a longer ability of asbestos-cement fibers to generate oxygen radicals by macrophages indirectly relates to one of the important problems of occupational pathology and hygiene — the extent of hazard of the intermittent effect. According to our data [31], a long-term effect of low doses of asbestos dust is more dangerous than a short-term effect of a high concentration. It should be noted, however, that this has been demonstrated in experimental conditions using a method, not very adequate to such works. But the problem remains. Fibrous carcinogenesis is significantly different from other types of blastomogenesis, and the occurring pathology and its mechanism are significantly different from that caused by non-fibrous dusts. At the same time, the distinctive feature of «carcinogenic» fibers is their fibrogenicity where active radicals, and oxygen ones in the first place, play important, if not the main role [20].

Is it the evidence of the link between asbestosis and cancer? Etiologically yes; in both cases we, probably, speak about one and the same inducing factors; but pathogenetically — no, as the mechanisms of developing fibrosis and cancer or mesothelioma are different. The cell DNA damage, disruption of the processes of its reparation and mutation play an important role in the latter. The target cells are also different. It should be noted, however, that the chronic inflammation that occurs in both cases can contribute to the endpoint but by different ways [7, 20]. All mentioned above allows one to assume that the effect of intermittent dust exposures for the development of fibrosis and cancer may be different and it is not correct to extrapolate regularities from the fist to the second one. In this connection, the conclusion about a lower biological activity of asbestos-cement fibers in inducing the generation of oxygen radicals by macrophages must be considered correct. Yet, is it enough to speak about its smaller carcinogenicity? Formally — yes as oxygen radicals are of key importance in asbestos carcinogenesis and the carcinogenesis induced by asbestos substitutes. At the same time, it is well-known that quite a number of non-fibrous and non-carcinogenic dusts stimulate the generation of oxygen radicals by macrophages rather actively. At this, peaks of chemiluminescence under effect of those dusts are similar to those caused by asbestos when doses are almost equal [11, 29].

Obviously, not belittling the importance of oxygen radicals in fibrous carcinogenesis, it is essential to think about the importance other factors and fiber properties. Probably this still makes researchers speak about the «inscrutability» of the mechanism of this type of blastomogenesis. It is not by chance that there are so many hypotheses on this issue [7].

The necessity of continuation and broadening of studies in this direction is obvious. Means of decreasing the carcinogenic risk of asbestos dust for humans mostly depend upon the understanding of the mechanism of its carcinogenic effect on the organism and, in the first place, of the transforming effect on the cell.

References

1. *Carel R., Olsson A.C. et al.* // Occup. Environm. Med. — 2006 (in press).
2. *Pylev L.N., Smirnova O.V.* // Hygiene and Sanitary. — 2006. — № 2. — P. 32–36.
3. *Pylev L.N., Krivosheyeva L.V., Levinsky S.S.* // Personal communication.
4. *Vezentsev A.I., Neyman S.M., Goudkova E.A.* // Building Materials. — 2006. — P. 104–105.
5. *Pylev L.N., Vasilyeva L.A. et al.* // Hygiene and Sanitary. — 2002. — № 3. — P. 61–64.
6. *Pylev L.N., Vasilyeva L.A. et al.* // Hygiene and Sanitary. — 2006. — № 4. — P. 70–73.
7. Mechanisms of Fibre Carcinogeneses / Ed. A.B.Kane, P.Boffetta et al. // IARC Sci. Publ., Lyon. — 1996. — № 140.
8. *Varga C., Szendi K., Ember I.* // In Vivo. — Vol. 20. — № 4. — P. 539–541.
9. *Vezentsev A.I., Goudkova E.A. et al.* // Building Materials (in press).
10. *Pylev L.N., Smirnova O.V. et al.* // Hygiene and Sanitary. — 2007. — № 2.
11. *Gusev B.A., Lomonosova O.S., Velichkovsky B.T.* // Issues of Medical Chemistry. — 1997. — Vol. 43. — № 3. — P. 148–152.
12. *Hei T.K., Xu A. et al.* // Inhal. Toxicol. — 2006. — Vol. 18. — № 12. — P. 985–990.
13. *MacCorkle R.A., Slattery S.D.* // Cell. Motil. Cytoskeleton. — 2006. — Vol. 63. — № 10. — P. 646–657.
14. *Panduri V., Surapureddi S. et al.* // Amer. J. Respir. Cell. Mol. Biol. — 2006. — Vol. 34. — № 4. — P. 443–452.
15. *Pezerat H., Zalma R. et al.* // IARC Sci. Publ., Lyon. — 1989. — № 90. — P. 100–111.
16. *Schins R.P.* // Inhal. Toxicol. — 2002. — Vol. 14. — № 1. — P. 57–78.
17. *Kamp D.W., Panduri V. et al.* // Mol. Cell. Biochem. — 2002. — Vol. 234–235 (1–2). — P. 153–160.
18. *Miura Y., Nishimura Y. et al.* // Apoptosis. — 2006. — Vol. 11. — № 10. — P. 1825–1835.
19. *Shukla A., Gulumian M. et al.* // Free Radic. Biol. Med. — 2003. — Vol. 34. — № 9. — P. 1117–1129.
20. *Vallyathan V., Shi X., Castranova V.* // Environm. Health Perspect. — 1998. — Vol. 106. — Suppl. 5. — P. 1151–1155.
21. *Weihong L., Ernst J.D., Broaddus V.C.* // Ibid. — 2000. — Vol. 23. — № 3. — P. 371–378.
22. *Xu A., Zhou H., Yu D.Z., Hei T.K.* // Environm. Health. Perspect. — 2002. — Vol. 110. — № 10. — P. 1003–1008.
23. *Lulz W., Krajewska B.* // Med. Pr. — 1995. — Vol. 46. — № 3. — P. 275–284.
24. *Wang X., Wu Y. et al.* // Amer. J. Respir. Cell. Mol. Biol. — 2006. — Vol. 34. — № 3. — P. 286–292.
25. *Wu J., Liu W. et al.* // Lung Cell. Mol. Physiol. — 2000. — Vol. 279. — № 5. — P. L916–L923.

26. *Pylev L.N., Vasilyeva L.A. et al.* // Issues of Oncology. — 2004. — Vol. 50. — № 6. — P. 678–682.
27. *Kravchenko I.V., Furalyov V.A. et al.* // Teratogenesis, Carcinogenesis and Mutagenesis. — 2001. — Vol. 21. — P. 315–323.
28. *Velichkovsky B.T., Korkina L.G., Suslova T.B.* // Occupational Hygiene. — 1983. — № 5. — P. 31–34.
29. *Durnev A.D., Suslova T.B. et al.* // Experimental Oncology. — 1990. — Vol. 12. — № 2. — P. 21–24.
30. *Kopnin P.B., Kravchenko I.V. et al.* // Oncogene. — 2004. — Vol. 23. — P. 8834–8840.
31. *Pylev L.N., Stadnikova N.M.* // Hygiene and Sanitary. — 1994. — № 7. — P. 30–32.

UDC 613–003.667.6

Chrysotile asbestos and health

Хризотил-асбест және денсаулық

Izmerov N.F.

Research Institute of Occupational Health of the Russian Academy of Medical Sciences, Moscow, Russia (E-mail: niimt@niimt.ru)

ДДҚ-ның қорытындысына сай, ДДҰ-ның жанасымды бөлімшелері асбест әсерінен ауруға шалдығулармен күресу үшін түрлі стратегияларды құрастыру керек. Стратегиялардың бірі — хризотил және хризотил өнімдерін аз мөлшерде пайдалану. Өкінішке орай, ДДҚ-ның шешіміне қарсы ДДҰ-ның кейбір шенеуніктері халықаралық ауқымда асбест және оның өнімдерін пайдалануға тыйым салуды қолдайды. Мұндай қарама-қайшылықтарды шешу үшін халықаралық ұйымдардың шеңберінде, сарапшылардың қатысуымен, барлық ғылыми мағлұматтарды мұқият әділ талдауға мүмкіндік беру қажет.

В статье дан анализ научных данных по борьбе с асбестообусловленными заболеваниями. Согласно решениям ВАЗ, соответствующие подразделения ВОЗ должны выстраивать различные стратегии по борьбе с асбестобусловленными заболеваниями. Одна стратегия — для хризотила и содержащих его изделий — это их контролируемое использование ввиду низкого риска. Другая стратегия — для амфиболовых асбестов и содержащих их изделий — запрет в соответствии с Конвенцией МОТ № 162. К сожалению, вопреки решению ВАЗ, некоторые чиновники ВОЗ, ответственные за осуществление решений ВАЗ, продолжают навязывать политику запрета применения всех видов асбеста в международном масштабе. Для решения имеющихся противоречий в рамках международных организаций необходимо проведение тщательного беспристрастного анализа существующих научных данных с участием экспертов, представляющих все точки зрения на проблему.

Introduction

The article presents results of studies of chrysotile asbestos and health conducted by the Russian Academy of Medical Sciences (RAMS) Institute of Occupational Health, a brief review of foreign studies, the list of protective measures in the use of asbestos and other fibrous materials ensuring their controlled use.

The Institute of Occupational Health founded in the Soviet Union in 1923 is the first institute not only in Russia, but in the whole world, that attended (and still attends) to occupational health problems. One of the issues of occupational health studied by our Institute is that of chrysotile asbestos and health [1].

In Russia chrysotile asbestos was found more than 300 years ago. Its industrial use dates back to the discovery of the Bazhenovskoye deposit (the town of Asbest, Sverdlovsk Region) in the end of the 19th century [2].

As is known, various types of fibers are widely used in industry today: asbestos and other natural and man-made mineral fibers (MMMF), synthetic, organic and many other fibers. Since this article concerns asbestos fibers, let us consider in detail the above-mentioned issue of chrysotile asbestos and health.

Until the end of the 20th century asbestos was considered to be the most important non-metallic mineral in the world used in the production of over 3 thousand asbestos-containing materials and products [3]. The term asbestos covers two groups of minerals: serpentine that includes chrysotile asbestos and amphiboles (amosite, crocidolite, anthophillite, tremolite, etc.). All types of amphiboles were banned for use by ILO Convention 162 due to their high biological aggressiveness [4].

Until 1980s the use of all types of asbestos was practically uncontrolled which led to a significant increase in the risk of such diseases as chronic bronchitis, asbestosis, lung cancer, and malignant mesothelioma [5]. This stimulated demands to ban the use of asbestos including chrysotile.

However, based on results of long-term Russian studies we can now claim that with the current level of equipment and technology, in case of controlled labor conditions and proper medical and preventive care of industrial workers provided, there are no grounds to ban the use of chrysotile [6]. The data of Russian researchers are confirmed by studies conducted with our foreign colleagues.

Our institute was the initiator of international studies conducted in 1994–1997 in mines and mills of Uralasbest, JSC in the town of Asbest, Sverdlovsk Region, by scientists of the U.S.National Institute of Occupational Safety and Health, the Finnish Institute of Occupational Health, the RAMS Institute of Occupational Health, and the Ekaterinburg Medical Research Center [7]. The joint Russian-Finnish-American research project was entitled «Health and Exposure Surveillance of Siberian Asbestos Miners». It included:

– an X-ray examination of 2,003 workers of Uralasbest;
– external respiration tests in 414 X-rayed workers;
– an in-depth medical survey of 289 workers;
– the analysis of current and past dust concentrations in mines and mills; and
– the analysis of the contents of fibrous particles in assays of lung tissue taken during autopsy of Asbest citizens or Uralasbest workers.

The mean age of the examined subjects was 47 years (range: 27–78 years). The length of service ranged 1–47 years (22 years on the average). The minimum time of exposure equaled a year and the maximum — 59 years, the average being 25 years. Most of the subjects worked at the time when dust concentrations in workplace air were tens and hundreds of milligrams per cubic meter.

At this, no radiological changes typical of chrysotile exposure were observed in almost 90 % of X-rayed workers despite high levels of dust in the workplace air and a long employment period. In 70 % of cases we found no X-ray changes at all. Abnormalities were mainly detected in workers of old asbestos mills already closed by the time of this study. We observed a statistically significant correlation between the dose of dust and its health effect.

It should be noted that malignant pleural mesothelioma is usually attributed to asbestos exposure although other causes of the disease are known today [8]. Mesothelioma is a very rare disease; its incidence rate is 1–3 cases per million a year. In the countries using chrysotile asbestos the rate of malignant mesothelioma was almost on the background level (Russia — 3, Latvia — 3, Lithuania — 3, etc.). It was much lower than in the countries with the past wide use of amphiboles (Belgium — 29, Australia — 22, Netherlands — 21, etc.).

In 1997–1999 the project for Prevention of asbestos-related diseases in Hungary, Estonia, and the Republic of Karelia of the Russian Federation was implemented on the grant of the European Union to study the incidence of pleural mesothelioma in those countries [9]. The researchers established that in 1990s the mesothelioma incidence was 8 cases per million a year in Hungary and 3 cases — in Estonia and Karelia.

The number of incident cases, at least relatively comparable to that in West European countries, was observed only in Hungary, the country with a history of partial industrial use of amphibole asbestos. Only in lung tissue assays from Hungary did we find amphibole fibers (amosite, crocidolite, and anthophyllite). Thus, the study became yet another proof of the link between the increase in mesothelioma incidence and the exposure to amphiboles, but not chrysotile mined in Russia. For many years Russia has been the world largest producer and consumer of chrysotile, the only type of asbestos used in the country for civil purposes, and unlike European countries it has not got the negative experience in the wide use of amphiboles.

As for occupational asbestos-related diseases, there exists evidence that the highest risk for workers and general population is posed by:

– exposure to amphiboles, as such and mixed with chrysotile;
– uncontrolled spraying, demolition, removal and maintenance of friable insulation materials containing all types of asbestos in construction and other industries by people having no special equipment and/or training; and
– other operations involving excess dust emissions made without proper safety precautions.

If we consider the use of asbestos-containing materials, it should be noted that almost 90 % of chrysotile mined worldwide is used in the production of asbestos-cement products, the risk of fiber emissions from which is minimal. Other types of chrysotile-containing products include friction materials (7 %), textiles, etc.

Let me remind you of the asbestos phobia that developed in Europe when public buildings were demolished as the proof of asbestos hazard. At that time we asked our foreign colleagues to show us an epidemiologic study indicating that indoor weathering of chrysotile fibers does pose health risk, that chrysotile-cement pipes cannot be used for the drinking water supply systems. We have never got the answer. The thing is that there exist no such studies.

Thus, to establish the possibility of population exposure to asbestos and other mineral fibers in construction materials, in 1999–2001 the RAMS Institute of Occupational Health conducted a study to estimate concentrations of respiratory fibers in ambient air of Moscow and in houses and public buildings constructed of materials and products containing chrysotile and man-made mineral fibers [10].

Based on our findings we came to the following conclusions:

– the use of asbestos-containing materials and products in industrial enterprises of Moscow, motor transport, and public and residential buildings does not lead to excess environmental pollution with respiratory fibers. The only exception includes areas in the vicinity of industrial premises where large volumes of asbestos-containing materials are used uncontrollably;
– a controlled use of asbestos-containing materials, both high density products (asbestos-cement sheets, panels, and blocks) and friable products (asbestos-containing plaster, pipe coating, and molded products) is no source of excess environmental or indoor air pollution with respiratory fibers; and
– the uncontrolled, irresponsible use of materials containing both asbestos and MMMF may be dangerous for health of workers and the general population. At the same time, there is no need to remove materials containing both asbestos and its substitutes, including friable and easily damaged insulation from public and residential buildings. The prerequisite of their further use is a controlled maintenance of objects in a satisfactory technical condition.

The discussion of chrysotile was especially sharp within the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade.

During the 5th Conference of Parties to the Rotterdam Convention, 20–24 June 2011, the issue of including chrysotile in Annex III of the Rotterdam Convention was raised for the 4th time. Yet another time the consensus was not reached and the decision was made to include the issue in the agenda of the next, 6th Conference of Parties to be held in 2013.

It should be noted that Annex III includes the list of dangerous pesticides and some hazardous industrial chemicals. As a rule, they are chemicals proven to be extremely hazardous for use of workers and general population and banned in the majority of countries.

The issue of including chrysotile in the PIC list was raised due to notices of its ban in some countries. The notices declare that the reason for the ban was concern about human health. At the same time, no comprehensive or unbiased analysis of scientific data in support of such conclusions had ever been carried out. We are of the opinion that there are neither scientific nor practical reasons to include chrysotile asbestos in the PIC list of Annex III.

We should pay significant attention to the possibility of decisions made by different international organizations that neglect differences between amphiboles and chrysotile as well as recent scientific evidence.

For example, in September 2006 the document on the policy of the WHO in elimination of asbestos-related diseases appeared on the official Website of the World Health Organization stating that the best solution of the issue was the ban on the use of all types of asbestos [11]. In this connection we have sent letters to the WHO and expressed our opinion that the document caused serious doubts. Here, like in many other documents calling to ban asbestos, the notions of «asbestos» and «chrysotile» and, which is more important, «danger» and «risk» are being confused [12].

It is well known that the risk of adverse health effects is determined by biopersistence of fibers, which, in its turn, depends on their quantity, duration of exposure, dimensional characteristics, and acid resistance.

When inhaled, chrysotile fibers are dissolved in the acid medium of the lings. Acid-resistant fibers of amphiboles and other fibers suggested as «safe» chrysotile substitutes remain in the lungs for the rest of the life [13].

Numerous studies give no grounds to speak about excess risk of exposure to chrysotile used under controlled conditions. Many issues still require further research. The same is written in the review of recent data on chrysotile prepared by the World Health Organization in 1998 [14].

Tenets about excess health risks posed by controlled chrysotile exposure were not confirmed in «Chrysotile Asbestos. Priority Chemical No. 9», the document prepared in Australia in 1999 within the National Industrial Chemicals Notification and Assessment Scheme, either.

«…Risk assessments made in many studies … were based on historical data when workers were exposed to very high concentrations of chrysotile-containing dust. Now the exposure levels are much lower, and thus past risk estimates seem overestimated. There are many other reasons to consider conclusions based on transferring data on historical exposure to present conditions as doubtful.»

MMMF become more are more prevalent in various industries of many countries of the world.

In November 2005 a WHO workshop on mechanisms of fiber carcinogenesis and assessment of chrysotile asbestos substitutes was held at IARC. This Workshop was convened in response to a request from the Intergovernmental Negotiating Committee for the Rotterdam Convention to consider modes of carcinogenic action of chrysotile and its substitutes.

Very interesting conclusions were made based on the results of discussing recent scientific data, namely:

– fully inert fibers that could have been used as a control in comparative assessment of biological effect, were not found;
– epidemiologic data on whiskers, fiberglass, stone and slag wool, and ceramic fibers considered by the IARC were found insufficient;
– there exist no epidemiologic data on special-purpose glass fibers and newly developed fibrous materials;
– sensitivity of European and American epidemiologic studies known to date may be insufficient due to the assessment of lung cancer only in workers of modern enterprises where exposure levels are negligible; and
– cancer risks cannot be excluded in industries consuming MMMF (e.g., construction), and airborne concentrations of fibers might be significantly higher especially among experienced workers, who apply and remove fibrous isolation.

Taking into account all mentioned above, today it is important to introduce such safety measures in the use of asbestos and other fibers as:

– the ban on amphibole asbestos;
– the ban on the production and use of friable materials containing asbestos and many other dangerous fibers;
– types of work involving possible emissions of high concentrations of asbestos fibers should be done by specially trained employees observing established safety rules;
– the ban on spraying of insulation materials containing asbestos and other fibers;
– compliance with special regulatory and method documents on safety in different types of activities involving the use of chrysotile at the industrial, national and international levels; and
– implementation of modern programs for medical services, early diagnostics of health changes in people with both occupational and environmental exposure to industrial dusts.

A very important document in this connection is the Global Plan of Action on Workers' Health 2008–2017 adopted by the 60th World Health Assembly (WHA) (23 February 2007) [15, 16]. Special attention should be paid to Article 10 of the Plan that says: «WHO will work with Member States to strengthen the capabilities of the ministries of health to provide leadership for activities related to workers' health, to formulate and implement policies and action plans, and to stimulate intersectoral collaboration. Its activities will include global campaigns for elimination of asbestos-related diseases — bearing in mind a differentiated approach to regulating its various forms — in line with relevant international legal instruments and the latest evidence for effective interventions…» By this formulation the WHA, the decision-making body of WHO, stated its position and determined the key strategy of elimination of asbestos-related diseases. This wording is consistent with results of numerous studies conducted worldwide.

According to WHA decisions appropriate offices of the WHO must develop different strategies for prevention of asbestos-related diseases. One strategy developed for chrysotile and chrysotile-containing products shall envisage their controlled use in view of low risk. Another strategy is that for amphiboles and amphibole-containing products providing for their ban in accordance with ILO Convention 162.

Unfortunately, some WHO officials responsible for implementation of WHA decisions keep imposing the policy of the global asbestos ban contrary to those decisions.

To eliminate the contradictions within international organizations it is critical to do a thorough, unbiased analysis of available scientific data with participation of experts representing all points of view on the problem.

References

1. *Izmerov N.F.* Asbestos: the Russian experience in occupational medicine // Safety and health in the production and use of asbestos and other fibrous materials: Collection of reports and presentations of the International Conference. — Ekaterinburg. — Asbest, 2003. — P. 13–18.
2. *Kashansky S.V.* A 300 Years History of the Discovery of Asbestos in the Urals // Asbestos Exposure and Asbestos Control: Volume 20 of the Sourcebook on Asbestos Diseases: Measurements, Controls and Bans, Pathogenesis, Diagnosis and Treatment. Edited by Peters G.A. and Peters B.J. — USA. LEXIS® Law Publishing, 1999. — P. 129–144.
3. *Shride A.F.* Asbestos / US mineral resources, Brobst D., Pratt W. (eds). Geological survey professional paper 820. — Washington DC, US Department of the interior, 1973. — P. 63–72.
4. Convention № 162 of the International Labour Organization «Concerning Safety in the use of asbestos.». http://www.businesspravo.ru/Docum/DocumShow_DocumID_18458.html
5. Pathology of asbestos-associated diseases / Editors: Roggli V.L., Oury T.D., Sporn T.A. —New York: Springer, 2004. — 421 p.
6. *Kashansky S.V.* Bibliography of the main works of biomedical problems of natural and artificial fibers, which were made the Russian-speaking authors (monographs, dissertations, and regulatory guidance documents, publications). — Yekaterinburg: Ural State Medical Publishing academy, 2011. — 188 p.
7. *Tossavainen A., Riala R., Kamppi R. и др.* Dust Measurements in the Chrysotile Mining and Milling Operations of Uralasbest Company, Asbest, Russia: Summary report. — Helsinki, 1996. — 220 p.
8. Malignant mesothelioma: advances in pathogenesis, diagnosis, and translational therapies / Edited by Pass H.I., Vogelzang N., Carbone M. — New York: Springer, 2005. — 854 p.
9. *Everatt R.P., Smolianskiene G. et al.* Occupational asbestos exposure among respiratory cancer patient in Lithuania // American journal of industrial medicine. — 2007. — Volume 50. — № 6. — P. 455–463.
10. *Kovalevsky E.V.* Assessment of concentrations of asbestos fibers in air of residential and public buildings and the air in Moscow // Building Materials. — 2002. — № 11. — P. 43–45.
11. Elimination of asbestos-related diseases // http://whqlibdoc.who.int/hq/2006/WHO_SDE_OEH_06.03_rus.pdf
12. *Bernstein D., Gibbs A. et al.* Misconceptions and misuse of international agency for research on cancer «classification of carcinogenic substances». The case of asbestos // Indoor and built environment. — 2007. — Vol. 16. — № 2. — P. 94–98.
13. *Bernstein D.M., Rogers R.A. et al.* Quantification of the pathological response and fate in lung and pleura of chrysotile in combination with fine particles compared to amosite-asbestos following short-term inhalation exposure // Inhalation Toxicology. — 2011. — Vol. 23. — № 7. — P. 372–391.
14. Chrysotile asbestos: Environmental Health Criteria 203. — Geneva: WHO, 1998. — 200 p.
15. *Izmerov N.F.* The Program of World Health Organization and the International Labour Organisation of the elimination of asbestos-related diseases. — 2008. — № 3. — P. 1–8.
16. WHA 60.26 Workers' health: Global Plan of Action. In: Sixtieth World Health Assembly, Geneva, 14–23 May 2007, Resolution and Decisions. Geneva: WHO. http://www.who.int/gb/ebwha/pdf_files/WHA60/A60_R26-en.pdf

UDC 613.6:616–006

Impact of occupational activity on development risk of malignant mesothelioma

Кәсіби қызметтің ісік мезотелиоманың дамуына әсері

Kashanskiy S.V.[1], Grinberg L.M.[2], Berzin S.A.[2]

[1]*Yekaterinburg Medical Research Center for Prophylaxis and Health Protection of Industrial workers;*
[2]*State budget educational institution of high professional development*
«Ural State Medical Academy», Yekaterinburg, Russia (E-mail: hlhdmrc@ymrc.ru)

24 жылдың ішінде (1981–2004) Свердлов облысының 66 муниципальді бөлімшесі ішінен 32-сінде 125 мезителиоммен морфологиялық верификацияланған жағдай тіркелді. Науқастық 1 жылдың ішінде 0,2-ден 27,1-ге дейін өсті. Облыс бойынша мезотелиома ауруына шалдыққан адамдар саны әлемдік деңгейге, яғни жылына миллион халыққа 1–2 жағдайға, жетті. Асбест экспозициясымен анықталған байланыс 12,0 % жағдайда анықталған. Барлық жағдайларда ауруға шалдыққандар XX ғасырдың 50–60-жылдарында сипат алған асбесттің жоғарғы деңгейдегі экспозициясының әсеріне ұшыраған. Авторлардың ойынша, асбест және хризотил-асбест аурудың дамуында жетекші этиологиялық фактор бола алмайды. Бұл ауру-сырқаттың полиэтиологиялық сипаты бар.

В статье рассмотрена картина заболеваемости мезотелиомой в Свердловской области за длительный период. За 24 года (1981–2004) в 32 из 66 муниципальных образований Свердловской области выявлено 125 случаев морфологически верифицированных мезотелиом. Заболеваемость варьировала от 0,2 до 27,1 случая на 1 миллион населения в год. В среднем по области заболеваемость мезотелиомой находится на уровне мировой фоновой — 1–2 случая на миллион населения в год. Достоверная связь с экспозицией асбеста выявлена в 12,0 % случаев. Во всех случаях больные подвергались воздействию повышенных уровней асбестовой экспозиции, характерных для 50–60-х годов XX в. По мнению авторов, асбест и в частности хризотил-асбест, не является ведущим, а тем более облигатным этиологическим фактором развития заболевания. Заболевание имеет полиэтиологический характер.

Introduction

Mesothelioma is a rare neoplasm of serosal surfaces (such as pleura, peritoneum, pericardium and others) [1]. The most common form of these neoplasms is malignant pleural mesothelioma, peritoneal and pericardium mesotheliomas occur tenfold rarer, and mesotheliomas of other localizations are the most uncommon. The median latency of the disease is 32 years but it may range from 5 to 70 years.

Overseas annually hundreds of articles on mesothelioma are published, especially in context of occasional mesotheliogenic potency of asbestos.* To our knowledge the first article on this issue was published in 1933. In 40–50s of the XXth century single papers on this issue were published. In 1960 the results of J.Wagner’s study on association between mesotheliomas and exposure to crocidolite asbestos, were published, and later this study was recognized as classical [1]. From 70s of the XXth in western countries the most common etiological factor of mesothelioma was an inhalation of asbestos dust, primarily of amphibole asbestos (especially tremolite asbestos), that play a major role in causing the disease [2].

Not denying the role of amphibole asbestos in causing mesothelioma, a number of authors are skeptical about mesotheliogenic potency of chrysotile asbestos [3, 4]. Recent reports more often indicate that mesotheliomas may occur after exposure to other chemical (man-made mineral fibres, 9.10-dimethyl-1.2-benzaanthracene, nickel, beryllium, mineralex, lead, polyurethane, ethylene oxide), physical (radioactivity), biological (Friend's virus (MC 29) and SV40) and many other carcinogenic agents [2–4].

Background incidence of mesothelioma is 1–2 cases per 1 million per year. In different countries incidence of mesothelioma varies widely from 0.15 to 29.01 cases per 1 million per year [1]. Mesothelioma incidence rates have been increasing throughout the industrialized countries in Western Europe, USA, Australia traditionally oriented to predominant use of amphiboles. The incidence in these countries varies from 4.33 in South Africa to 29.01 cases per 1 million per year in Belgium, at the average 8.06 cases as in USA. Mesothe-

* Asbestos is generic commercial name for a naturally occurring group of six different mineral fibers that differ in mineralogical structure, physicochemical properties and biological aggressivity and are uniform only on fibre structure. As these groups differ from each other on important features, which play the main role for its use, the types of asbestos are classified into two groups: serpentine and amphiboles. Serpentine includes magnesium silicate – chrysotile asbestos (white asbestos). The second group includes iron silicates, are known as amphiboles (actinolite, amosite (brown asbestos), anthophyllite, crocidolite (blue asbestos) and tremolite) [4].

lioma incidence rates in countries traditionally using chrysotile varies from 0.15 (Ecuador) to 4.81 per 1 million per year in Latvia, at the average 1.51 — for instance, in Estonia.

Incidence of mesothelioma in Russia is unknown [5]. In Russia a national register of mesothelioma doesn't exist, and because of its' rarity mesotheliomas haven't been emphasized in official oncological statistics. Only in 1994 in St. Petersburg population cancer register mesotheliomas were classified as individual group of malignant neoplasms.

During the XXth century in Russia only 4 epidemiological studies of mesothelioma were conducted: local studies in Asbest [6] and Yekaterinburg [7], and two regional studies in the Republic of Karelia [8] and a pilot study in Sverdlovsk region [9]. The studies show that only in 12.0–29.4 % of cases an occupational exposure to asbestos may cause of mesothelioma [7–9].

So, currently we haven't got reliable data on epidemiology of the mesothelioma in Russia and role of occupational factors, particularly asbestos, for developing this neoplasm. For clarification of range of statements on this issue we conducted comprehensive epidemiological analysis of mesothelioma in Sverdlovsk region, one of the most industrial administrative territories in Russian Federation.

The population of Sverdlovsk region is more than 4.5 million people, about 4.6 thousands of enterprises are situated here where about 2.1 million people are employed and more than 550 thousands from them work in harmful and dangerous conditions, and more than 100 thousands of people are exposed to substances, products, industrial processes and factors with proved carcinogenic potency and likely cancerogenic for the man [10].

In this region the largest deposit of chrysotile asbestos in the world named Bazhenovskoye, which is characterized by absolute absence of contamination with tremolite asbestos, is situated. The deposit is a part of eastern gabbro peridotite pack in Middle Ural, which also includes Alapayevskoye, Ostaninskoye and Rezhevskoye deposits of chrysotile asbestos. In the region there are 4 leading enterprises on asbestos production and field technological institute. In Sverdlovsk region more than 15000 of workers occupationally contact with chrysotile. Moreover situated in the region Sysert district is high in anthophyllite asbestos (Sysert region), there are 29 industrially significant deposits of anthophyllite and deposits of other amphiboles, development of which has been ceased.

Materials and Methods

As primary data we used official records of Sverdlovsk regional oncologic dispensary on new-onset diseases with clinicoradiologic diagnosis of mesothelioma for the period from 1981 to 2004. In all cases included into the study the diagnoses were confirmed using standard pathomorphological studies, and re-examination of histologic specimens was carried out. The data on population size in different areas and in Sverdlovsk region as a whole were obtained in regional statistical department.

Collected data were processed using recommended descriptive and cross epidemiological research methods. Incidence of mesothelioma was calculated per 1 million per year and was standardized by direct method, both for the region as a whole and for every municipal unit where they were revealed.

For all patients included into analysis it were studied occupational history personally or through relatives, and paraoccupational and environmental exposures to asbestos using special questionnaire developed by the group of international experts, for identifying potential asbestos exposure. Findings were specified in personnel department of enterprises where the patients with mesothelioma worked.

For all patients with occupational exposure to asbestos the value of total dust load on full weight of dust, received for the whole period of work activity was calculated.

Results

For 24 years (from 1981 to 2004) 226 diseases with primary clinicoradiologic diagnosis mesothelioma were registered in Sverdlovsk region. In 125 (55.3 %) cases the primary diagnosis was confirmed after morphological re-examination, and 101 (44.7 %) cases were excluded from the study because the primary diagnosis mesothelioma was proved incorrect. In addition 24 cases of lung cancer with pleural lesion, 19 cases of metastases of other cancers, 12 cases of pleuritis of nonneoplastic etiology and one case of complicated pancreatitis were revealed. In 14 cases intravital and postmortal morphological verifications were not carried out, in 28 cases primary materials were lost and 3 patients were inhabitant of other regions.

From 125 verified mesotheliomas 116 (92.8 %) cases were pleural mesotheliomas, 7 (5.6 %) were peritoneal mesotheliomas and 2 (1.6 %) were pericardial mesotheliomas. In 112 (89.6 %) patients malignant neoplasmes were revealed (including extrapleural) and in 13 (10.4 %) patients benign types of «mesothelioma» were revealed. By term «benign mesothelioma» we nominally mean localized mainly fibrous neoplasmes of pleura. Among malignant mesotheliomas on histologic type tumors of epithelioid type (72.9 %) prevailed, less often there were mesotheliomas of sarcomatous (13.6 %) and biphase (10.2 %) types.

The age of patients (67 men and 58 women) varied from 12 to 70 years, at an average 55.9±1.0 years, 55.9 % of patients were productive age. Age and sexual differences at the diagnosis in cases of malignant and benign types of neoplasmes of different localizations and lesion area were not statistically significant.

Unless one case of pleural mesothelioma revealed during autopsy the lifetime of patients from the diagnosis of malignant mesothelioma ranged from 10 days to 1.10 years, at an average 7.1±0.8 months which is equivalent of results mentioned by Russian and foreign publications [1].

The interactive study of incidence of mesothelioma showed that despite of some increased incidence in 1985–1990 in the region the tendency to stabilization and even decrease is observed (Table 1).

Table 1

Total rates of incidence of mesothelioma on Sverdlovsk region

Rates	Period of observation, years					Total
	1981–1985	1986–1990	1991–1995	1996–2000	2001–2004	
Absolute	20	39	25	21	20	125
Incidence per 1 million per year	0.88	1.67	1.04	0.97	1.11	1.11
The portion of patients with mesothelioma in total regional cancer morbidity, %	0.036	0.063	0.039	0.032	0.036	0.041
The portion of patients with pleural mesothelioma in total regional respiratory cancer morbidity, %	0.19	0.31	0.21	0.19	0.25	0.23

Mesotheliomas were revealed in 32 from 55 municipal units of Sverdlovsk region. The bulk of neoplasmes was diagnosed in municipal unit Yekaterinburg — 50 cases (40.0 %), Asbest — 12 cases (9.6 %), Serov and Pervouralsk — 7 cases (5.6 %) and Kamensk-Uralsky — 6 cases (4.8 %) (Figure).

The incidence varied from 0.2 (Nizhny Tagil) to 27.1 cases per 1 million per year (Novoasbest), at an average 1.1 cases per 1 million per year for the period of study. In 16 (50 %) municipal units and in the region as a whole an average incidence of mesothelioma is agreed with global background level, i.e. 1–2 cases per 1 million per year.

In areas with enterprises on mining and manufacture of asbestos the incidence varied from 4.3 (Asbest — mining of chrysotile) to 27.1 cases per 1 million per year (Novoasbest — mining of crocidolite), and in Sysert antophillit province the incidence was 7.1 cases per 1 million per year. In towns Sukhoy Log and Beloyarsky, where enterprises «Sukholozhskasbocement» and «Beloyarskaya factory on asbestos board production» (which use chrysotile asbestos) are situated, mesotheliomas were not revealed.

Occupational exposure to asbestos was revealed only in 15 (12.0 %) patients (Table 2). During labour activity 11 (8.8 %) patients occupationally contacted with chrysotile asbestos and 4 (3.2 %) patients — with amphiboles, including 3 patients contacting with crocidolite and one patient contacting with tremoilite. 7 from 15 patients worked at «Uralasbest», JSC (chrysotile), three patients — at mining and concentration complex Anatolyevsky (crocidolite) and three patients — at different motor transport enterprises in Yekaterinburg (chrysotile). One patient worked at talc plant Shabrovsky (tremolite) and one patients worked at «UralATI», JSC (chrysotile).

The age of patients with occupational exposure to asbestos varied from 37 to 75 years, at an average 55.7±2.6 years and was equal to corresponding figures for all patients with mesothelioma (55.9±.0 years). The age of patients at the first contact with asbestos varied from 18 to 27 years, at an average 21.5±1.1 years; and work experience varied from 3 months to 45 years, at an average 21.3±3.2 years. Mesotheliomas developed during 13–68 years after beginning of exposure, at an average — after 33.9±3.8 years. It is important to note that occupational activity of patients with occupational exposure to asbestos in all cases was in conditions of high levels of exposure, which were common to 50–60s years of the XXth century [11].

The labor activity of patients not associated with asbestos was presented by wide range of occupations, including 46 workers (36.8 %), 17 technologists (13.6 %), 13 clerks (10.4 %), 9 medicine workers (7.2 %) and 7 scientific workers (5.6 %). In 15 patients (12.0 %) the area of working activity wasn't revealed but at they didn't work at enterprises on mining, processing and manufacture of asbestos on Sverdlovsk region. In one case (0.8 %) the patient with malignant mesothelioma was 12-years-old boy.

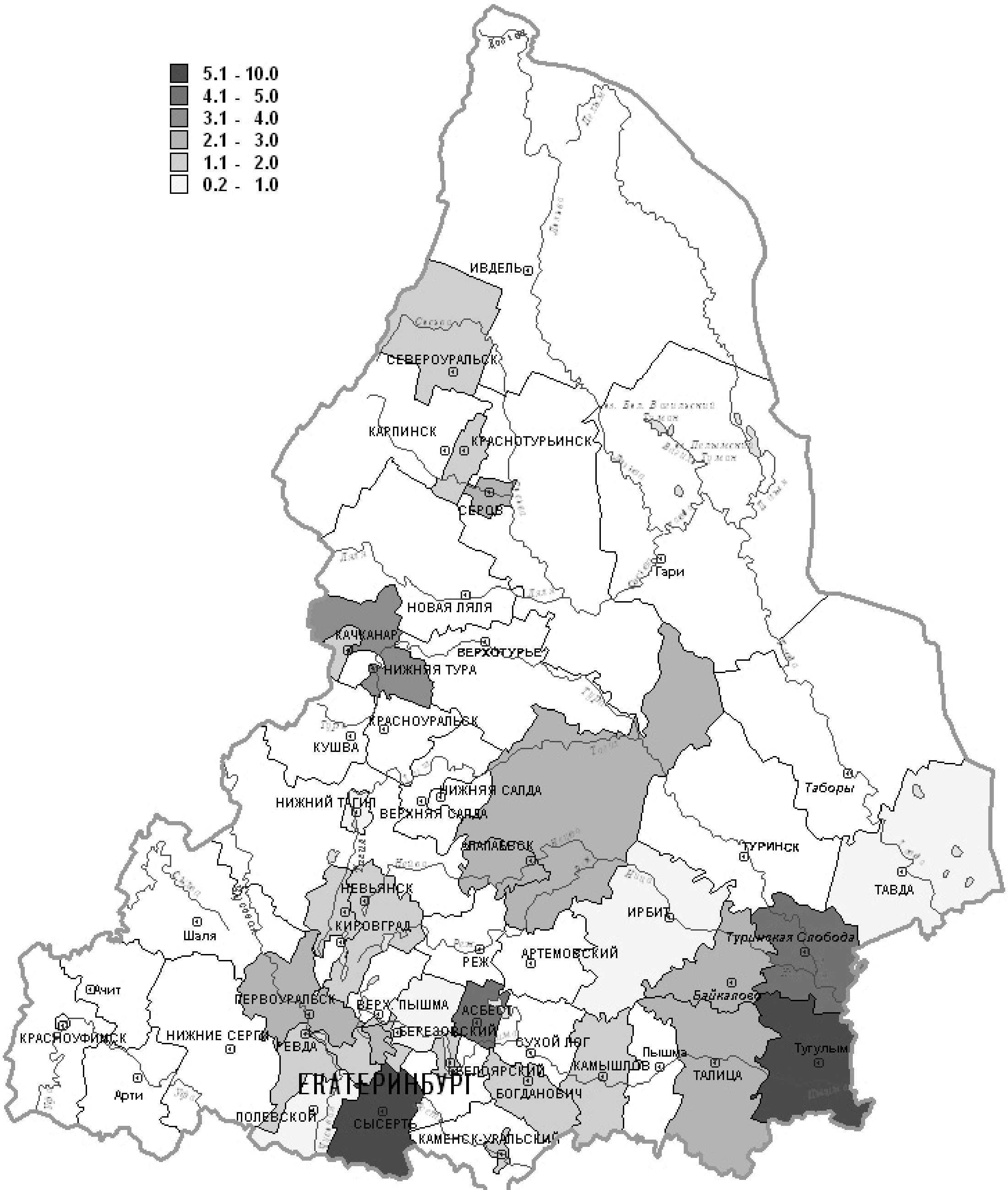


Fig. The incidence of mesothelioma in municipal units of Sverdlovsk region

Among nonprofessional occupations during labour activity not associated with asbestos but with different harmful factors the most patients with mesothelioma occupationally contacted with substances, products, industrial processes and factors, potentially causative for mesothelioma: nickel, chrome, smut, man-made mineral fibres, and radiological agents.

Differences in age, sex and localization at the diagnosis in cases occupational malignant and benign mesotheliomas were not statistically significant.

Life expectancy of patients with occupational exposure to chrysotile asbestos from the diagnosis of malignant mesothelioma was 5.4±1.3 months; and for amphiboles — 6.5±2.2 months, and in both cases this figure was statistically significantly lower ($p<0.01$) than for patients without exposure to asbestos.

Some features of development of malignant mesothelioma in patients with occupational exposure to different types of asbestos are shown in the Table 3.

Table 2

Occupational activity of patients with mesothelioma

Occupational activity	Number	
	Absolute	%
Associated with asbestos: automechanic, borer in mine, driver, screener, laboratory assistant, machinist of mineral processing equipment, carman, maintenance fitter, electrician	15	12.0
Not associated with asbestos but with different harmful occupational factors: gas welding operator, doser, tool maker, bricklayer, assembler, checker inspector, woodcutter, painter, metallurgist, mechanic, glazer, field engineer, brancher, vegetable grower, felt boot manufacturer, foreman, operator, maintenance fitter, maintenance fitter, joiner, builder, turner, tractor operator, filter operator in production of alumina, moulder, mine worker, electrician	46	36.8
Not associated with asbestos and without harmful occupational factors: accountant, military man, physician, geologist, parlormaid, dispatcher of aircraft-traffic control station, canteen manager, engineer, cameraman, constructor, laboratory assistant, nurse, musical worker, butcher, research assistant, cook, salesman, telephonist, charwoman of shop floor, medical assistant, seamstress, economist.	48	38.4
Pupil	1	0.8
The data on occupational activity are absent but patients didn't work at enterprises on mining and manufacture of asbestos	15	12.0
Total	125	100.0

Table 3

Some data of occupational history in patients with malignant mesothelioma with exposure to asbestos, M±m (variations)

Feature, years	Contact with asbestos		Statistically significant differences. p<
	Chrysotile	Amphiboles	
Mean age at the diagnosis	63.0±2.5 (55–75)	48.3±2.7 (41–53)	0.05
Mean age at the first contact with asbestos	22.3±0.6 (18–21)	19.3±0.3 (19–20)	0.05
Mean work experience with asbestos	25.8±2.5 (10.5–45)	10.2±3.0 (5–18)	0.05
Period from the first contact with asbestos to development of the disease	36.6±5.2 (13–57)	26.7±4.2 (22–35)	–
Dust burden for a whole period of occupational contact. grams	609.0±61.2 (292.7–1062.6)	205.4±78.1 (72.6–369.4)	0.05

As the table 3 suggests in the group of patients with the exposure to amphibole asbestos mesotheliomas statistically significantly ($p<0.05$) developed in earlier age, with less work experience and virtually in 3 times lower dust load, than in the group of patients with exposure to chrysotile asbestos. Malignant neoplasms also were diagnosed after shorter time from the first contact with asbestos, but in that case the differences were not statistically significant.

Conclusions

1. The first Russian integrated epidemiological study of mesothelioma in Sverdlovsk region showed that an average incidence of mesothelioma is agreed with global background level, i.e. 1–2 cases per 1 million per year.
2. Asbestos, particularly, chrysotile is not a leading, and moreover obligate causative factor for development of the disease. The disease has got pluricausal nature.

References

1. *Wagner J.C., Sleggs C.A., Marchand P.* Diffuse pleural mesothelioma and asbestos exposure in the Northwestern Cape Province // British journal of industrial medicine. — 1960. — Vol. 17. — № 4. — P. 260–271.

2. Malignant mesothelioma: advances in pathogenesis, diagnosis, and translational therapies / Edited by Pass H.I., Vogelzang N., Carbone M. — Springer: New York, 2005. — 854 p.
3. Chrysotile asbestos: Environmental Health Criteria 203. — World Health Organization. — Geneva, 1998. — P. 106–128.
4. Asbestos and other natural mineral fibres: Environmental Health Criteria 53. — World Health Organization. — Geneva, 1986. — P. 11.
5. *Bianchi C., Brollo A. et al.* Malignant mesothelioma in Central and Eastern Europe // Acta Medicina of Croatia. — 2000. — Vol. 53. — № 4–5. — P. 161–164.
6. *Kogan F.M., Berzin S.A.* Incidence of pleural mesothelioma under impacts of chrysotile asbestos dust // Occupational hygiene and occupational diseases. — 1986. — № 9. — P. 9–12.
7. *Kashansky S.V., Tomilova N.E. et al.* Mesothelioma incidence in Yekaterinburg (preliminary report) // Current problems of preventive medicine in Ural region: collection of scientific papers and scientific-practical work, dedicated to 80th anniversary of Russian sanitary and epidemiological service. — Yekaterinburg, 2002. — P. 139–143.
8. *Romanchuk I.Y.* Impact of occupational exposure on cancer morbidity of inhabitants of republic of Karelia // Materials of the International seminar of working group on cooperation under the program «Asbestos», May 18–20, 1999, Petrozavodsk. — Petrozavodsk, 1999. — P. 13–23.
9. *Fedosenko N.E.* Mesothelioma in Sverdlovsk region // Issues on cancer care facilities at the stage of reforming of public health service [collected works]. — Yekaterinburg, 1996. — P. 28–29.
10. *Shaburov A.P., Kashanskiy S.V., Kashanskaya E.P.* Occupational oncopathology in Sverdlovsk region (preliminary results) // Current issues of preventive medicine, environment and public health in industrial regions in Russia: Collection of scientific papers, dedicated to 75th anniversary of foundation of Yekaterinburg medical research center for prophylaxis and health protection of industrial workers. — Yekaterinburg, 2004. — P. 414–421.
11. *Kashanskiy S.V., Scherbakov S.V., Kogan F.M.* Dust levels in workplace air (a retrospective view of «Uralasbest») // Treatment and prevention of asbestos diseases: Volume 15 of the sourcebook on asbestos diseases: medical, preventive, and socio-economic aspects. — Edit. Peters G.A. and Peters B.J. — LEXIS® Law Publishing, 1997. — P. 337–354.

UDC 016:553.676

Recent international medical research on asbestos concerning the use of chrysotile

Хризотилдың қолдануына қатысты асбест туралы ең жаңа халықаралық медициналық зерттеулер

Kochelayev V.A.

Non-profit Organization «Chrysotile Association», Asbest, Sverdlovsk Region (E-mail: sec2@uralasbest.ru)

Мақалада ең жаңа медициналық зерттеулердің нәтижелеріне шолу жасалған. Бұл зерттеулерді 1998–2009 жылдар аралығында әр түрлі мемлекеттердің ғалымдары өткізген, мысалы, Австрия, Ұлыбритания, Греция, Израиль, Литва, Польша, Украина, ЮАР және тағы басқалары. Автордың ойынша, ең жаңа медициналық ғылыми мәлімет және практикалық тәжірибе нәтижесінде, өндірісте қауіпсіздік ережелерді сақтау айтулы кәсіптік асбесттен болған ауруларды азайтуға кепіл бола алады.

В статье сделан обзор результатов новейших международных медицинских исследований, касающихся возможности безопасного использования в контролируемых условиях хризотил-асбеста, его биологической активности в сравнении с амфиболами. Исследования проведены в 1998–2009 гг. учеными разных стран: Австрии, Великобритании, Греции, Израиля, Литвы, Польши, Украины, ЮАР и др. Новейшие медицинские научные данные и практический опыт, по мнению автора, подтверждают, что соблюдение правил безопасности на производстве гарантирует минимизацию случаев профессиональных асбестообусловленных заболеваний.

Asbestos is a common name of six natural fibrous minerals used in industrial products. There are two groups of these minerals: serpentine (chrysotile) and amphibole (crocidolite, amosite, anthophillite, tremolite, and actinolite).

Particularly in the past decade the issue of health effects of these groups of minerals has become the topic of numerous discussions when it became the focus of numerous very different interests: medical, environmental, commercial, political, etc. Further in this article the question will be only about chrysotile since the use of amphiboles is banned by ILO Convention No.162 on Safety in the Use of Asbestos [1].

Continuing discussions in the world scientific society are mainly related to the question whether the levels of exposure to chrysotile corresponding to the current normatives, at the modern level of equipment and technology in the production of chrysotile and chrysotile-containung materials and products, in the availability of known methods applied for prevention, can cause an increased risk of cancer diseases?

The answers to these questions concern not only the future of chrysotile workers but also of billions of people in the world in need of affordable shelter and pure drinking water. (Chrysotile is one of the components used for the production of slate, the most popular and affordable roofing material for the general population, and the most hygienic, according to the WHO, and cheap chrysotile cement pipes).

To answer these questions, in the second part of the 20th century a lot of studies of health effects of asbestos were conducted. Yet, the majority of researchers did not differentiate the risks of its different types. Only in the past decade many scientists have recognized the necessity to differentiate risks of exposure to chrysotile and amphiboles and to assess the true hazard of the use of pure chrysotile under controlled conditions.

Below are given the conclusions of scientists based on results of recent epidemiologic studies of health effects of pure chrysotile published during 1998–2011.

First of all, the study ***«Occupational exposure to asbestos and man-made vitreous fibers and risk of lung cancer: a multicenter case-control study in Europe»*** conducted in 1998–2002 under the guidance of the International Agency for Research on Cancer [2].

Seventeen scientists from leading institutes of 11 countries including the U.K., Hungary, Israel, New Zealand, Poland, Russia, Romania, Slovakia, France, the Czech Republic, and Sweden took part in it.

Both occupational and socio-demographic information about 2,205 incident male lung cancer cases and 2,305 controls was collected in the study. The study subjects included residents of the U.K. and of 16 towns of six countries of Central and Eastern Europe.

Based on the study results the researchers concluded that:

– no increased risk of lung cancer related to chrysotile was found in the countries of Central and Eastern Europe. (Notes from the author: the countries of Central and Eastern Europe mostly used chrysotile from the USSR and very small amounts of amphiboles; spraying of asbestos was not applied.);

– an increased risk of lung cancer was registered among the Englishmen exposed to amphiboles.

A number of studies was conducted by scientists at asbestos cement plants in Poland and Lithuania used pure chrysotile asbestos.

The study «***Mortality of workers at two asbestos-cement plants in Poland»*** was published in the International Journal of Occupational Medicine and Environmental Health in 2000 [3]. The plants using pure chrysotile only were the study object. The scientists concluded that no increased risk of lung cancer was found in the cohort of workers.

The study ***«Cancer mortality and morbidity among Lithuanian asbestos-cement producing workers»*** was published in the Scandinavian Journal of Work, Environment & Health in 2004 [4]. The main conclusion drawn by the researchers was that no increased risk of lung cancer was found when studying disease incidence rates at two Lithuanian asbestos-cement plants using pure chrysotile.

Most often authors of anti-asbestos publications indicate a close relationship between asbestos (without differentiation on types) and mesothelioma (a rare form of cancer) as proved by the predictions for Europe published in 1999 over the next 35 years [5].

A large epidemiologic study «***Three decades of pleural cancer and mesothelioma registration in Austria where asbestos cement was invented»*** was carried out in 2003 [6]. The priority of the invention of asbestos cement in 1901 and the onset of its production belongs to this country.

The scientists analyzed pleural cancer incidence and mortality rates for the previous 30 years (1970–2001) in Austria and concluded that:

– predictions were based on data from the U.K. and six other countries that widely used amphibole asbestos. Besides, some dubious methods of overdiagnosis were applied in calculations;

– in Austria there were no reasons to expect a significant increase in the number of mesothelioma cases in the future since the use of asbestos there had been always controlled better than in the countries where the predictions were made;

– a smaller increase in the mesothelioma rate was determined by different types of asbestos used;

– the predictions were far-fetched, and their extrapolation to other countries was erroneous.

The study ***«South African experience with asbestos-related environmental mesothelioma. Is asbestos fiber type important?»*** was published in 2007 by U.S. scientists [7].

The researchers analyzed four studies covering the period of 1976–1992. It should be noted that South Africa was the world largest producer of amphibole asbestos (280 thousand tons of crocidolite and amosite per year) and its main exporter to Western Europe and the USA. At the same time, about 100 thousand tons of chrysotile asbestos were mined there annually.

The researchers concluded that:

– the relationship between amphiboles and mesothelioma was obvious;

– no chrysotile-induced cases of mesothelioma were found.

The study ***«Mortality from occupational exposure to relatively pure chrysotile: a 39-year study»*** was published in 2008 by Greek scientists [8].

Having analyzed the data for almost 40 years the authors found that:

– no mesothelioma cases were registered;

– the general mortality rate of the workers was much lower than that of the general population in Greece;

– the occupational exposure to a relatively pure chrysotile within permissible levels was not related to a significant increase in lung cancer or mesothelioma rates.

«Complex clinical hygienic and epidemiologic studies of labor conditions and health of workers of ten asbestos-cement Ukrainian plants» were conducted in 2006–2008 by the Research Institute of Occupational Medicine of the Ukrainian Academy of Medical Sciences headed by Academician Yu.I.Kundiyev [9]. This work is of particular interest since only chrysotile asbestos from Russia and Kazakhstan has been always used in the Ukraine.

Epidemiologic studies helped establish the rates and risks of cancer among workers (30660 person-years) of asbestos-cement industries in 1996–2005. The results were as follows:

– the annual cancer incidence rate was 88.1 per 100,000 workers (RR = 0.26), i.e. 3.8 times lower than the rate for the general population;

– compared to the regional levels, the relative risk in the industries studied ranged 0.06 to 0.67.

Of great importance are the studies of ***the biological persistence*** of fibers conducted by scientists from Switzerland, Germany, and the USA in 1999–2006 [10]. They made unique laboratory experiments on animals showing that inhaled chrysotile fibers are quickly cleared from lungs whereas amphibole fibers resistant to the acidic lung medium are retained in them for the period of one year and over. Those studies have become an important basis for the kinetic and pathological substantiation of differences between chrysotile and amphibole fibers. The scientists established that the toxicology of chrysotile that is easily disintegrated in lungs into many small particles was comparable to that of non-fibrous minerals, whereas the toxicology of amphiboles is the response to their fibrous insoluble structure.

The authors established that the clearance half-time of asbestos fibers longer than 20 μm was: tremolite — ∞; crocidolite — 536 days; amosite — 418 days; chrysotile — 0.3–11 days.

For comparison the researchers reported data on the clearance half-time of mineral fibers > 20 μm that are used as chrysotile substitutes and claimed to be safe by their manufacturers: ceramic fibers — 55 days; fiberglass — 6–79 days; rockwool — 5–67 days; para-aramid fibers — 45 days; cellulose fibers — 1046 days.

In this regard it should be noted that the Directive of the European Commission on Man-Made Mineral Fibers (1997) states that if long fibers are easily dissolved or broken apart and cleared from lungs they have no carcinogenic effect. Among all mineral fibers the solubility of **chrysotile** is the best.

Naturally, the scientists wondered why animal studies of pure chrysotile usually showed a high cancer incidence rate. The answer was provided by toxicology studies: the long-term inhalation exposure of animals to chrysotile was, as a rule, very high compared to that under modern labor conditions. In this connection their relevance to human exposures is extremely low.

Toxicological studies of fibers *in vitro* are often very useful to establish possible mechanisms of pathogenesis; yet, their results are very difficult to interpret as they do not account for differences in solubility of different fibers. High doses of fibers are used in the experiments to get the positive result but it is very difficult to extrapolate it to low exposures that occur *in vivo.*

To prove that the authors conducted an experimental study on laboratory animals with different exposures to chrysotile and obtained the following results:

– no fibrosis was observed following the 90-day exposure to chrysotile fibers > 20 μm at the average concentration of 76 f/cm^3 and 92 post-exposure days;

– a slight fibrosis was observed following the exposure at 207 f/cm^3, L > 20 μm.

The researchers came to the following conclusions: a long-term exposure to sufficiently high concentrations of chrysotile-containing or any other mineral dust has a potential to induce a professional disease including cancer. If the exposure levels are low, human lungs can cope with inhaled short fibers and particles well.

«Quantification of the pathological response and fate in the lung and pleura of chrysotile in combination with fine particles compared to amosite-asbestos following short-term inhalation exposure» is a continuation of the above study [11].

The authors describe the results of this work in the Abstract:

«The marked difference in biopersistence and pathological response between chrysotile and amphibole asbestos has been well documented. This study is unique in that it has examined a commercial chrysotile product that was used as a joint compound. The pathological response was quantified in the lung and translocation of fibers to and pathological response in the pleural cavity determined. This paper presents the final results from the study. Rats were exposed by inhalation 6 h/day for 5 days to a well-defined fiber aerosol. Subgroups were examined through 1 year. The translocation to and pathological response in the pleura was examined by scanning electron microscopy and confocal microscopy (CM) using noninvasive methods. The number and size of fibers was quantified using transmission electron microscopy and CM. This is the first study to use such techniques to characterize fiber translocation to and the response of the pleural cavity. Amosite fibers were found to remain partly or fully imbedded in the interstitial space through 1 year and quickly produced granulomas (0 days) and interstitial fibrosis (28 days). Amosite fibers were observed penetrating the visceral pleural wall and were found on the parietal pleural within 7 days postexposure with a concomitant inflammatory response seen by 14 days. Pleural fibrin deposition, fibrosis, and adhesions were observed, similar to that reported in humans in response to amphibole asbestos. No cellular or inflammatory response was observed in the lung or the pleural cavity in response to the chrysotile and sanded particles (CSP) exposure. These results provide confirmation of the important differences between CSP and amphibole asbestos».

On the basis of the aforesaid the conclusions can be drawn that the results of the studies conducted by scientists from Russia, the Ukraine, Austria, the United Kingdom, Lithuania, Poland, Germany, the USA, and other countries show their practical identity that the risk of developing a professional disease is negligible by using pure chrysotile under control. At the same time the studies show a high risk of negative consequencies of using amphiboles.

But different anti-asbestos organizations still create an atmosphere of fear and even psychosis around the use of chrysotile. For this purpose they carry out powerful PR-actions by using mass media, at numerous international seminars and conferences in different countries. Unfortunately, without delving into essence of arguments of one of the parties that is substantiating the possibility of a safe use of the mineral by scientific studies (in 60 countries of the world chrysotile has been used for over 100 years) some officials from international organizations have agreed with the arguments of initiators of the anti-asbestos campaign, the goal of which is to ban the use of all types of asbestos including chrysotile on an international scale.

On the basis of the results of the above recent scientific studies there are no doubts that the anti-asbestos campaign is mostly based on unreliable, flawed in essence and often false predictions of the future epidemics of asbestos-related diseases, for example, in 1980 and then in 2000. Now predictions relate to 2020–2050.

Unfortunately, predictions are taken by the public very seriously, and the anti-asbestos campaign distracts attention from real factors having a negative impact on the health.

Today, when over 30 years have passed after the first predictions, we can state that they have nothing to do with reality. The predictions are nonexistent, nobody can even remember them, but the produced asbestos scare is still there in people holding no information about scientific evidence.

Many of the above studies were conducted by scientists from the countries that had already banned asbestos. So the question is how justified the bans are? The answer is practically unequivocal: in all these countries political decisions to ban asbestos were first made and only after that people began to try to find out medical grounds for it. The asbestos scare intensively forced by certain circles is frequently perceived by some politicians without any analysis of its negative influence on the national economy, on the solution of social problems of the society.

It is no wonder that in October 2007 the American Council on Science and Health in its position paper «Asbestos exposure: how risky is it?» [12] stated: «The challenge today is whether regulatory agencies will utilize current scientific knowledge even though it will necessitate a paradigm shift in long-held views on asbestos exposure and its implications for human health».

References

1. ILO Convention № 162 «On Safety in the Use of Asbestos», 1986 y. // decentwork.ru/library/conv162.html
2. *Carel R., Olsson A.C. et al.* Occupational Exposure to Asbestos and Man-made Vitreous Fibers and Risk of Lung Cancer: A Multicenter Case-control Study in Europe // Occup. Environ. Med. — 2006. (published as 10.1136/oem.2006.027748 in oem.bmj.com, October 19).
3. *Szeszenia-Dabrowska N., Wilczynska U., Szymczak W.* Mortality of workers at two asbestos-cement plants in Poland // Int. J. Occup. Med. Environ. Health. — 2000. — № 13. — P. 121–130.
4. *Smailyte G., Kurtinaitis J., Andersen A.* Cancer mortality and morbidity among Lithuanian asbestos-cement producing workers // Scand. J. Work, Environ. Health. — 2004. — № 30. — P. 64–70.
5. *Peto J., Decarli A. et al.* The European mesothelioma epidemic // Br. J. Cancer. — 1999. — № 79. — P. 666–672.
6. *Neuberger M., Vutuc C.* Three Decades of Pleural Cancer and Mesothelioma Registration in Austria where Asbestos Cement was Invented // Int. Arch. of Occup. and Environ. Health. — 2003. — № 76. — P. 161–166.
7. *White N., Nelson G., Murray J.* South African experience with asbestos related environmental mesothelioma: Is asbestos fiber type important? // Regul. Toxicol. and Pharmacol. — 2008. — P. 92–96.
8. *L.Sichletidis D., Chloros D. et al.* Mortality from Occupational Exposure to Relatively Pure Chrysotile: A 39-Year Study. Respiration, Published Online: October 9, 2008. // http://content.karger.com/ProdukteDB/produkte.asp7Aktion=AcceptedPapers&ProduktNr=224278
9. *Cherniuk V.I., Kucheruk T.K. et al.* Is it possible to use chrysotile asbestos safely? Ukrainian perspective. — Kyiv, 2008.
10. *Bernstein D.M., Hoskins J.A.* The health effects of chrysotile: Current perspective based upon recent data // Regulatory Toxicology and Pharmacology, 2006. — P. 252–264.
11. *Bernstein D.M., Rogers R.A. et al.* Quantification of the pathological response and fate in the lung and pleura of chrysotile in combination with fine particles compared to amosite-asbestos following short-term inhalation exposure // Inhalation Toxicology. — 2011. — № 23(7). — P. 372–391.
12. Asbestos exposure: How risky is it? A position paper of the American Council on Science and Health // URLs: http://www.acsh.org http://www.HealthFactsFears.com October 2007.

UDC 616.24–002.153:616–003.667.6

Features of prevention and rehabilitation of asbestos-related bronchopulmonary diseases in workers exposed to chrysotile

Асбест өндірісінде істейтін жұмыскерлердің асбестке байланысты болған өкпе аурулардың алдын алу және айықтыру жолдарын жетілдіру

Plukhin A.E., Bourmistrova T.B.

Research Institute of Occupational Health of the Russian Academy of Medical Sciences, Moscow, Russia,
(E-mail: lorik2006.06@mail.ru)

Авторлар асбест өндірісінде істейтін жұмыскерлерде асбестке байланысты болған өкпе аурулардың алдын алу жолдары мен айыықтырудың негізгі жағдайларын тұжырымдайды. Асбест әсерінен болған ауруларды жоюға барлық медициналық және техникалық шараларды үндестіруге айрықша көңіл бөлінді, сондай-ақ бұл ауруларды жою бағдарламасын әзірлеу маңызды қоғамдық-экономикалық міндет болып табылады. Бұл міндет асбест жұмысшыларына сапалы медициналық қызмет көрсетуге бағытталған барлық медициналық және техникалық шаралардың элементтерін ықпалдастыруын ескереді.

В статье указаны основные критерии для постановки диагноза связанных с асбестом заболеваний легких и признаки воздействия асбестсодержащей пыли, определены группы риска для бронхолегочных заболеваний. Авторы сформулировали основные положения профилактики и реабилитации связанных с асбестом заболеваний легких у работников асбестовой промышленности. Особое внимание уделено гармонизации всех медицинских и технических мер по предупреждению и ликвидации болезней, вызываемых асбестом. Разработка национальной программы по предупреждению и ликвидации связанных с асбестом заболеваний является наиболее важной социально-экономической задачей, которая предусматривает интеграцию и согласование всех элементов медицинских и технических мер, направленных на улучшение качества медицинского обслуживания работников асбестовых производств.

Introduction

The problem of asbestos-related lung diseases remains urgent although many foreign and domestic studies, including hygienic, epidemiologic, and clinical X-ray studies, have been devoted to this issue.

Only chrysotile asbestos is produced and applied in Russia. Russia has a perspective source of raw chrysotile prepared of a long-term exploitation [1]. Over 40 thousand workers are exposed to asbestos dust.

The main industries with potential occupational exposures to asbestos dusts include asbestos mining and milling and the production of asbestos-containing products (asbestos-cement, asbestos technical and asbestos textile materials).

The main asbestos consumer today is the production of asbestos-cement products (corrugated and flat sheets, pipes, etc.) that are widely used in industrial and civil construction.

Other widely used asbestos-containing materials include asbestos-containing noise and heat insulation — molded products, friable covers (asbestos perlite, vermiculite, etc.) that are prepared in place by mixing asbestos with different fillers; asbestos board; asbestos-technical friction products — clutches, brake linings and pads, etc.; asbestos textile products — fabric, cords, gaskets and pads, etc. It is also possible to use asbestos in the product of asphalt, bituminous mixtures and many other materials and products.

The exposures to asbestos dust above the exposure limits can be observed at various types of activities related to installation, maintenance, alteration, and removal of asbestos-containing building materials, especially of low-density insulation in many industries (construction of industrial and civil objects, energetic, ferrous and non-ferrous metallurgy, glass industry, shipbuilding, etc.) [2]. This fact should be taken into consideration when planning and conducting pre-exposure and periodic preventive medical check-ups.

The main occupations with potential high exposures to chrysotile include asbestos miners and millers, insulation workers (including those involved in shipbuilding) and other builders who apply, repair or remove chrysotile-containing heat and noise-insulation materials. Exposures to high concentrations of chrysotile fibers are also possible in the manufacture of asbestos textiles, asbestos cement and asbestos technical products, during some operations, e.g. mixing of basic components, if the established safety measures are neglected [1].

The exposure to amphibole fibers that poses a much higher health risk for workers even at minimal levels compared to chrysotile fibers is possible during maintenance and repair of ships built abroad [1].

A long-term exposure to chrysotile dust above the exposure limits and even to minimal concentrations of amphiboles can increase the risk of asbestos-related bronchopulmonary diseases, transform clinical and X-ray manifestations, the clinical course and outcomes of asbestos-related diseases. Distinctive features of the development and clinical course of asbestos-related diseases make it necessary to take preventive actions in order to eliminate them. The main direction of prevention of occupational asbestos-related lung diseases nowadays is the development of criteria of health disorders based on early and reversible changes preceding the manifestation of apparent clinical signs and syndromes in comparison with the total asbestos exposure [3]. The basis for medical prevention is the development of criteria of risk of lung diseases, early detection and timely rehabilitation in case of asbestos exposure [4]. Rehabilitation actions aimed at a complete health recovery in workers with primary disorders of various organs and systems [3, 5] and at preserving work potential should be based on rehabilitation medicine aimed at improving workers' health and raising functional reserves.

With this goal in view we analyzed the results of an in-depth clinical, X-ray, laboratory, and functional examination and of hygienic studies of 771 persons with different asbestos-related diseases and signs of health disorders that can be related to asbestos exposures.

On the basis of obtained data we established the most significant criteria of effect of asbestos dusts on respiratory organs — from the initial signs of effect to the development of the pathologic process. This allowed us to substantiate and define three risk groups by the development of bronchopulmonary pathology in workers following the asbestos exposure:

– The first risk group includes workers at risk of bronchitis: patients complain of inconstant nonproductive cough, exercise dyspnea; at auscultation rough breathing is heard and a positive forced expiratory spirogram is sometimes noted, in some cases — the decrease in the rates of the respiratory function to Stage 1.

– The second risk group includes workers at risk of asbestosis: early diffuse changes in the lung parenchyma (profusion 0/1 and 1/0) are determined during the X-ray examination, peribronchial sclerosis in the middle and lower lung compartments, early isolated changes of the visceral pleura (interlobar, costal and diaphragmatic) and possible early restrictive impairment of the respiratory function.

– The third risk group includes individuals with presumable asbestosis (0–1): early diffuse lung fibrosis (profusion 1/1) is determined during the X-ray examination, without changes or with prevalent blurred lesions of the visceral pleura, isolated changes of the parietal pleura; patients complain of inconstant dry cough, exercise dyspnea, and early restrictive impairment of the respiratory function.

In order to develop systematic measures for prevention, medical rehabilitation and detection of early signs of exposure to asbestos dust we analyzed results of mass prophylactic examinations of 774 workers involved in asbestos mining, milling, and the production and use of asbestos-containing products. In accordance with the defined risk groups we took into account the frequency and prevalence of signs of effect of asbestos dust on respiratory organs of the workers, the number of diagnosed asbestos-related bronchopulmonary diseases among the examined workers of various production groups, and the analysis of asbestos dust concentrations at workplaces.

Individuals of the first and second risk groups by the development of bronchitis and chrysotile asbestosis are subject to case follow-up with an in-depth clinical examination. The risk group including individuals with presumable chrysotile asbestosis is the third group requiring the verification of X-ray changes in lungs in hospital environment.

The analysis of results of mass prophylactic examinations of 774 workers involved in production (the Mining and Ore Dressing Companies «Tuvaasbest» and «Orenburgasbest», the Sukholozhsky Plant of Asbestos-Cement Products) by taking into account clinical functional and X-ray criteria specified by us for the development of bronchopulmonary pathology helped define the risk groups for the development of bronchitis and chrysotile asbestosis, presumable chrysotile asbestosis (0–1) and the groups with bronchopulmonary pathology: professional bronchitis and chrysotile asbestosis (Table 1).

The low frequency of workers of the risk group by the development of bronchitis (2.3 %) was noted among the examined workers of all enterprises. Professional bronchitis was diagnosed in 5.3 % of cases and definitely more often in workers of the «Tuvaasbest» Company (7.6 %) than in workers of the «Orenburgasbest» Company (2.2 %). Professional bronchitis was diagnosed in 5.5 % of the examined workers of the Sukholozhsky Plant of Asbestos-Cement Products. Chrysotile asbestosis was revealed in 2.5 % of the examined workers and it was revealed more often in workers of the «Tuvaasbest» Company (4.7 %) with high exposures to asbestos rock dust. Chrysotile asbestosis was revealed in 2.2 % of workers of the Sukholozhsky Plant of Asbestos-Cement Products and chrysotile asbestosis at the «Orenburgasbest» Company was not diagnosed at all.

Table 1

Among the workers of all enterprises the sufficiently high frequency was defined for individuals of the risk groups by the development of chrysotile asbestosis (39.5 %) and to a lesser extent the frequency was defined for individuals with presumable chrysotile asbestosis 0–1 (14.5 %)

				Risk groups by the development of bronchitis	Risk groups by the development of asbestosis	Presumable asbestosis	Occupational bronchitis	Asbestosis	Non-occupational bronchitis
«Tuvaasbest»	278	abs	55±	6	110	46	21	13	27
		%	19.8±2.7	22±0.9	39.6±3.7	16.5±2.4	7.6±1.6	4.7±1.3	9.7±1.8
«Orenburgasbest»	226	abs	47	3	109	32	5	0	30
		%	20.8±3.0	1.3±0.8	48.2±4.6	14.2±2.5	2.2±0.9	0.0	13.3±2.4
Sukholozhsky ACP	270	abs	76	9	87	34	15	6	43
		%	28.1±3.2	3.3±1.1	32.2±3.4	12.6±2.1	5.5±1.4	2.2±0.9	18.9±2.6
Total	774	abs	178	18	306	112	41	19	100
		%	23.0±1.7	2.3±0.5	39.5±2.2	14.5±1.4	5.3±0.8	2.5±0.6	12.9±1.3

In order to reveal early signs of exposure to chrysotile-containing dust and take preventive actions all examined workers of the «Tuvaasbest» and «Orenburgasbest» Companies, the Sukholozhsky Plant of Asbestos-Cement Products were distributed by groups depending on the dust load value (DL) for all years of work (Table 2).

Table 2

The number of workers with a different degree of risk for developing asbestos-related diseases depending on the dust lung load

Risk groups and bronchopulmonary pathology	«Tuvaasbest»				«Orenburgasbest»				Sukholozhsky ACP			
	The total number of workers	Groups depending on the dust load (in grams)			The total number of workers	Groups depending on the dust load (in grams)			The total number of workers	Groups depending on the dust load (in grams)		
		to 50 (n=8)	50–100 (n=25)	>100 (n=245)		to 50 (n=73)	50–100 (n=71)	>100 (n=50)		to 50 (n=145)	50–100 (n=41)	>100 (n=79)
Risk groups by the development of bronchitis	6	0	0	6	3	2	0	0	9	0	4	5
		0.0	0.0	2.4±1.0		2.8±1.9	0.0	0.0		0.0	9.8±4.9	8.9±3.3
Risk groups by the development of asbestosis	110	4	14	92	94	31	39	24	87	30	17	40
		50.0±25.0	56.0±14.9	37.6±1.5		42.5±7.6	54.9±8.8	48.0±9.8		20.7±3.8	41.5±10.0	50.6±8.0
Presumable asbestosis	46	0	3	43	26	4	11	11	34	7	5	22
		0.0	12.0±6.9	17.6±2.7		5.5±2.7	15.5±4.7	22.0±6.6		4.8±1.8	12.3±5.5	27.8±5.9
Occupational bronchitis	21	0	1	20	4	1	1	2	15	4	4	7
		0.0	4.0±4.0	8.2±1.8		1.4±1.4	1.4±1.4	4.0±2.8		2.8±1.4	9.8±2.4	8.9±3.3
Asbestosis	13	0	1	12	0	0	0	0	6	0	0	6
		0.0	4.0±4.0	4.9±1.4		0.0	0.0	0.0		0.0	0.0	7.6±3.1

The analysis of clinical functional and X-ray data depending on the dust lung burden of asbestos miners and millers helped reveal a clear association between the frequency of some signs of asbestos exposure and the dust burden close to 50 grams, which became the critical exposure value for the development of asbestos-related bronchopulmonary diseases. The obtained results give the opportunity to control the development of asbestos-related lung diseases and take timely medical and social measures for their prevention and rehabilitation.

The current system and principles of primary prevention, medical diagnosis and rehabilitation require the improvement of organizing medical and sanitary care for individuals exposed to asbestos.

Medical preventive measures should combine two main directions: conducting pre-exposure and periodic medical examinations in order to prevent the development of bronchopulmonary pathologies, defining groups of workers at risk of asbestos-related diseases, and prescribing preventive rehabilitation of workers at risk to restore the adaptive failure and preserve health.

The analysis of obtained data enables us to substantiate the main provisions and the plan of medical and social measures for prevention and rehabilitation of asbestos-related bronchopulmonary diseases from the position of clinical, X-ray, functional and hygienic criteria:

1. Constant medical surveillance of workers exposed to asbestos dust during the employment and postexposure periods.

2. Timely formation of risk groups taking into account a complex effect of asbestos and other adverse occupational and environmental factors on workers.

3. Special attention to detection of early signs of health effects of asbestos not only in workers of asbestos mines, mills and the production of asbestos-containing materials but also of industries with potential asbestos exposures related to the uncontrolled use of asbestos-containing materials and products.

4. Provision of personal recommendations for preserving and prolonging the ability to work.

5. Provision of personal recommendations for taking preventive and rehabilitative measures.

6. Development of the database on workers' health, starting with the pre-exposure medical examination, with the following accumulation and registration of all health disorders (including results of preventive medical examinations, admissions and results of check-ups) including occupational and somatic diseases.

7. Based on accumulated data and systematization of results a health passport of each worker is created with the purpose of case follow-up.

8. Application of standard documentation for the follow-up and registration with the evaluation of results of preventive medical examinations for timely definition of risk groups and taking preventive and rehabilitation actions aimed at preserving and improving health.

To improve and optimize medical preventive actions for early detection, treatment and rehabilitation of individuals exposed to asbestos, it is necessary to develop medical standards including the plan of medical surveillance of workers (during pre-exposure and periodic medical examinations) and cases of asbestos-related diseases, basic therapy treatment and rehabilitation actions including specific recommendations for sanatorium and spa treatment.

Difficulties in diagnosis and differential diagnosis, in solving expert questions are primarily caused by insufficient equipment of medical units, Centers and departments of occupational pathology with modern X-ray, laboratory, and functional instrumentation. It is also important to note insufficient preparation of occupational pathologists at postgraduate courses on issues of prevention, early detection, diagnosis, treatment, and rehabilitation of asbestos-related diseases.

Nowadays much attention is paid to prevention of asbestos exposure at workplaces and related health changes in the majority of chrysotile mines, mills and in the production of chrysotile-containing products. At the same time, it has been noted that in many industries (primarily in energetic and shipbuilding) insufficient attention is paid to those cases where the uncontrolled use of friable products may pose a real health risk to workers.

The issues of health protection of asbestos workers include training on prevention of respiratory diseases, including asbestos-related diseases. It covers comprehensive health-improving measures aimed at increasing resistance of the organism: healthy lifestyle (no smoking, no alcohol abuse, etc.), going in for sports, healthy nutrition, and timely treatment of colds.

Measures for prevention and elimination of asbestos-related diseases also include basic responsibilities/obligations of asbestos workers:

– workers employed by industries with potential asbestos exposures shall be trained beforehand in accordance with instructions of the enterprise on safety in the use of asbestos;
– according to the Order of the Ministry of Health and the Ministry of Industry of the Russian Federation of 14 March 1996 No. 90 workers employed by industries with potential asbestos exposures shall take a pre-exposure medical examination and regular medical examinations;
– within the limits of their responsibilities and work descriptions workers must contribute to control, prevention and minimization of asbestos concentrations in the work environment. They must report about extraordinary conditions at workplaces and/or situations disrupting the production process;

– workers must periodically participate in educating and instructing programs on occupational safety;
– all workers exposed to asbestos must use personal protective equipment in accordance with typical and departmental standards supplied by the employer;
– workers with frequent colds and somatic diseases are liable to dispensary registration in medical units or local polyclinics because these illnesses may become risk factors of asbestos-related diseases.

Thus, the development of a national program for prevention and elimination of asbestos-related diseases is the most important socio-economic task that envisages integration and harmonization of all elements of medical and technical measures aimed at improving the quality of medical care for asbestos workers.

References

1. Asbestos-related pathology: diagnosis, clinical picture, pathomorphology, prevention and rehabilitation: Handbook for Physicians. — M., 2008. — 67 p.
2. *Domnin S.G., Kashansky S.V. et al.* Asbestos — modern problems of occupational medicine and environmental science // Prevention of asbestos-related diseases: Collected articles. — Asbestos, 2002. — P. 118–122.
3. *Izmerov N.F., Kovalevsky E.V.* Fundamentals of developing of national program for elimination of diseases which depend on asbestos // Occupational Medicine: Implementing the Global Plan of Action for the health of workers in 2008–2017: Proceedings of the All-Russian conf. on the 85th anniversary of the Institute of Occupational Medicine, RAMS. — M., 2008. — P. 116–118.
4. *Kovalevsky E.V.* Assessment of natural and artificial mineral fiber particles in the air, non-production objects // Occupational Medicine and Industrial Ecology. — 2004. — № 1. — P. 10–16.
5. *Razumov A.N., Bobrovnitskii I.P., Shakulov A.V.* Restorative medicine and its role in public health // Bulletin of the Scientific Board of «Medical and ecological problems of workers». — 2004. — № 3. — P. 81–84.

The dynamics of lung cancer incidence rates for the male population of the town of Asbest, Sverdlovsk region

Свердлов облысы Асбест қаласындағы ер адамдардың өкпе ісік ауруларының динамикасы

Kashanskiy S.V.[1], Berzin S.A.[2]

[1]Yekaterinburg Medical Research Center for Disease Prevention and Health Protection in Industrial Workers;
[2]Ural State Medical Academy, Ekaterinburg, Russia (E-mail: hlhdmrc@ymrc.ru)

Свердлов облысы Асбест қаласындағы хризотил асбестке бейімделген және бейімделмеген ер адамдардың өкпе ісік ауруларының 51 жылда (1958–2008) таралуына эпидемиологиялық зерттеулер жүргізілген. Зерттеу нәтижесінде «Ораласбест» ААҚ көлемді шығарылымдарының азаюы нәтижесінде Асбест қаласының экологиялық жағдайы бірден жақсарды. Осыған байланысты соңғы 20 жылдағы зерттеулер нәтижесі бойынша кейінгі 30 жылда ер адамдардың өкпе ісік аураларының тұрақты төмендеуі тіркелген.

В статье проанализировано эпидемиологическое исследование распространенности рака легких у мужчин г. Асбеста Свердловской области за 51 год (1958–2008), профессионально экспонированных и не экспонированных к хризотил-асбесту. Установлено, что в результате уменьшения валовых выбросов ОАО «Ураласбест» произошло кардинальное улучшение экологической ситуации в г. Асбесте, которое через 30 лет привело к устойчивому снижению заболеваемости мужчин раком легких на протяжении последних 20 лет.

The Directive of the European Union 1999/77/EU on the global asbestos ban is based on results of occupational studies and the assessment of risk of asbestos-related respiratory diseases (such as lung cancer, malignant pleural mesothelioma, etc.) in workers since such diseases develop only after 20–40 years from a long-term exposure to high concentrations of asbestos-containing aerosols. At the same time, the results of assessing risks of developing a respiratory malignancy from environmental exposures to low concentrations of chrysotile dust still remain the subject of debate.

A statistically significant increase in the incidence rates of lung cancer and malignant pleural mesothelioma was observed only in the population environmentally exposed to amphibole asbestos [1, 2]. Moreover, primary attention is paid to mesotheliogenic effects of asbestos. Meanwhile, the incidence rate of lung cancer in men is two to three orders of magnitude higher than that of pleural mesothelioma.

According to the data of the Ekaterinburg Medical Research Center for Prevention and Health Protection in Industrial Workers of Rospotrebnadzor the most significant sources of air pollution from the point of view of environmental hygiene are gross emissions from chrysotile mines and mills and fiber emissions from uncultivated tailing dumps, especially dusty ones [3]. We, therefore, conducted an epidemiologic study of respiratory malignancies in men residing in the town of Asbest, Sverdlovsk Region. This town has been chosen as the study object because it is located in the vicinity of the world largest Bazhenovskoye deposit of chrysotile asbestos that has been developed for over 125 years now. The urban population mostly suffers from para-occupational and environmental exposure to chrysotile.

As primary data we used official reports of the Sverdlovsk Regional Cancer Dispensary that contain information about all incident lung cancer cases among men registered in the town of Asbest and the Sverdlovsk Region during 51 years (1958–2008).

The occupational history of the male lung cancer cases in Asbest was established using archive data of the personnel departments of Uralasbest, JSC, UralATI, JSC, and other asbestos industries in Russia and CIS countries. All persons with the registered occupational contact with chrysotile asbestos lasting at least a year were considered occupationally exposed.

Information about the size of population and its sex and age composition was obtained from the Sverdlovsk Regional Statistical Office.

Based on the accumulated data we estimated intensive indicators of the incidence per 100 thousand of the total male population of Asbest, male population of Asbest never employed in the asbestos industry and of the Sverdlovsk Region as a whole. In order to eliminate age differences we performed a direct standardization taking the age-specific structure of the population of the Sverdlovsk Region based on census data for the appropriate year as a *standard.*

To have a clearer understanding of the dynamics of lung cancer incidence rates we compared 5-year averages. The analysis was performed in Microsoft Excel 1997–2003 and STATISTICA v 6.0.

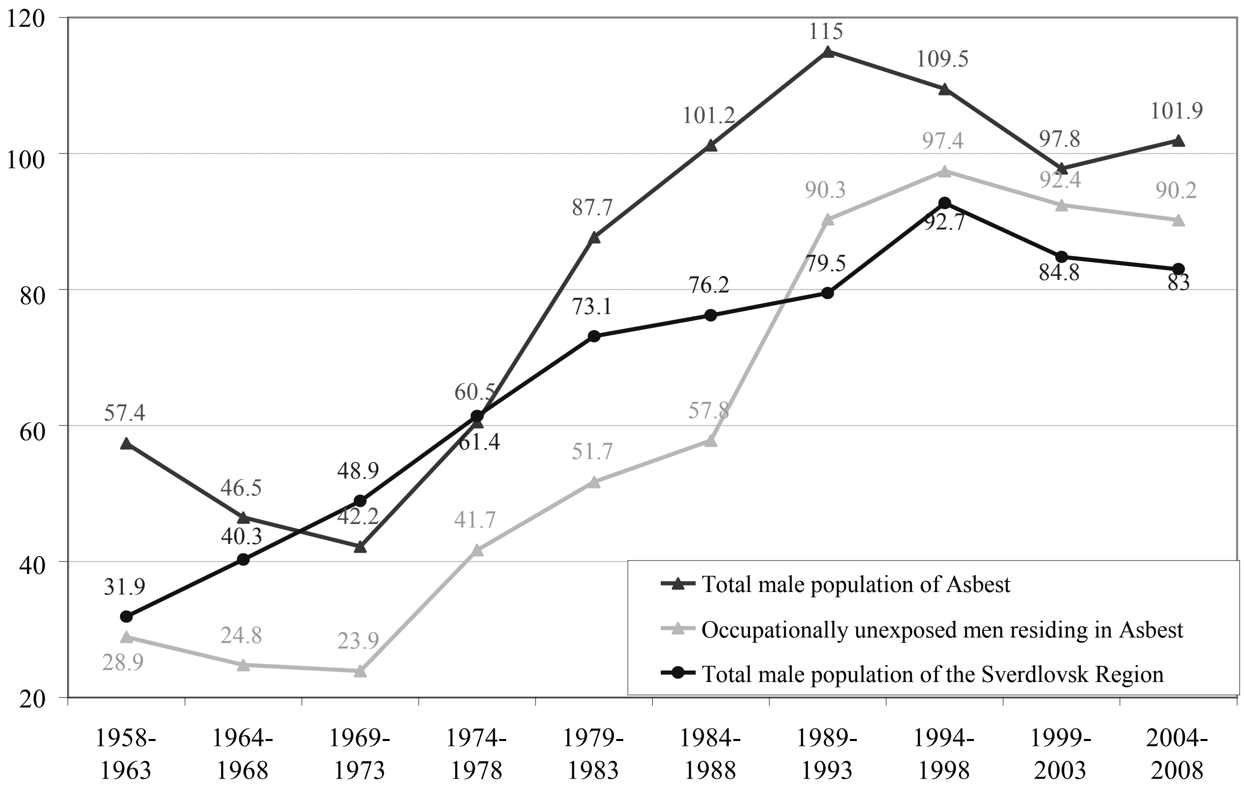


Fig. 1. Lung cancer incidence rates for the male population of the town of Asbest and of the Sverdlovsk Region in 1958–2008, per 100,000

Due to huge emissions of Uralasbest mills in 1930–1940s average airborne dust concentrations in the residential area of Asbest exceeded the then current maximum permissible concentration of 0.5 mg/m^3 by tens and hundreds of times.

A fundamental improvement of the situation was first noted in the town in late 1950s when old factories constructed in the residential area in the end of the 19th and the first part of the 20th century were demolished and new, hygienically and technologically advanced and powerful factories built outside the residential area and having proper sanitary zones were put into operation; at the same time, the existing factories and mills were equipped with effective electric and hose filters. In 1969 the centralized system of pneumatic transport and aspiration with efficiency to purify the contaminated air in hose filters equaling 99.9–99.999 % was installed in Mill No. 6 for the first time in Russia. As a result of this improvement total ambient emissions of asbestos dust dropped from 200 tons per day in 1960 to 5.8 in 2008 (by 34.5 times).

A dramatic improvement of ambient air quality indices was registered in 1994 when Mill No. 5, the last mill located in the residential area of the town, was closed. Complex measures for reduction of industrial emissions in ambient air taken at Uralasbest, JSC led to a significant decrease in ambient air pollution with asbestos dust in late 1990s to concentrations of 0.15–0.17 mg/m^3 and with chrysotile fibers — to 0.02 f/ml, i.e. to the level and below hygienic standards equaling 0.15 mg/m^3 and 0.06 f/ml, respectively.

During that period areal distribution of asbestos dust including chrysotile fibers was uniform across the whole residential area of the town. Average monthly concentrations in samples taken at stationary monitoring sites at distances of 1.0, 2.0, and 2.5 km from the open pit were almost similar. In some daily average samples we found a slight excess of the maximum permissible concentration of asbestos dust but the percentage of such samples was only 15–20 %.

The study of lung cancer incidence in men living in Asbest, both occupationally and environmentally exposed to chrysotile asbestos, showed that not a single case of lung cancer had been registered in the age group under 30.

We found no statistically significant differences in the age structure of lung cancer cases among men residing in Asbest, both occupationally and environmentally exposed to chrysotile, and in the Sverdlovsk Region as a whole. The highest incidence rates (37.0–38.5 %) in all exposure groups were registered in the age group of 60–69 years.

A comparative study of lung cancer incidence rates for men in Asbest and the Sverdlovsk Region showed that in different intervals of this period they varied in a wide range (Fig. 1). During 10 years, 1958–1967, the incidence rate for the total male population of Asbest was 1.3 times higher than that in the Sverdlovsk Region (46.0 vs. 35,2 ‰ on the average for the period). In the following 11 years (1967–1977) the picture changed to the opposite: the incidence rate in Asbest dropped and became 1.2 times lower than that in the Region (41.4 against 50.8 ‰). Only in 1973 the incidence rate in Asbest was 1.4 times higher than that in the region (70.4 vs. 51.2 ‰). During the period of 1958–1977 all differences were not statistically significant. From 1978 the lung cancer incidence rate for the total male population of Asbest exceeded the regional average: by 1.3 times in 1980–1999, by 1.2 times in 2000–2008, but only in 1984–1988 and in 2004–2008 it was significantly higher than the regional average ($p<0.05$).

For the whole observation period the percentage of occupationally exposed men from the total lung cancer incident cases in Asbest dropped from 49.6 % in 1960s to 9.0 % in the beginning of the 21st century ($R_2 = 0.766$).

The analysis of characteristics of the lung cancer incidence rate for occupationally unexposed male residents of Asbest after exclusion of the exposure group showed that during 31 years, 1958–1988, it was significantly 1.1–2.0 times lower than the regional average ($p<0.05$). Since 1989 the incidence rate in this group has been 1.1 times higher than the regional average one but this difference is not significant.

Having compared lung cancer incidence rates for the male population of Asbest to emissions of Uralasbest, JSC and airborne dust concentrations in the town we found that only during 15 years, 1958–1973, these indicators decreased simultaneously (Fig. 2). In 1973–1989, despite a continuous improvement of environmental conditions in the town, the lung cancer incidence rate in the male population of Asbest increased steadily.

Since 1989 a sustained decline in the lung cancer incidence rate for men by 4.8–10.7 % every 5 years has been registered in Asbest. A similar decrease in the lung cancer incidence rate in the Sverdlovsk Region and among the unexposed male population of Asbest has been observed since 1994 by 2.1–8.5 % and 2.4–5.1 %, respectively.

Thus, the reduction in gross emissions of Uralasbest, JSC resulted in a dramatic improvement of environmental conditions in Asbest that, in its turn, after 30 years led to a registered in the past 20 years sustained decline in lung cancer incidence rates for men.

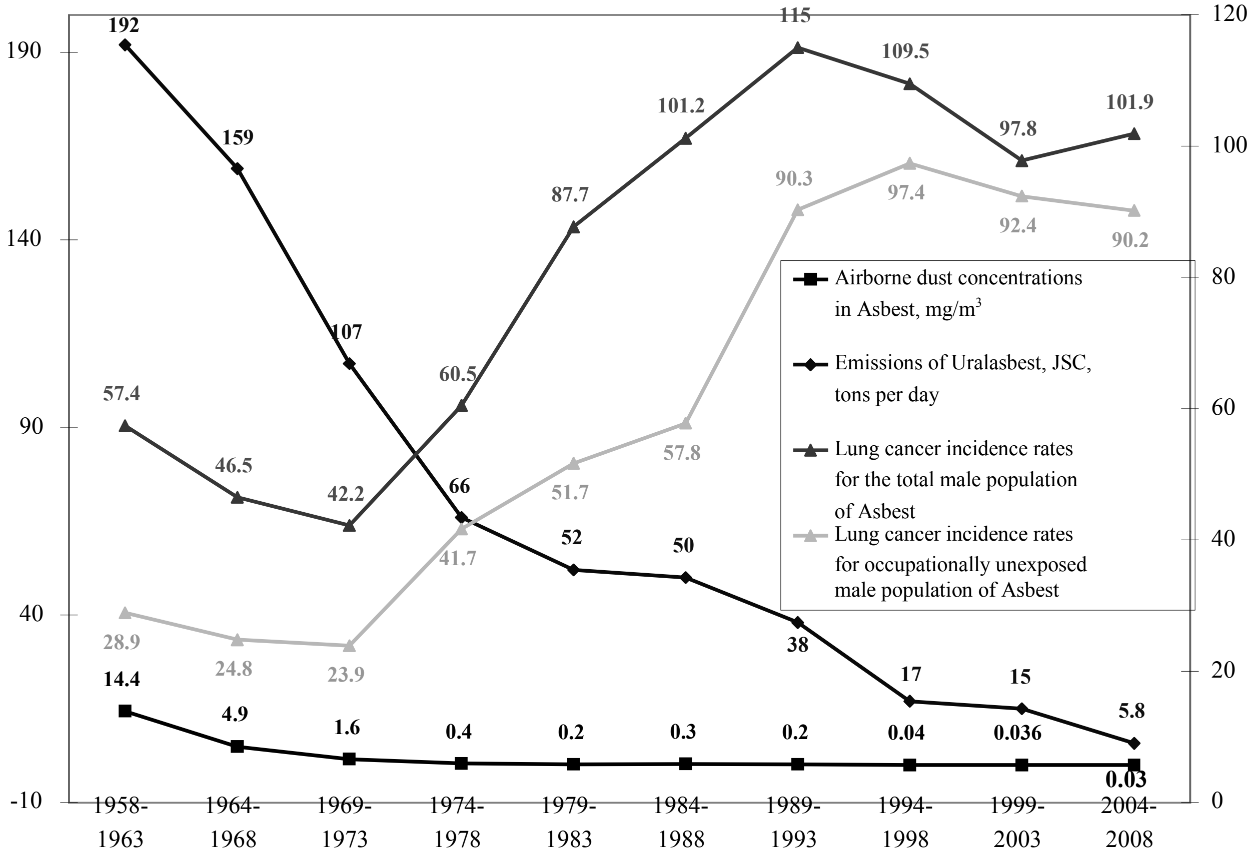


Fig. 2. The dynamics of airborne dust concentrations, emissions of Uralasbest, JSC, and lung cancer incidence rates for the male population of the town of Asbest

These epidemiologic studies have also demonstrated that the observed lung cancer incidence rate for men in Asbest appeared to be 44 % lower than the predicted value [4]. This finding is yet another evidence of greater reliability of epidemiologic studies compared to modeling that has a large number of uncertain variables.

References

1. Malignant mesothelioma: advances in pathogenesis, diagnosis, and translational therapies / Pass H., Vogelzang N., Carbone M. (eds.). — Springer: New York, 2005. — 854 p.
2. Pathology of asbestos-associated diseases / Roggli V.L., Oury T.D., Sporn T.A. (eds.). — Springer: New York, 2004. — 421 p.
3. *Plotko E.G., Selyankina K.P. et al.* Hygienic issues of environmental protection and public health in the areas of chrysotile asbestos production and use // Hygiene and Sanitation. — 2005. — № 6. — P. 70–71.
4. *Berzin S.A., Kogan F.M., Vasyov R.V.* Lung cancer incidence rates in the town of Asbest, Sverdlovsk Region, in 1958–1997 // Ural Medical Review. — 2000. — № 3–4. — P. 55–57.

UDC 616–057:622.874

Hygienic characteristics of labor conditions for main occupations in the asbestos cement industry of the Ukraine

Украина асбестцементті өндірісіндегі негізгі кәсіби мамандардың еңбек әрекетінің гигиеналық сипаттамасы

Kundiyev Yu.I., Chernyuk V.I., Karakashyan A.N., Kucheruk T.K., Martynovskaya T.Yu., Demetskaya A.V., Salnikova N.A., Chuy T.S., Pyatnitsa-Gorpinchenko N.K.

Institute of Occupational Medicine of AMS of Ukraine, Kiev (E-mail: ukrchrysotile@online.ua)

Мақала авторлары Украина асбестцементті өндірісіндегі негізгі кәсіби мамандардың еңбек әрекетінің сипатын және еңбек жағдайын зерттеді. Сондай-ақ ауа жағдайын сипаттайтын, микроклиматтық жағдай, шу деңгейі, вибрациялық жүктеме және еңбек процесінің ауырлығы мен еңбек қауырттылығы бойынша көрсеткіштерді анықтады.

На основе изучения условий труда и характера трудовой деятельности рабочих основных профессий асбестоцементных предприятий Украины представлены показатели, характеризующие состояние воздушной среды, микроклиматические условия, уровни шумовой, вибрационной нагрузки, тяжесть и напряженность трудового процесса.

The issue of asbestos use is a critical world problem [1–3]. It has been long debated and being primarily a medical problem it has also acquired an economic and political nature. The presence of a certain risk of asbestosis, a specific fibrosis of lung tissue, and of a blastomogenic process (bronchial carcinoma, pleural and peritoneal mesothelioma) in workers occupationally exposed to asbestos raises no doubt [4–8]. However the body of evidence showing that asbestosis and specifically lung cancer are related to the uncontrolled use of amphibole asbestos has been increasing recently [9, 10]. Thus, the ban of this type of asbestos is perfectly substantiated today [11, 12]. As for chrysotile asbestos accounting for almost 95 % of all asbestos mined in the world, there appear more and more convincing data in the world literature proving that this type of asbestos is low aggressive and can be safer for human health than its substitutes, the number of which exceeds 20, in case of its controlled use [13, 14]. At least at the moment there exist no epidemiologic studies giving evidence of a higher health risk of chrysotile compared to its substitutes.

According to some researchers (Yu.I.Kundiyev, E.P.Krasnyuk, A.A.Dobrovolsky [15]) the problem of the continued use of chrysotile asbestos must be solved by improving the control of its concentrations in workplace air. Russian researchers E.I.Likhachev et al. [16] also note that in modern conditions of the chrysotile mining and milling with low asbestos dust concentrations the average duration of dust exposure of workers until the development of asbestosis increases to 20.5 years; the progression of fibrous changes in lungs prolongs, too. One of the ways of a safe and controlled industrial use of chrysotile asbestos is the estimation of exposure doses of dust on respiratory organs of workers (personal dust loads). Based on data obtained by a team of researchers of the RAMS Institute of Occupational Medicine, a «critical value» of the dust burden for the whole period of exposure to asbestos-containing dust has been substantiated; it can help effectively prevent the development of dust-related diseases [17].

In the Ukraine there is no medical statistics that gives evidence of a high health risk of the use of chrysotile asbestos in the production of asbestos cement. Only 18 cases of asbestosis have been registered in the Ukraine for the last 25 years of monitoring of occupational diseases; cases of occupational cancer (pleural mesothelioma, lung cancer, etc.) have not been registered at all.

One of the a priori explanations of the situation is the circumstance that asbestos is not mined in the Ukraine and 11 asbestos-cement factories working with the imported raw (chrysotile asbestos) deal with bound asbestos in the form of an asbestos-cement mixture. Yet, in some shops (a preparation department) a direct contact of workers with chrysotile fibers is possible. Besides, fine asbestos dust, especially in dry weather conditions, can move freely in the air of most industrial premises. It can be found as airborne dust at workplaces with no sources of chrysotile emissions.

The effect of the dust factor is certainly related to the dust load, which, in its turn, is determined not only by dust concentrations in workplace air but also by the duration of dust exposure, the respiration depth and rate. The latter depends on the severity of work and microclimate at workplace.

Thus, there are grounds for a complex approach to the dose evaluation of dust loads affecting workers of the asbestos-cement production with account for the duration, severity and conditions of the microclimate. And, finally, when the task is set to study the heath risk of workers exposed to adverse occupational factors, the most important provision of the methodology of the occupational risk assessment is the consideration of the whole complex of adverse factors at the workplace.

This study on the hygienic evaluation of occupational conditions at the main asbestos cement enterprises of the Ukraine was conducted from these positions. Similar studies have never been conducted in the Ukraine before.

Materials and methods. Measurements and hygienic evaluation of factors of occupational environment and work processes were performed at the following enterprises: «Kievsky Slate Factory, Ltd.», «Balakleysky Slate Combine, Ltd.», «Kramatorsky Shifer, Ltd.», a subsidiary of private company «Kryazh» Krasnogvardeysky Slate Factory, «Techprom, Ltd.» Amvrosiyevka, JSC «Zaporozhsky Factory of Asbestos Cement Products», «Firm «Delta Boug, Ltd.».

Dust concentrations in workplace air were measured in accordance with Method Guidelines of the Ministry of Health of the USSR № 4436–87, *Measuring concentrations of aerosols with a predominantly fibrogenic effect.*

Air sampling was performed using aspirators «Typhoon» R-20–2 on filters AFA-VP-10. Then the filters were weighed using the analytical balance VLR-200. The duration of measuring maximum concentrations was 30 minutes with the volume velocity of sampling 20 l/min. At some workplaces the volume of pumped air was increased to 2,000 liters.

Dust concentrations were calculated as follows (1):

$$V_N = \frac{V(273+20)(P-P_N \cdot f)}{(273+t^\circ)(760-P_0)}, \qquad (1)$$

Where, V_N is a normalized air volume, dm; P is the shift average atmospheric pressure at the site, gPa; P_N is the pressure of the saturated steam at a certain temperature, gPa; f is the relative air humidity at the site, fractions; $t°$ is the average air temperature at the site, °C; P_0 is the pressure of water vapors at 20 °C and air humidity of 50 % (this value is constant and equal to 8.7 mm Hg or 1,160 Pa).

The air volume is calculated as (2):

$$V = gt, \qquad (2)$$

Where, g is air flow for 1 minute and t is the time of measurements in minutes.

For a quantitative determination of asbestos concentrations in the airborne dust we conducted an X-ray structural analysis in accordance with Guidelines for measuring a mass portion of chrysotile in samples by a quantitative X-ray phase analysis developed by the Asbestos Research Institute («NIIprojectasbest»), 2004, Asbest (Russia) [18].

To establish the number of asbestos fibers in the airborne dust we applied a counting method in accordance with the Methods of establishing the fiber count in ambient and workplace air developed by «NIIprojectasbest» in 2001, Asbest, Russia [19]. The measurements were conducted during sequential sampling (during at least 75 % of the work shift with the coverage of all basic work operations), the duration of sampling — 30 minutes per sample, the minimum number of samples — 3.

Measurements of noise and total vibration were conducted according to acting normative and method documents (GOST 12.1.050–86, *SSBT (Systems of Standards in Occupational Safety). Methods of measuring noise at workplaces*, DSN 3.3.6.037–99, *Ukrainian State Sanitary Norms of Occupational Noise, Ultrasound and Infrasound*; GOST 12.1.012–90, *SSBT. Vibration Safety — General Requirements*, DSN 3.3.6.039–99, *State Sanitary Norms of Occupational Total and Local Vibration*») using a sound level meter and spectre analyzer «Oktava-101 A», a noise measurer VSV-003-M2 with vibropacks (DN-3, DN-4).

The noise exposure was assessed based on the equivalent level of noise in acoustic decibels and the vibration exposure — by the equivalent adjusted level of vibration acceleration of total vibration in decibels.

Microclimate parameters (temperature, relative humidity, and air velocity) were measured in the beginning, in the middle and in the end of the work shift, 0.5–1.0 m above the floor if the worker sits and 1.5 m above the floor if he stands most of the work shift.

The air temperature was measured by an aspiration psychrometer «Assmana»; the air velocity was measured using a flowmeter IS-02 in warm seasons at constant workplaces.

The evaluation of microclimate parameters was performed in accordance with requirements of GOST 12.1.005–88, *General Sanitary and Hygienic Requirements for Workplace Air*; DSN 3.3.6.042–99, *State Sanitary Norms for the Microclimate of Workplaces*.

The study of the severity of labor was based on indices of the dynamic work, the mass of the lifted and transferred load, static load, the number of routine movements of hands and fingers, and the work posture.

Labor intensity was assessed by indices of the attention function, tension of analyzing functions, emotional and intellectual tension, and indices of labor monotony.

Assessment of labor severity and intensity was performed according to criteria of the Hygienic Classification of Labor (based on indicators of hazard and risk of factors of the occupational environment, severity and intensity of the work process) No. 4137–86.

A complex assessment of labor conditions was also performed in accordance with the criteria of this classification.

Results

Our studies showed that the technological process of manufacturing asbestos-cement products in all factories is similar. Its main stages include asbestos batching, mixing it with Portland cement and preparing an asbestos cement mixture (Portland cement — 80-90 %, chrysotile asbestos — 10–20 %, water), forming asbestos cement products in sheet forming machines, drying and moving them to the warehouse of finished products.

The study results indicate that asbestos-containing dust is the main adverse factor in the asbestos cement industry. A significant dust generation and dust emission was observed at all workplaces under study (Table).

Table

Maximum*, shift average concentrations of dust and respirable fibers*** of chrysotile asbestos in workplace air for the main occupations**

Enterprises	Concentrations of dust, mg/m^3 and respirable fibers/cm^3							
	Batching workmen		Operators of the preparation department		Operators of sheet forming machines		Operators of electric bridge cranes	
«Kievsky Slate Factory, Ltd.»	16.6–21.5* 5.2–7.0**	0.09–0.32***	1.1–1.5* 0.8–2.0**	0.09–0.12***	0.9–2.6* 0.6–1.6**	0.09–0.11***	0.8–1.5* 0.7–1.0*	0.094–0.26***
«Balakleysky Slate Combine, Ltd.»	9.8–14.3* 2.2–3.0**		6.9–8.6* 1.7–2.8**		1.7–2.9* 0.9–1.6**		0.8–1.8* 0.8–1.5**	
«Kramatorsky Shifer, Ltd.»	13.3–20.4* 1.9–2.7**		2.8–3.3* 1.9–2.9**		2.9–3.0* 1.8–2.6**		1.8–2.0* 1.4–1.7**	
A subsidiary of private company «Kryazh» Krasnogvardeysky Slate Factory	18.9–20.0* 1.5–1.6**		3.1–4,3* 1,2–1,5**		1.4–3.2* 1.1–1.8**		1.1–2.9* 1.3–2.0**	
«Techprom, Ltd.» Amvrosiyevka	9.7–11.0* 0.6–0.9**		0.7–1.8* 0.6–1.0**		1.0–2.4* 0.7–1.4**		0.5–1.9* 0.6–0.8**	
JSC «Zaporozhsky Factory of Asbestos Cement Products»	6,8–10,7* 0,6–0,8**		0.6–0.7* 0.5–0.9**		0.6–0.7* 0.6–0.7**		0.3–0.4* 0.2–0.3**	
«Firm «Delta Boug, Ltd.»	7.7–11.6* 0.7–0.9**		0.5–0.6* 0.6–0.7**		0.4–0.5* 0.5–0.6**			

Note: Maximum permissible concentrations: *Maximum — 2.0 mg/m^3 (if the percentage of asbestos in dust exceeds 20 % according to GOST 12.1.005–88, supplement 4); **Work shift average — 0.5 mg/m^3 (if the percentage of asbestos in dust exceeds 20 % according to GOST 12.1.005–88, supplement 4); ***of respirable fibers — 0.2 f/cm^3 (USA, 1986).

According to the table the excess of maximum permissible concentrations of chrysotile asbestos was noted:

• For maximum concentrations – at all workplaces of batching workmen (3.4–10.8 times); at workplaces of operators of the preparation department of the Krasnogvardeysky Slate Factory, Balakleysky Slate Combine Ltd., Kramatorsky Shifer Ltd. (1.4–4.3 times); at workplaces of operators of the sheet forming machine of the Kievsky Slate Factory, the Krasnogvardeysky Slate Factory, Balakleysky Slate Combine, Ltd., Kramatorsky Shifer Ltd., Techprom Amvrosievka Ltd. (1.2–1.6 times), at the workplace of the operator of the electric bridge crane of the Krasnogvardeysky Slate Factory — 1.5 times;

• For work shift average concentrations – at all workplaces (1.1–14.0 times);

• For the asbestos fiber count in 1 cm^3 of air – at workplaces of batching workmen and the operator of the electric bridge crane (1.6 and 1.3 times according to U.S. standards, 1986) in the Kievsky Slate Factory, Ltd.

Thus, according to the criteria of the «Hygienic Labor Classification…» No. 4137–86 labor conditions of workers of the main occupations must be attributed to Class III of hazard and risk degrees 1, 2 and 3 by the factor «Dust of predominantly fibrogenic effect».

Microclimate parameters at workplaces of the above occupations significantly depended upon meteorological conditions of the environment and technological processes. When the ambient temperature exceeded 25 °C, the temperature at workplaces was 2–6 °C higher than normative values. In some cases high levels of relative humidity and air mobility were noted.

The main sources of noise and vibration at asbestos-cement enterprises are batchers, mullers (with SM-139 and SM-874 drives), hydrofluffers, turbo mixers, ladle stirrers (SMA-159 A, SM-889), sheet forming machines (SM-943), and electric bridge cranes.

High levels of noise were mostly observed at workplaces of operators of sheet forming machines (the maximum permissible level was exceeded by 4–10 dB), operators of the preparation department (by 2–11 dB) and operators of bridge cranes (by 3–6 dB).

As for the vibration load from total vibration, then the maximum permissible level was exceeded at workplaces of operators of sheet forming machines (by 1.5–5.9 dB), operators of bridge cranes (by 1.7–4.8 dB) and at the workplace of operators of the preparation department of the Balakleysky Slate Combine — by 6 dB.

Differences in the levels of noise and vibration at similar workplaces of different factories are often related to distinctive features of organization of the technological process, the extent of the equipment wear, and the location of the workplace with regard to noise and vibration sources, which is determined by a specific design. An example is the workplace of the operator of the preparation department of the Balakleysky Slate Combine where the control panel is located on metal scaffolds close to the equipment generating noise and vibration. As a result, the operator is exposed to highest levels of noise and vibration (5–12 dB and 10–13 dB higher than in other factories, respectively).

In asbestos-cement factories the main stages of the technological process are mechanized and automated. Nevertheless, some technological operations require manual labor. Here we speak about the work of batching workmen. Their responsibilities include unpacking of the 50-kg sacks with chrysotile asbestos and emptying them into the bunker of the batcher-mixer.

Some elements of manual labor can be also found at the next stages of the technological process just like the necessity to work in a forced work posture, with often tilts, etc. These very components of physical activity mainly determine severity of labor for the described occupations. Based on criteria of the «Hygienic classification of labor…» No. 4137–86 some of them (the batching workman, for instance) should be attributed to Class III of Degree 2 of hazardous and risky labor conditions. Workers of these very job categories with high physical activity accompanied by a significant increase in the respiration depth and rate obviously experience higher dust exposure in conditions of an asbestos-cement enterprise.

Labor intensity of workers of main occupations in asbestos-cement industry is chiefly determined by levels of sensor loads and in operators of bridge cranes — also by a high level of emotional stress. Our data shows that labor intensity is very high for operators of the preparation department, operators of sheet forming machines (Class III, Degree 1) and especially for operators of bridge cranes (Class III, Degree 2).

Conclusions

1. The leading adverse industrial factor in asbestos cement production is chrysotile dust, the mass portion of which in the airborne dust at the workplace of the batching workman can be as high as 100 %; and at workplaces of the operator of the preparation department, the operator of the sheet forming machine and the operator of the electric bridge crane – over 50 %.

2. Maximum concentrations exceeded the maximum permissible concentration of chrysotile dust at all workplaces of asbestos batching workmen (3.4–10.8 times) and at workplaces of operators of the preparation department. Average work shift concentrations exceeded the maximum permissible concentration of chrysotile dust at all workplaces (1.1–14.0 times). Concentrations of respirable asbestos fibers in the workplace air

can vary in the wide range – from 0.09 to 0.32 f/cm^3. At the workplaces of the asbestos batching workmen and the electric bridge operator the maximum permissible concentration was exceeded by 1.6 and 1.3 times, respectively (according to U.S. regulatory values, 1986).

3. Workers of the main occupations of the asbestos cement production are exposed to a complex of adverse industrial factors such as elevated temperature and air humidity, noise (the excess of the maximum permissible level varies from 2 to 11 acoustic decibels), total vibration (the excess of the maximum permissible level varies from 1.5 to 6.0 dB based on vibration acceleration), which corresponds to Class III, Degree 1–2 of hazardous and dangerous labor conditions according to criteria of «Hygienic Labor Classification…» No. 4137–86. The occupation of the asbestos batching workman must be also attributed to the category of rough labor in asbestos cement industry (Class III, Degree 2); to the category of intensive labor — work of the operator of the preparation department and the operator of sheet forming machines (Class III, Degree 1); work of the operator of the bridge crane (Class III, Degree 2).

4. Accepting the concept of the controlled use of chrysotile-asbestos, in accordance with Convention No. 162 and Recommendations No. 172, the hygienic ensuring of labor safety on asbestos cement factories should provide for the introduction of progressive technologies with complex automation and mechanization of industrial processes, exclusion or minimization of manual labor; optimization of use of collective (during unpacking of asbestos in the first place) and personal (special work clothes, respirators) protective means; a systematic medical control of workers' health and the follow-up of accumulation of critical doses of dust loads in workers and their timely removal from occupation; safety instructions and promotion of a healthy mode of living.

References

1. *Dalton A.J.P.* // Lancet. — 1998. — Vol. 352. — № 9124. — P. 322–323.
2. *Seaton A.* // Schweiz. Med. Wochenschr. — 1995. — Vol. 125. — № 10. — P. 453–457.
3. *Yano E., Wang Z.M. et al.* // Amer. J. Epidemiol. — 2001. — Vol. 154. — № 6. — P. 538–543.
4. *Coggon D., Inskip H. et al.* // Occup. Environm. Med. — 1995. — Vol. 52. — № 11. — P. 775–777.
5. *Eglite M., Jekabsone I. et al.* // Abstr. Glob. Congr. Lung Health and 29th World Conf. Int. Union against Tuberc. and Lung Diseases (IUATLD/UICTMR). — Bangkok, 23–26 Nov., 1998.
6. *Shepherd J.R., Hillerdal C., McLarty J.* // Occup. Environm. Med. — 1997. — Vol. 54. — № 6. — P. 410–415.
7. *Swaen G.G., Teggeler O., van Amelsvoort L.G.* // Int. J. Epidemiol. — 2001. — Vol. 30. — № 5. — P. 948–954.
8. *Wong O.* // Regul. Toxicol. Pharmacol. — 2001. — Vol. 34. — № N 2. — P. 170–177.
9. *Dodic Fikfak M., Kriebel D. et al.* // Ann. Occup. Hyg. — 2007. — Apr. — № 51(3). — P. 261–268.
10. *Fournier P.E.* // Med Sci. — 1997. — № 13. — № 3. — P. 422–423.
11. Guide helps identify asbestos cancer. Work Health Safety, 1993. — Helsinki, 1993. — P. 2.
12. WHO/IPCS. Environmental Health Criteria 155: Biomarkers and Risk Assessment: Concepts and Principles. WHO, International Program on Chemical Safety. — Geneva, 1993.
13. *Kashansky S.V., Kogan F.M. et al.* // Issues of Occupational Hygiene, Occupational Pathology and Industrial Toxicology. — 1996. — P. 71–81.
14. *Nikitina O.V., Kogan F.M. et al.* // Occup. Hygiene. — 1989. — № 4. — P. 7–10.
15. *Kundiyev Yu.I., Krasnyuk E.P., Dobrovolsky L.A.* // Journal of the Ukrainian Academy of Medical Sciences. — 1999. — Vol. 5. — № 2. — P. 290–298.
16. *Likhacheva E.I., Semenikova T.K. et al.* // Occupational Medicine. — 1999. — № 5. — P. 4–8.
17. Safety and Health in the Production and Use of Asbestos and Other Fibrous materials: Proceedings of the international conference; 3–7 June 2002, Ekaterinburg. — Asbest: Non-Profit Organization «Chrysotile Association», 2003.
18. Methods of measuring a mass portion of chrysotile in a dust sample using a quantitative X-ray phase analysis. — Asbest, 2004.
19. Methods of establishing count concentrations in ambient air and workplace air. — Asbest, 2001.

UDC 616–057:622.874

The controlled use of chrysotile asbestos in Ukraine

Украинада хризотил-асбесттің бақылау қолдануы

Demetskaya O.V., Leonenko O.B., Tkachenko T.Y., Moshkovsky V.E., Movchan V.A.

SI «Institute for Occupational Health of NAMS of Ukraine», Kiev, Ukraine (E-mail: dalexandra@ukr.net)

Мақалада бақыланбайтын жағдайда асбестқұрамды шаңның әсері қолқа-өкпелік және ісік аурулардың даму қауіпін тудырады. Аурудың дамуының негізгі себебі ағзаның компенсаторлық мүмкіндігінен жоғары мөлшерде адамның тыныс алу жолдарында асбест талшықтарының жинақталуынан болады. Өз кезегінде мақала авторлары Украинаның асбестцементті өнеркәсібінің кәсіпорындарында жүргізілген зерттеулер хризотилдың қауіпсіз қолдану мүмкіндіктері бар екенін дәлелдейді.

В статье показано, что в неконтролируемых условиях влияние асбестосодержащих пыли увеличивает риск развития бронхолегочных и онкологических заболеваний. Условием развития заболевания является накопление в органах дыхания человека волокон асбеста в количествах, превышающих компенсаторные возможности организма. В свою очередь авторы статьи отмечают, что исследования, проведенные на предприятиях асбоцементной промышленности Украины, свидетельствуют в пользу возможности контролируемого безопасного использования хризотила.

The main consumers of chrysotile in Ukraine are asbestos cement and asbestos technical enterprises. It should be noted that Ukraine neither mines nor mills asbestos. Asbestos-consuming industries import the raw from the Russian Federation and Kazakhstan. The annual volume of import is 85–100 thousand tons. It is important to stress that Ukraine uses only chrysotile that belongs to the serpentine group of asbestos and has physico-chemical properties and, respectively, biological effects quite different from those of amphiboles (crocidolite, anthophillite, amosite) that were widely used in many countries during a long time in the past [1, 2].

As is known, asbestos is one of the most important non-metallic minerals. Thanks to its unique properties it has been used for over 100 years in thousands of commercial products. It should be noted that until 1970s asbestos was uncontrollably used worldwide, especially in the developed countries, almost in all industries — over 3,000 asbestos-containing products are known to date. This has led to an increase in asbestos-related disease incidence and mortality rates for workers and general population and, consequently, to the ban on all types of asbestos in some European countries. Differences between amphiboles and chrysotile as well as different historical patterns of the use of asbestos in different regions have been neglected.

The majority of well-known epidemiologic studies conducted abroad considered amphiboles or their mixtures with chrysotile. Thus, it is impossible and wrong to attempt to extrapolate data used for assessing health effects of amphibole asbestos in Western Europe and the U.S. to the situation in Ukraine without conducting domestic epidemiologic studies due to significant differences between these groups of fibrous minerals and spheres of application of asbestos [3, 4].

In 2005–2007 researchers of the Institute for Occupational Health of NAMS of Ukraine studied health effects of labor conditions in workers of the Ukrainian asbestos cement industry in order to obtain reliable data on health risks from current exposures to chrysotile. Neither clinical nor epidemiologic data confirmed cases of occupational cancer diseases in workers of the asbestos cement industry of Ukraine. These study results prove feasibility of the safe use of chrysotile with regulated dust exposures [5, 6].

Nowadays in Ukraine dust concentrations in the workplace air are measured using a gravimetric method (maximum permissible concentrations range 2 mg/m^3 to 10 mg/m^3 depending on the percentage of asbestos fibers) whereas in the EU, the U.S. and some other countries the control is exercised based on the asbestos fiber count [7, 8].

As for the study results obtained for the Ukrainian asbestos cement industry using the gravimetric method, we found that both the maximum short-term and average shift permissible concentrations were exceeded and the mass fraction of asbestos at major workplaces was 50 to 100 %. At workplaces of the asbestos dosing operator both average shift and maximum short-term concentrations of asbestos dust were 1.6 to 14.0 times higher than maximum permissible concentrations; of warehouse operators and operators of the sheet-forming machine — 1.2 to 5.2 times higher. As for operators of electric bridge cranes, 8-hour asbestos dust concentrations at their workplaces were 1.6 to 4.0 times higher than the MPC.

It should be emphasized that the highest dust concentrations were registered during manual loading of asbestos and transferring it to the conveyor (at the workplace of the asbestos dosing operator).

The issues of regulating chrysotile dust in workplace air have certain specificity. As is has been already noted, in the countries of the European Union the control is based on asbestos fiber counting. The advantage of this method is the possibility to regulate and control the fibrous component of dust. Moreover, in many cases establishing the percentage of fibers in dust is technologically difficult. Here it is critical to note that there exists no universal coefficient that can be used to calculate the mass potion of asbestos in dust based on the fiber count and vice versa even though it is possible to determine the ratio between count and mass concentrations at some workplaces under constant conditions of dust formation.

In order to bring measurements in accordance with the international practice an interdepartmental testing laboratory has been set up in the Institute for Occupational Health of NAMS of Ukraine to measure airborne asbestos fibers. During the research done by the Institute concentrations of respirable chrysotile fibers in workplace air (f/ml) in the asbestos cement industries of Ukraine were established.

The findings showed that at three Ukrainian asbestos-cement factories the lowest concentrations of respirable chrysotile fibers were found in the workplace air of the operator of the sheet-forming machine (0.02 to 0.14 f/ml). It is obvious that these values are within strict international standards (0.1 f/ml for all types of asbestos in the USA). A rather favorable situation was also noted at the workplace of the operator of the electric bridge crane (0.02 to 0.26 f/ml).

Yet, concentrations of respirable chrysotile fibers at the workplace of the asbestos dosing operator were as high as 0.09–1.0 f/ml. It should be emphasized that this workplace is the most hazardous at the enterprises of the asbestos cement industry where hoppers are still used. This issue requires urgent attention.

Although at the majority of workplaces in the Ukrainian asbestos cement industry chrysotile fiber concentrations are within strict international limits, it should be considered that this conformity involves considerable material expenditures and financial costs and is scientifically unfounded. On the other hand, material resources could be directed to other activities that might be more important, efficient and expedient from the point of view of occupational safety and health (information and training programs, more frequent hygienic control, improved medical surveillance, etc.).

Based on substantiated standards for chrysotile asbestos set in other countries of the world as well as results of domestic hygienic, clinical and epidemiologic studies, we believe it is expedient to establish the standard of 1.0 f/ml for chrysotile asbestos fibers in the workplace air [6, 9].

In combination with the ban on amphibole asbestos this limit is quite adequate and contains a safety margin. This very value of 1.0 f/ml was recommended by the World Health Organization in 1989, before the global economic war involving businessmen, scientists, and officials at all levels started.

In accordance with item 10 of the WHO Global Plan of Action on Workers' Health 2008–2017 and item 10 of the Parma Declaration on Environment and Health the Institute for Occupational Health of NAMS of Ukraine has developed draft State Sanitary Regulations and Standards, *The use of chrysotile and chrysotile-containing materials*. These sanitary regulations envisage control of asbestos fiber concentrations in the workplace air. They also establish requirements for occupational safety at civil enterprises that use chrysotile asbestos and chrysotile-containing products, for health protection of the population exposed to industrial emissions of such enterprises, and for the current system of hygienic assessment of industrial data and manufactured products in accordance with the current Ukrainian legislation and with account for the international experience, i.e. provisions of ILO Convention 162 on Safety in the Use of Asbestos, ILO Recommendations № 172, and ILO international rules of safety in the use of asbestos.

This control shall be exercised according to requirements of the method of testing No. 081/12–0673–10 dated 09.03.2010, *Asbestos counting in the workplace air and ambient air by optical microscopy*, developed by the Institute for Occupational Health of NAMS of Ukraine. It is recommended to study patterns of asbestos fiber distribution in the workplace air twice a year (during the warm and cold periods) and after all types of repair and maintenance.

According to DSP-201–97, *State Sanitary Rules of protection of ambient air of populated areas (from contamination with chemical and biological agents)*, asbestos fiber concentrations in the ambient air of populated areas in Ukraine shall not exceed 0.06 f/ml [10]. The studies conducted by the Institute for Occupational Health of NAMS of Ukraine showed that the concentration of chrysotile in the streets of Kyiv was 0.04 f/ml. Thus, concentrations of chrysotile fibers remain within permissible limits despite heavy traffic, ongoing repairs, and demolition of buildings.

This can be explained by the fact that in products of the domestic asbestos cement and asbestos technical industries chrysotile fibers are encapsulated in the cement matrix that prevents their release in the environment under the influence of natural and anthropogenic factors. Over the last 30 years studies of chrysotile fiber release from asbestos-cement products have been conducted worldwide. According to Russian experts, for example, emissions of chrysotile fibers from asbestos cement roofing materials under the influence of natural and anthropogenic factors are negligible. Seasonal temperature fluctuations, contamination of ambient air with aggressive gases, and the service life of buildings do not affect the intensity of asbestos release from asbestos cement materials in indoor air of residential and public buildings as well as in ambient air. Concentrations of respirable fibrous particles in indoor air of public buildings were 2 to 20 times lower than the maximum permissible concentration of asbestos dust in ambient air [11].

German studies of fiber release from chrysotile cement roofing showed low emission levels regardless of minor surface damages. In Austria comparative studies of asbestos concentrations in areas with and without chrysotile cement roofing have demonstrated no statistically significant correlation between the use of chrysotile cement materials and ambient concentrations of chrysotile fibers [12].

At the same time it is impossible to successfully plan actions for elimination of asbestos-related diseases without a comprehensive preventive evaluation of introducing available asbestos substitutes in various industries in accordance with Article 10 of ILO Convention 162.

It is particularly important to emphasize that no conclusions have been drawn so far about the lack of sufficient data for health risk assessment and even potential hazard identification with respect to the majority of fibers, such as carbon, cellulose, polyethylene, PVC, polypropylene, graphite, and magnesium sulfate fibers and graphite whiskers. This, in its turn, hampers the prediction of long-term health effects of the production and use of these fibers. It is, therefore, necessary to conduct a comprehensive in-depth study of asbestos substitutes and their biological effects in particular.

We hope that implementation of all these measures will help improve labor conditions in the asbestos industry and preserve health of workers and population.

References

1. *Virta R.L.* Asbestos: Geology, mineralogy, mining, and uses // US Geological Survey Circular, 1255-KK, 2002. — 28 p.
2. http://www.atsdr.cdc.gov/asbestos/more_about_asbestos/what_is_asbestos/
3. *Batrip P.W.* History of asbestos related disease // Postgrad. Med. J. — 2004. — Vol. 80. — № 9. — P. 602–610.
4. Toxicological profile for asbestos / Agency for Toxic Substances and Disease, Registry Division of Toxicology/Toxicology Information Branch. — 2001. — 441 p.
5. *Kundiyev Yu.I. et al.* Hygienic characteristics of labor conditions of workers of major professions in asbestos cement industry of Ukraine // Occupational Medicine and Industrial Ecology. — 2008. — № 3. — P. 21–27.
6. *Chernyuk V.I. et al.* Is it possible to use chrysotile asbestos safely? The experience of Ukraine. — Kyiv, Ukraine. — 2008. — P. 36.
7. GOST 12.1.005–88, SSBT. General sanitary and hygienic requirements for workplace air.
8. http://www.who.int/occupational_health/topics/asbestos_documents/en/index.html
9. Substantiation of hygienic standards for harmful chemical substances in various environments on the basis of a systematic approach. Methodical instructions CF 1.1.5.-88-02: Official Publications (zatv. Decision of Chief state sanitary doctor of Ukraine 12.04.2002 p., № 14). — K., 2002. — 40 p.
10. DSP-201-97 «Public health rules for the protection of atmospheric air of population aggregate (from contamination of chemical and biological substances)».
11. *Kovalevsky E.V.* Concentrations of natural and man-made mineral fibrous particles in indoor air of non-production facilities // Occupational Medicine and Industrial Ecology. — 2004. — № 1. — P. 10–15.
12. *Rödelsperger K.* Measurement of inorganic fibrous particulates in ambient air and indoors with the scanning electron microscope // IARC Sci. Publ. — 1989. — № 90. — P. 361–366.

UDC 616–003.66:553.676

The evaluation of carcinogenic risk when exposed to asbestos dust on the population

Халыққа асбест тозаңның әсерінен туындайтын канцерогенді тәуекелді бағалау

Amanzhol I.A.[1], Mukasheva M.A.[2], Surzhikov D.V.[3], Ibrayeva L.K.[1]

[1]*National center for occupational hygiene and occupational diseases MH RK, Karaganda;*
[2]*Y.A.Buketov Karaganda State University;*
[3]*Scientific research institute of complex problems of hygiene and occupational deseases, Siberian branch of the Russian Academy of Medical Sciences, Novokuznetsk, Russia (E-mail: ncgtpz@gmail.com)*

Мақалада асбесттің өндірістік және өндірістік емес әсеріне байланысты халық саны өкпе ауруы және мезотелиома қатерлі ісіктеріне шалдығуының көлемін анықтап, бағалау әрекеті жүзеге асырылған. Адам ағзасында асбесттің әсер етуінде қосымша фактор анықталып, ол биоперсистенция (биологиялық тұрақтылық) жұту бөлшектерінің патогендік әлеуетін анықтауда маңызды шарт деп белгіленген. Науқастыққа шалдығу тәуекелділігін бағалаудың әр түрлі әдіснамалары қолданылған.

В статье предпринята попытка оценить масштабы заболеваемости злокачественными мезотелиомами и раком легких, связанными с непрофессиональным и производственным воздействием асбеста на население. Определен дополнительный фактор влияния асбестов на организм человека и признан как важный параметр для патогенного потенциала вдыхаемых частиц — биоперсистенция (биологическая стойкость). Авторы отмечают, что для прогнозирования отсроченной частоты асбестообусловленной патологии все более активно используются различные методологии оценки риска.

The main source of asbestos in environmental air are, apparently, construction materials, and also those industrial sectors where professional contact to dust which contains asbestos is possible. It's, first of all, industries which product production and enrichment of asbestos, asbestos-containing materials (enterprises of asbestos and cement, asbestos technical and asbestos fiber materials). The main consumer of asbestos today is production of asbestos and cement products (wavy and flat plates, pipes, etc.) which are widely used in industrial and civil construction [1–3].

According to classification of the International agency by research of a cancer (IARC) the hrizotil-asbestos is a carcinogen of the 1st category [4]. Along with existence of unique physical and chemical, and mechanical properties, asbestos possesses carcinogenic activity. In this regard, in many countries the prohibition of production and using of all types of asbestos and asbestos-containing production introduced into practice [5–7].

In the International Labour Organization convention (ILOC) № 162 «About labor protection when using asbestos» the concepts «asbestos», «an asbestos dust» and all kinds of activity connected to influence of asbestos on workers in production are defined. In the document are provided a measure of protection and prevention according to the prevention of influence of asbestos, methods of monitoring of harmful production factors and human health are regulated. It obliges to assist in distribution of information and education of workers about the unhealthy factors appearing in the course of a production activity, and also assistance in training of the people working with asbestos, and in the questions concerning environmental protection.

Recently the additional factor of influence of asbestos on a human body was defined and is recognized as important parameter for pathogenic potential of inhaled particles — a biopersistentsiya (biological resistance). It is characterized by duration of fibers' finding (survivability) in a pulmonary tissue. The risk of negative impact increases by health at the expense of duration of fibers' finding in a temporary corridor of a pulmonary tissue (biological resistance of fibers). Inhaled particles with short biological resistance are quickly removed and characterized by decrease of risk. During research it is established that hrizotil-asbestos it is quickly dissolved in the sour environment and it is deduced from lungs quicker unlike amphiboles which are more acids resistant [8].

The researches which have been carried out in Switzerland, Germany and the USA prove that the half-cycle of cleaning of lungs from fibers of hrizotil-asbestos (number of the days necessary for removal of 50 % of fibers, remaining in lungs after the termination of the period of influence), makes 15 days, and for amphibolic asbestos (amozites) — it is more than a year. It is the main proof that amphiboles are more dangerous, than hrizotil. For this reason amphibolic asbestos is forbidden around the world [9–11].

Hrizotil-asbestos in modern industry of Russia in a format of hygienic researches takes over 70 years. An assessment of influence of asbestos on health working and the population became since 1939. The early hygienic studies are carried out in 1936 during which was established that dust's content levels at asbestos dressing plants reached hundred mg/m^3. According to the recommendation of the International agency of cancer studying (France) professor F.M.Kogan in Russia carried out for the first time researches of epidemiology of malignant neoplasms at production and asbestos enrichment, in asbestos cement and asbestos technical sectors, and also in production of asbestos-containing heat insulating materials. In the middle of the XX century professor F.M.Kogan with the professor of the Ural state medical academy S.A.Berzin studied epidemiology of a malignant mesothelioma, among workers of Bazhensky minefield of hrizotil-asbestos. Now monitoring of mesothelioma in Sverdlovsk region is held under direction of S.V.Kashanskogo [12].

The last ten years the Ekaterinburg medical scientific center of prevention and health protection of industrial plants' workers of the Russian Agency for Health and Consumer Rights successfully develops scientific contacts and carries out integrated researches in various directions of the problem «Asbestos and health» with scientists of foreign countries (Great Britain, Italy, Kazakhstan, China, the USA, Ukraine, Finland, Japan, etc.).

According to Russian scientists, there is a concept «respirabel fibers» which easily get into distal segments of bronchopulmonary system, hold there for the longest term, and, therefore, possess the expressed biological action, thus «respirabel» fibers in length more or equal 5 microns and less or equal 3 microns are considered diameter at ratio of length by the diameter more than 3:1 which most well get into lungs. Fibers with diameter less than 0,25 micron and length more than 8 microns [13–18] best of all remain.

The Russian oncologic scientific center named after N.N.Blochin of the Russian Academy of Medical Science developed crystal-chemical model of hrizotil's fibers' calcinations in cement matrix, change of its some physical and chemical, and biological aggressive properties is shown. When an asbestos cement dust get into a human body, big carcinogenic danger, probably, have the bunches covered with a cement matrix (units of fibers) which can be source of invariable fibers of hrizotil, than separate fibers and fibrils [15].

Over a period about 40 years fibers which considerable part is identified as asbestos were find in lungs of citizens in the western countries [19, 20].

The measurements which have been carried out in the big cities of USA, showed that atmospheric concentration of asbestos fluctuate in range 0,09–70 ng/m^3. In air of the small cities and in rural areas asbestos is present at much smaller concentration — about 0,1 ng/m^3. Considering distribution of the population of USA, the average level of influence of asbestos out-of-doors can be estimated amount of 1,5 ng/m^3 [21, 22].

The assessment of carcinogenic effect of so low concentration of asbestos appears quite difficult task as attempts of direct definition of carcinogenic action of low doses didn't give result, and indirect data are irreconcilable. There is no consensus even on such question, as a contribution of professional influence of asbestos to the general mortality from a cancer: the most of researchers estimate this contribution in the size equal of 1–3 %, and by the assessment given by the government of USA in 1978, it much higher and makes 13–18 % [23].

For the assessment of cases of lungs' cancer caused by influence of low concentration of asbestos, extrapolation of the dependences received for the highest doses (can be applied at professional influence). This reception was already applied in research of 1981 studying of a contribution of dryers for hair with asbestos thermal screens and mortality from lung cancer was which subject.

Estimates of carcinogenic effect of low doses in this research were based on linear extrapolation of the dependence established for mortality from lung cancer among pensioners which was exposed to professional influence. Use of the results which were received allowed to estimate risk of cases of lungs' carcinoma, connected with asbestos influence in air during the whole period of life. In the making calculations was accepted that 1 ng contains 40 asbestos fibers in length more than 5 microns, seen in an optical microscope. It was considered, in addition, that lung's carcinoma can arise in 20 years after the beginning of influence and that average life expectancy makes 70 years so the effective period of influence is equal 50 years. Calculations showed that at the accepted assumptions the risk of disease of lung's carcinoma as a result of influence of 1,5 kg of asbestos in air during life is equal 2,08 on 1 million people. For all population of the USA (225 million people) it gives 468 cases of death (during the whole period of life) from lung's carcinoma [24].

Linear extrapolation of the data reported in English research led to a bit different conclusions, about association of professional influence of asbestos with lung's carcinoma. Using of data of this research in association with the same assumptions gives for all population of the USA figure of 60 cases of death from carcinoma of lung (during the whole period of life). However, there are bases to consider that levels of professional influence of asbestos carried out in English research are underestimated by workers approximately in 3 times. If this assumption is truly, figure of 1960 death has to be reduced in 3 times that will quite well be coordinated with the first of the received estimates (468 cases of death from lung cancer) [23].

Carcinogenic effect of asbestos is shown also in diseases by malignant mesothelioma. The total of diseases of malignant mesothelioma makes 1000 cases in a year (about 750 men and 250 women). In accordance with estimates carried out in literature, the contribution of professional influence of asbestos to incidences of malignant mesothelioma makes about 410 cases (397 men and 13 women). For nonprofessional influence of asbestos in air (1,5 ng/m^3) various estimates, which given in literature, give figure about 333 diseases in a year. It means that the risk of a disease of malignant mesothelioma during life owing to nonprofessional influence of asbestos is equal 100 on one million people [12].

It is noted that influence of air pollution on human's health was established at the beginning of the twentieth century. Authors refer to increase of mortality from pulmonary diseases in Pittsburg (USA) in 1930–1948 toxic which reason were emissions of steelmaking and zinc enterprises; then the murrain was observed. The similar cases which were taking place in 1924–1927 in East Prussia, and also sharp increase of smog in London are mentioned on December 5–9, 1952 that led to increase of mortality from diseases of lungs in 4 times (in 2 weeks 4000 people died) [24].

Incidence and mortality questions from carcinoma of lung depending on character and extent of air pollution in some cities and industrial centers of Germany are considered. The special group created in 1955 at VDI (association of German engineers) developed recommendations about decrease of air pollution in industrial regions. In the sequel, at VDI the Committee on air protection was created, to which duties development of actions and acts on control of pollution and protection of atmospheric air in cities were assigned [19].

In the analysis of atmospheric air in Hamburg (1961–1962) it was identified 12 substances polluting air, including beryllium in concentration of 0,6 mkg/1000 m^3 and asbestos — 0,6 mkg/1000 m^3. Among factors which can influence on decrease of pollution of city air, the main place is allocated for activity of government and its bodies. It is noted that during 1961–1968 mortality indicators from carcinoma of lung increased in separate cities for 20–40 %, meanwhile greatest number of cases was the share of persons of middle age. However some decrease in this indicator (for 15 %) was noted among the women living in cities with a small number of the industrial enterprises [20].

One of essential factors of uncertainty in the making calculations is the factor of transfer of asbestos from ng in number of fibers. According to some data, it is accepted figure (40 fibers in ng) can be overestimated. In that case received estimates also are overestimated. On the other hand, one of few undertaken and reflected in literature (made in 1981 on the instructions of government of Germany Schneiderman's report) attempts to estimate carcinogenic effect of nonprofessional influence of asbestos gave much higher figures. Observational consideration of the empirical data presented in the report of Schneiderman and соавт., shows, however, that they include too small number of cases for removal of reliable dependences between level of influence and effect [20].

The received estimates specify that the risk of a disease of malignant mesothelioma owing to nonprofessional influence of asbestos in 50 times exceeds risk of disease of lung's carcinoma. These results won't be coordinated with data on professional influence of asbestos for which the risk of disease of lung's carcinoma occurs risk of a disease of malignant mesothelioma in 2–3 times. One of possible explanations of such difference is that nonprofessional influence of asbestos begins at very early age, and it, possibly, considerably increases risk of a disease of malignant mesothelioma. According to some data, mesothelioma develop in many years after the beginning of influence of asbestos, while carcinoma of lung can develop quickly enough after beginning of influence of asbestos so even if this beginning is the share of age of 30–40 years, there is a big risk of emergence of carcinoma of lung during the remained term of life (before manifestation of other causes of death) [19, 20].

Probably, the received assessment of risk of disease of lung's carcinoma as a result of nonprofessional influence of asbestos is underestimated. This assessment depends on the accepted size of the relation of effect to influence level. If instead of accepted to enter into calculations the highest of sizes of this relation specified in literature, the assessment of risk makes 40 diseases of lung's carcinoma during life on 1 million people. The risk, however, still will be less, than risk of a disease of malignant mesothelioma.

Today the world scientific community is familiar with individual works of Kazakhstan authors on prevalence of mesothelioma in Republic of Kazakhstan. In the republic there are neither national, nor regional registers of mesotheliomas. The first finding of a malignant mesothelioma was fixed in Kazakhstan in 1948. From the first message Kazakhstan authors published 69 observations of mesotheliomas of various localizations, including 87 % — pleura's mesotheliomas, 11,6 % — mesotheliomas of peritoneum and 1,4 % — pericardium's mesotheliomas. The greatest number of findings is the share of age groups till 60 years. According to Kashansky S.V. and ctr. [25] during mesothelioma observation in Republic of Kazakhstan it is registered in the territory 5 of 14 areas.

Distinctive feature of geography of mesotheliomas is absence of data on majority of countries of the world. Authentic indicators of prevalence and mortality from a mesothelioma are available only for 15 % of the population of the globe. Morbidity of mesothelioma varies in a wide range from 0,2 morbid event on 1 million population a year in Ukraine, to 35 morbid event on 1 million population in Australia. According to World Health Organization, background incidence of a mesothelioma makes 1–2 cases on 1 million people a year [12].

In recent years for forecasting of delayed frequency of asbestos conditional pathology various methodologies of assessment of risk more and more actively are used. Often in a basis of these calculations influence levels, characteristic for the period of uncontrollable use of asbestos (the 80th years of the XIX century — the 70th years of the XX century), without modern levels of a dust content on workplaces and type of used asbestos, distorted (as a rule, overestimated) information on quantity of cases of diseases that causes overestimate of indicators of risk of development of asbestos-conditioned incidence are put. Despite an asbestos' prohibition, only in countries of European Union mortality from mesotheliomas will grow from 5000 cases in 1908 to 9000 cases in 2008 and within the next 35 years from mesotheliomas about 250 thousand people will die. The peak of morbidity in these countries is predicted for 2010–2040 [26].

At the present time for the solution of problems of asbestos conditioned diseases in Republic of Kazakhstan the need is ripe of development and carrying out fundamental hygienic, sanitary-engineering, clinical, epidemiological and experimental research programs with monitoring creation in format of carcinogenic risk of republican level.

References

1. *Pylev L.N., Smirnova O.V.* Onkological danger at production and use asbestos product in life // Hygiene and sanitariya. — 2006. — 2. — S. 32–36.
2. *Vezencev A.I., Neyman S.M. et al.* To question about safe using of asbestos-cement // Building materials. — 2004. — № 4 — P. 38–39.
3. *Vezencev A.I., Gudkova E.A. et al.* To question about change surface and biological characteristic of chrysotile in asbestos-cement // Building materials. — 2008. — № 9. — P. 26–27.
4. *Ulvestad B., Kjaerheim K. et al.* Cancer incidence among workers in the asbestos-cement producing industry in Norway // Scand J. Work. Environ. Health — 2002. — Vol. 28. — P. 411–417.
5. International Programme on Chemical Safety (IPCS) Man-made mineral fibers. World Health Organization — Geneva: Environmental Health Criteria, 1977. — 165 p.
6. *Kishimoto T., Okada K. et al.* Evaluation of the pleural malignant mesothelioma patients with the relation of asbestos exposure // Environ. Res. — 1989. — Vol. 48. — № 1. — P. 42–48.
7. *Berry G.* Prediction of mesothelioma, lung cancer, and asbestosis in former Wittenoom asbestos workers // Brit. J. Ind. Med. — 1991. — Vol. 48. — № 2. — P. 793–802.
8. *Bernstein D.M., Rogers R., Smith P.* The Biopersistence of Brazilian Chrysotile Asbestos Following Inhalation // Inhalation Toxicology. — 2004. — Vol. 16. — P. 11–12.
9. *Langer A., Nolan R.* Physical chemical properties of fibers other than asbestos in global use // J. Occup. Health. Safety. — 1996. — Vol. 12. — P. 263–278.
10. *Stayner L.T., Dankovic D.A., Lemen R.A.* Occupational exposure to chrysotile asbestos and cancer risk: a review of the amphibole hypothesis // Am. J. Public. Health. — 1996. — Vol. 86. — P. 179–186.
11. *Lippmann M.* Biophysical factors affecting fiber toxicity // Fiber Toxicology. — Academic Press, San Diego, 1993. — P. 259–303.
12. *Kashanskiy S.V.* Mezotelioma in Russia: system review 3576 published events with position of medicine of the labour // Medicine of the labour and industrial ecology. — 2008. — № 3. — P. 15–21.
13. *Nagornaya A.M., Varivonchik D.V. et al.* Oncological disease of workers of asbestos-cement production // Medicine of the labour and industrial ecology. — 2008. — № 3. — P. 27–33.
14. *Kovalevskiy E.V.* The Asbestos and other fiber material, using in industry: their using, influence on person and some given about biological action // Collection report and appearances international seminara. — Asbestos, 2004. — P. 3–32.
15. *Nudeliman B.I., Ismatov B.I.* Physico-chemical particularities of the use of chrysotile-asbestos // Modern condition and prospects of the development asbestos-cement industry of the C.I.S. countries of Central-asiatic region in condition controlled, safe use of asbestos products and materials: Regional international seminar. — Tashkent, 2004. — P. 86–90.
16. *Pylev L.N., Smirnova O.V. et al.* Experimental motivation to carcinogenic danger of asbestos-cement industry and its product // Hygiene and sanitariya. — 2010. — № 6. — P. 61–65.

17. *Pylev L.N., Smirnova O.V. et al.* Influence of the modification to surfaces of the filaments chrysotile on its biological activity // Hygiene and sanitariya. — 2007. — № 2. — P. 77–80.
18. *Pylev L.N., Vasilieva L.A. et al.* Active radicals of the oxygen and stringy asbestos cancerogenesis // Toxicological vestnik. — 2009. — № 1. — P. 27–31.
19. *Hasanoglu H., Bayram E. et al.* Orally Ingested Chrysotile Asbestos Affects Rat Lungs and Pleura // Arch. Environ. Occup. Health. — 2008. — Vol. 63. — № 2. — P. 71–75.
20. *Bertolotti M., Ferrante D. et al.* Mortality in the cohort of the asbestos cement workers in the Eternit plant in Casale Monferrato (Italy) // Epidemiol. Prev — 2008. — Vol. 32. — № 4–5. — P. 218–228.
21. *Bridle J., Stone S.* Casitile, the new asbestos: Time to clear the air and save 720 Billions. — 2006. — http.www.chrys-otile.com.
22. *Burdett G.* Investigation of the chrysotile fibres in an asbestos cement sample // HSL. — 2007. — Vol.11. — www.hsl.gov.uk.
23. *Miserocchi G., Sancini G. et al.* Translocation pathways for inhaled asbestos fibers. Environmental health: a global access science source // Environ. Health. — 2008. — Vol. 7. — P. 4.
24. *Pylev L.N.* Pretumorous lesions, lung and pleural tumors induced by asbestos in rats, Syrian golden hamsters, and monkey Macaca rhesus / In: Wagner, J.C., ed. Biological effects of mineral fibres // IARS Sci. Publ. Leon — 1980. — Vol. 1. — № 30. — P. 343–355.
25. *Kashanskiy S.V., Zhetpisbaev B.A. et al.* Mezotelioma beside populations in republic Kazakhstan (the review) // Hygiene and sanitariya. — 2008. — № 5. — P. 13–17.
26. *Vanchugova A.I., Kashanskiy S.V. et al.* The Modern directions to methodologies risk assessment // Medicine of the labour and industrial ecology. — 2008. — № 3. — P. 33–37.

UDC 613.6:576.211–008.4

The morphofunctional state of the mucous membrane of the upper respiratory ways among workers of chrysotile-asbestine production of JSC «Kostanaisky minerals»

«Қостанай минералдары» АҚ хризотил-асбест өндірісіндегі жұмысшылардың жоғарғы тыныс алу жолдарындағы шырышты қабықшасының морфофункционалдық жағдайы

Duzbaeva N.M.

Y.A.Buketov Karaganda State University (E-mail: nazira.71@mail.ru)

«Қостанай минералдары» АҚ хризотил-асбест өндірісінің байыту цехындағы тексерілген жұмысшылардың мұрынының шырышты қабықшасы (МШҚ) мен ұртының буккальды эпителийі (ҰБЭ) жасушаларының цитоморфологиялық зерттеу нәтижелері берілген. Еңбек өтіліміне қарай хризотил-асбест шаңы әсерінен жұмысшыларда МШҚ мен ҰБЭ цитоморфологиялық өзгерістері анықталды. МШҚ мен ҰБЭ жасушаларының функционалдық жағдайының бұзылуы еңбек өтілімінің жоғарлауына байланысты клиникалық көріністермен жүреді, сондай-ақ оған жергілікті иммунитеттің төмендеуі ықпал жасап, ол өз кезегінде жоғары тыныс алу жолдарының кәсіби аурулары дамуының негізгі қауіп факторы болып табылады.

В статье представлены результаты цитоморфологических исследований клеток слизистой оболочки носа (СОПН) и буккального эпителия щек (БЭЩ) у обследованных рабочих хризотил-асбестового производства цеха обогащения АО «Костанайские минералы». Авторы отмечают, что в зависимости от стажа работы при контакте с хризотил-асбестовой пылью у рабочих достоверно изменялся цитоморфологический состав СОПН и БЭЩ. Нарушения функционального состояния клеток СОПН и БЭЩ с повышением стажа работы сопутствуют клиническим проявлениям, но им нередко предшествует снижение местного иммунитета, что является основным фактором риска в развитии производственных заболеваний верхних дыхательных путей.

Introduction

Industrial dust in the conditions of modern production influences on the respiratory tract and mostly on the upper respiratory ways. Taking into account that between the nasal mucosa, pharynx, larynx and bronchi exist close morphofunctional connection, we can assume the presence of a common pathogenesis of professional diseases of the upper and lower respiratory tract infections. Numerous authors note that industrial dust causing a breach of mucociliary clearance, which in its turn contributes to the penetration of dust into the respiratory system deep laying parts and leads to the development of professional pathology of the respiratory system (sub-and atrophic rhinitis, the dust bronchitis, pneumoconiosis and asthma).

The topicality of work is determined by the social significance of the «dust» pathological respiratory tract, deficient study of genetic relationship pathogenesis of chronic respiratory diseases and diseases of broncho-pulmonary system, and the need to develop methods for early detection of chronic nasal cavity diseases, buccal cheek epithelium taking into account the work experience in the industry.

These numerous studies show that all of the asbestos fibers chrysotile is the least dangerous and rapidly derived from organism, and amphibole asbestos has a high biological activity and resistance in biological spheres [1].

Issues of occupational pathology of the upper respiratory tracts among workers of asbestos production are devoted to a relatively small number of works. However, the most serious danger is posed by asbestos particles floating in the air and trapped in the respiratory ways that has caused the development of heavy types of silicosis — asbestosis. In this regard, particular importance has the fact that upper respiratory tracts are the «outpost» in the way of air flow and its various parts affected by dust in different degrees [2, 3].

There is the need to study the problems of effects on the organism the industrial factors of chrysotile asbestos production carefully.

The problem of formation of upper respiratory diseases from influence of asbestos dust is still relevant.

In recent years under the screening examinations in the expedition and the experimental conditions in the hygiene practices to detect early forms of upper respiratory tract diseases as a convenient object of studying the non-invasive tests — cells of rinotsitogramma and buccal cheeks epithelium are used [4].

Cytological condition of the mucous membranes of the nasal cavity (MMNC) and buccal cheek epithelium (BCE) reflects the changing state of the body depending on the pollution of the working environment. Studies have shown the epithelium of the mucous membranes of various degrees of differentiation are in definite and stable correlation with each other and vary from different adverse effects both chemical and biological nature and thus can be considered as a target [5].

Researches showed that dust containing asbestos chemically inert and the mechanism of its effects on the human body is not fundamentally different from that of other types of mineral dust (cement, silica, etc.). Under the small concentrations of asbestos fibers in the air they are mostly trapped in the upper respiratory tract and are excreted naturally (e.g. with sputum). Those fibers that infiltrated the lungs can infiltrate the lung tissue. However they are immediately attacked by phagocytes — cells that perform safety functions in the body. Phagocytes accumulate around the foreign body and dying create around him an aggressive (acidic) environment destroying and rejecting fiber. Chrysotile asbestos in these conditions is destroyed and its breakdown products are excreted [6].

Amphibole asbestos, as being acid are not destroyed by phagocytes. But they contain traces of biologically active compounds (compounds of Fe, Co, Ni, and others), which was the reason for the ban of their production and use of the International Convention for Labour Safety under the use of asbestos in 1986 [7, 8].

The aim of work is studying the cytomorphological indices of mucous membranes of the nasal cavity and buccal cheek epithelium of the workers in the asbestos production in the conditions of chrysotile asbestos dust depending on the work experience.

Materials and methods of research

65 people were investigated who were divided into 4 groups. In the 1st group consisted of 16 people not contacting with industrial dusts (middle age 32,3 ± 0,95) in the 2nd group — 17 workers (middle age 35,6 ± 1,67, 5–10 years of work experience) in the 3rd group — 15 workers (middle age 38,0 ± 1,93 11–15 years of work experience), the 4th group contains 17 workers (middle age 48,8 ± 1,95, 16–20 years of work experience).

By profession they are electricians on the equipment repairing, regulators, engineers on the shop of enrichment.

Dust chrysotile asbestos refers to a highly fibrogenic containing free silicon dioxide from 20 % to 70 %. MPC dust of chrysotile asbestos is 2,0 mg/m^3. Middle changeable concentration of MPC is 0,5 mg/ m^3. State of matters in the air in terms of production — an aerosol, class of danger 3, class of labour conditions 3, a feature of the organism to cause is fibrogenic.

With sterile cotton balls by rotational motions from the inner side of the nasal mucosa secretation was taken and thin smears — imprints from the surface of the mucous membranes of the nasal cavity (MMNC) were made on a glass slide. To study the imprint smears from the mucous membrane of cheek, smears were taken with a spatula, laid on a glass slide, smears were dried at room temperature, fixed in May-Grunwald solution. They were painted by the method of Romanovsky-Gimsa. Under the microscoping 300 cells from cytomorphological study were counted. Assessment of the significance of the results was performed by the 1st criteria of Student (p <0,001). Total number of analyzes are 260.

The results of research and discussion

In analyzing the results of MMNC study (on rinotsitogramma) it was found that workers of the 2nd, 3rd and 4th groups compared with donors the decrease in the number of squamous epithelium in 4 times, 7,2 times and 16,9 times, respectively is observed. The number of squamous epithelium with signs of damage increased in all 3 groups in 12,9 times, 10,3 times and 12,2 times, respectively (Table 1).

Table 1

Cytomorphological and morphometric parameters (in %) of cells in the examined workers MMNC (enrichment shop) (M ± m; n = 65)

Type of cells	Group 1 n=16	Group 2 n=17	Group 3 n=15	Group 4 n=17
Squamous epithelium	80,47 ± 2,49	20,17±3,09*	11,23±2,27*	4,74±1,43*
Squamous epithelium with signs of damage	4,84±1,02	62,56±5,25	50,10±5,55	59,32±6,09*
Cubic and cylindrical epithelial cells	10,47±1,83	4,09±0,87*	4,23±0,65*	2,08±0,62*
Cubic and cylindrical epithelial cells with signs of damage	0,94±0,34	2,97±0,97*	6,30±0,96*	6,24±1,63*
The segment and stab neutrophils	2,84±0,37	1,88±0,80	8,10±1,23*	7,74±2,13*
The segment and stab neutrophils with signs of damage	0,44±0,18	8,33±1,77*	20,40±2,92*	19,88±2,85*
Eosinophile	0,0±0,00	0,0±0,00	0,0±0,00	0,0±0,00
The index of alteration: squamous epithelium	0,06±0,01	0,76±0,04*	0,83±0,05*	0,91±0,04*
Cubic and columnar epithelium	0,06±0,02	0,23±0,04*	0,53±0,06*	0,64±0,04*
Neutrophilen	0,06±0,01	0,50±0,02*	0,56±0,05*	0,69±0,05*
Microflora contamination (streptococci and staphylococci)	5,78±1,39	5,0±1,46	11,37±2,54*	11,85±2,57*

Note. * — Significant changes compared with donors (p <0,001).

Number of cubic and cylindrical epithelial cells was reduced by 2,6 times, 2,5 times and 5 times, and with signs of damage to the same cells were increased in all 3 groups of investigated workers in 3,1 times, 6,7 times and 6,6 times respectively. Number of segments and stab neutrophiles was increased in the 3rd and 4th group in 2,8 times and 2,7 times, and with the signs of damage (vacuolated and destructive) was increased in the 3 groups in the18,9 times, 46,3 times and 45,2 times, respectively (p <0,001).

The index of alteration of the squamous epithelium was also increased in all three observed groups in 12,6 times, 13,8 times and 15,2 times, cubic and columnar epithelium in 3,8 times, 8,8 times and in 10,6, neutrophiles in 8,3 times, 9,3 times and in 11,5 times, respectively, compared with donors.

The increase in the number of microorganisms was mentioned (streptococci and staphylococci) at the third working and Group 4, on average in 2 times.

Our results showed that the impact of production factors in the upper respiratory ways dystrophic processes of varying degrees of severity develop: 16 donors' (group 1) MMNC state among 15 (93,7 %) has no change, 1 observed person (6,3 %) had catarrhal rhinitis.

In group 2 among 4 workers (23,53 %) — catarrhal rhinitis, in 13 (76,47 %) — chronic atrophic rhinitis.In the third group, six workers (40 %) — catarrhal rhinitis in 9 (60 %) — chronic atrophic rhinitis. In the 4th group in 4 (23,53 %) — catarrhal rhinitis, in 13 (76,47 %), chronic atrophic rhinitis.

These results are consistent with published data. Coming into the body harmful industrial substances cause general toxic action in the first polymorphic MMNC changes. The largest changes are observed in acute and chronic rhinitis. Our observations showed that the workers decreased cleaning ability of the epithelium of the upper respiratory tract infections. There is increasing pressure on phagocytic cells. Overloaded with dust and the metabolites they are not functionally active and able to settle in the respiratory ways epithelium. Part of the dust penetrates to the basal layer, which is probably one of the triggers of early alterations in the flat, cubic and cylindrical epithelium, and leukocytes neygrofilnyh; violation of their functional properties with increasing length of service, significantly increases inhibition of transport function of the mucociliary clearance and acid — base balance.

In parallel, cytological status of buccal cheek cells was investigated in the same groups of workers.

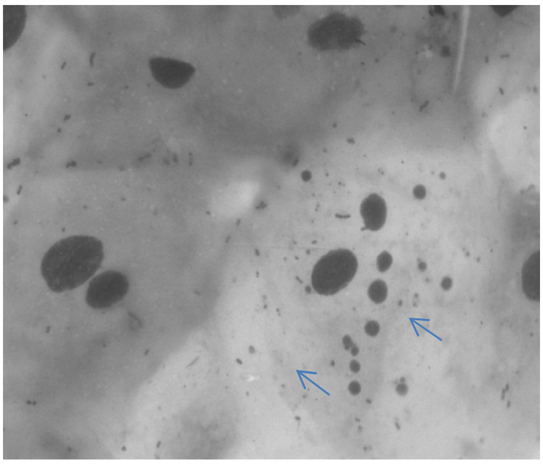
Under and buccal cheek epithelium (BCE) cells cytomorphological evaluation among workers of the 2nd, 3rd and 4th groups were found the normal epithelial cells decrease by 38 %, 52 %, and in 2,9 times compared with donors (Table 2). Observed increase in phagocytic apoptotic (residual) cells in group 2 (Pictures 1, 2), 4,7 times in the third group, 7,6 times in the 4th group, 8,7 times, with signs karyorhexis in 5,3 times, 4,3 times and in 11,3 per cent. The number of nuclear-free cells increased among the workers in Group 2 5 times, the third group by 6,5 times and the 4th group is 3,7 times the number of degenerated neutrophils increased in the 2nd group of workers is 2,1 times in the third group of 2-fold and 4-th group by 3,7 times. In the 4th group the increase in the number of cells in the dual-core 2,2 times was observed. In the 3 groups (2nd, 3rd and 4th) the increased cell vacuolar degeneration in 8,5 times, 10,5 times and 25,3 times was observed. There is increased microbial contamination (streptococci and staphylococci) in 6,5 times, 7 times and 8 times compared with donors (Table 2).

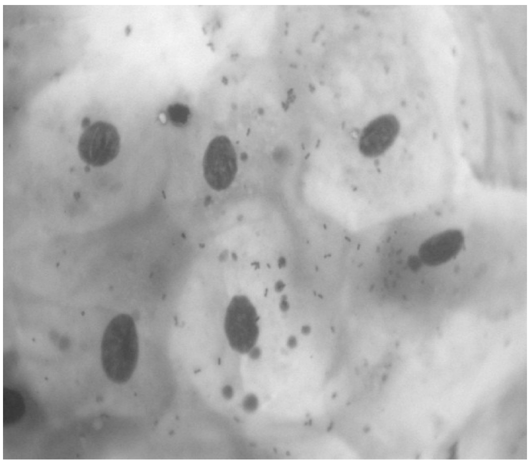
Table 2

Cytomorphological indices (in%) of BCE cells in the examined workers (enrichment plant) (M± m; n = 65)

Type of cells	1 group n=16	2 group n=17	3 group n=15	4 group n=17
Normal epithelial cells	83,9 ± 1,39	60,05±4,24*	55,30±3,83*	28,44±3,17*
Phagocytic apoptotic (residual) cells	0,41±0,11	1,94±1,01*	3,1±0,62*	3,59±0,73*
Karyorhexis	1,44±0,26	7,65±1,18*	6,16±1,04*	16,26±2,65*
Non -nuclear cells	1,84±0,11	9,32±1,39*	12,06±1,73*	7,0±0,73*
Degenerated neutrophilic leukocytes	8,0±0,99	16,56±1,56*	16,06±2,08*	30,20±2,78*
Dual-core cells	4,09±0,77	2,61±0,94	4,40±1,54	8,94±1,88*
Cell vacuolar degeneration	0,22±0,04	1,87±0,73*	2,38±1,34*	5,57±1,32*
Microbial contamination (streptococci, staphylococci)	7,06±0,99	45,59±4,17*	49,90±5,62*	56,53±4,80*

Note. * — Significant changes compared with donors (p <0,001).





Pictures 1, 2. Phagocytic apoptotic (residual) cells. Increase 1600 time

As shown by our study, and buccal cheek epithelium (BCE) cytological status of the workers (of enrichment plant) is intended to change of the barrier properties of the epithelial layer. Increased phagocytic apoptotic (residual) cells in the epithelial cells indicate the effects of toxic factors of industrial environment on the organism of the workers. Buccal epithelial cells are sensitive to various exogenous and endogenous ecological factors impact, which affects the functional changes in cells, where there are various violations of local importance.

Thus, summing up the described research we can note that the enrichment shop workers' the state MMNC and BCE with varying work experience have established that prolonged exposure to dust leads to a violation of a protective-adaptive mechanisms of the respiratory ways, the severity of which depends on the duration of exposure to dust factors and individual characteristics of the organism. As shown by our study buccal epithelial cells are an indicator of changes in epithelial differentiation, detected cytomorphological (size and number of inclusions in the cytoplasm and signs of changes in the nucleus), which are used for screening health assessment of workers and workers in hazardous industrial environments factors.

Conclusions

1. Depending on the work experience with chrysotile asbestos dust on floor at the shop enrichment workers' cytomorphological MMNC state significantly changed according to the number of degenerated epithelial cells, cubic, cylindrical, and neutrophils as well as a high index of alteration in these cells.

2. The nature of degenerative changes in the mucous membranes of the upper respiratory tract (catarrhal, chronic atrophic rhinitis) depends on the duration of productive work experience. It was noted under the professional experience after 5–10 years there are catarrhal changes in the mucous epithelium of the nose, and after 10 to 20 years mainly dominated by the sub-processes and atrophic.

3. Violations of the functional state of MMNC and BCE cells accompanied by clinical manifestations, but they are often preceded by a decrease in local immunity, which is a major risk factor in the development of professional diseases of the upper respiratory tract.

References

1. *Izmerov N.F.* Health of able-bodied population of Russia // Medicine of work and industrial ecology. — 2005. — № 11. — P. 3–9.
2. *Tulebaev R.K.* Scientific researches and innovative workings out on problems of a respiratory pathology in Republic Kazakhstan//Materials 2 National congresses of regions of Kazakhstan and the International conference young otolaryngologists «Pathologies of a respiratory path». — Astana — Shymkent, 2005. — P. 5 — 11.
3. *Piskunov S.Z., Zavjalov F.N., Yerofeev L.N.* Research mucosiliar transport system of a mucous membrane of a nose at healthy faces // Russian rhinology. — 1995. — № 3–4. — P. 60–62.
4. *Kulkybaev G.A.* Work medicine in Kazakhstan // Medicine of work and industrial ecology, 2003. — № 10. — P. 2–8.
5. *Bazelyuk L.T.* Morfometrichesky and cytochemical tests at the workers contacting with dust gas by mixes // Methodical recommendations. — Karaganda, 1994. — 21 p.
6. *Beljaeva N.N., Sycheva L.T. et al.* The estimation of the cytologic status of a mucous membrane of a nose and a mouth at the person // Methodical recommendations. — M., 2005. — 37 p.
7. *Husainov I.S., Varvuleva I.J., Kazhina N.A.* Estimation of cytologic indicators buccal epithelium for diagnostics of a functional condition of the person // Clinical laboratory diagnostics. — 1997. — № 3. — P. 10–12.
8. *Kutepov E.N., Beljaeva N.N. et al.* The estimation of the cytologic status of a cavity of a nose and a mouth // Hygiene and sanitary. — 1998. — № 4. — P. 54–57.

UDC 612.017:553.676

Characteristics of the immune system of the organism of workers in chrysotile-asbestos production

Хризотил-асбест өндірісіндегі жұмысшылардың иммундік жүйесінің сипаттамасы

Amanbekova A.U.[1], Azhimetova G.N.[1], Gazizov O.M.[2], Bekpan A.Zh.[3]

[1]*National center for occupational hygiene and occupational diseases MH RK, Karaganda;*
[2]*Karaganda State Medical University;*
[3]*Regional diagnostic center, Astana (E-mail: ncgtpz@gmail.com)*

Өндірістік ортаның жағдайына бейімделу барысында адам денсаулығын қорғау үшін иммундық жүйе маңызды рөл атқарады. Авторлар хризотил-асбест шаңының әсер ету ортасында қызмет атқаратын қызметкерлердің иммундық жүйесінің жасушалық және гуморалдық тізбегін бағалаған. Жоғарғы тыныс алу жолдарының патологиясының қауіпті факторы болып иммунитеттің жасушалық және гуморалдық тізбектерінің тежелуімен жүретін қызметкерлердің ағзасындағы иммунореактивтің өзгеруі анықталды. Сонымен қатар хризотил-асбест шаңының әсерінен сілемейлі барьердің бұзылысына және жоғарғы тыныс алу жолдарының сілемейлі қабықшасының жергілікті иммунитетінің нашарлауына себепші болады.

В статье показана важная роль иммунной системы в сохранении здоровья человека при адаптации к условиям производственной среды, приведена оценка клеточного и гуморального звеньев иммунной системы организма работающих в условиях воздействия пыли хризотил-асбеста. Авторами выявлено, что фактором риска в развитии патологии верхних дыхательных путей является измененная иммунореактивность организма работающих, проявляющаяся угнетением клеточного и гуморального звеньев иммунитета. Установлено также, что воздействие пыли хризотил-асбеста приводит к нарушению слизистого барьера и снижению местного иммунитета слизистой оболочки верхних дыхательных путей.

Actuality

An estimate of the risk of respiratory pathology depends on experience exposure. With the increase of length of service in the «dusty» occupations mucosal defenses are gradually depleted, that confirmed by cytochemical and functional studies. Determination of the critical work experience in hazardous conditions can produce, according to some authors, to some extent alleviate prenosological diagnosis of occupational or professional work-related diseases [1, 2].

According to the concept of local immunity and mucous membranes and skin of both covers, addressed to the external environment, internal environment to protect and preserve its continuity through the close interaction of the complex evolution of produced non-specific and specific defense mechanisms [3].

Originally a local immunity implied complex cellular and secretory nonspecific and specific responses, including the barrier function of mucosal cells, the phagocytic activity of neutrophils and macrophages, T-cell immunity, antibody, anti-microbial proteins external secrets enzyme inhibitors. Local immunity is not identified with secretory immunity, but as it was considered a focal point of B-cell response to mucosal lymphoid tissue with glandular epithelium, which supplies the secretory component. Later, the concept of local immunity has expanded and now includes a set of responses of all cells of lymphoid series, occupying the mucous membranes, in cooperation with macrophages, neutrophilic and eosinophilic granulocytes, mast cells and other cells of connective tissue and epithelium [4].

Local immunity in otolaryngology — a barrier function of the mucous membranes, including limfoepithelial bodies of the pharynx, located at the intersection of the respiratory tract and esophageal, first responding to another antigenic stimulation (infection) the inclusion of mechanisms of immune protection, and non-specific protective factors mucosa (mucociliary transport, production lysozyme, lactoferrin, interferon and others) [5, 6].

Change the immune status is one of the earliest and most sensitive signs of the impact of unfavorable factors of production in the body and can serve as a criterion for the risk of respiratory diseases among workers of chrysotile asbestos production.

The stability of the mucous membranes of microbial contamination is a «first wave immunity» and the state of the immune defense of the mucous membranes depends on the degree of exposure, a measure of pollutants from entering the air inhaled by man [7].

Indicators of the immune system of mucous membranes (the activity of lysozyme, secretory IgA, etc.) are highly informative in assessing the level of protection of mucous from harmful environmental factors [8].

Clinical manifestations and course of lung disease in asbestos workers in the production of defined immunological reactions in violation of immunoregulation and the development of secondary immunodeficiency, as well as relevant individual characteristics of the organism [9–11].

Thus, changes in immune reactivity play a leading role in the pathology of the respiratory system and study of the immune system in early stages of the disease process to predict the nature and degree of activity.

The aim of investigation

The aim of investigation is to study the cellular and humoral immune system in persons working under the impact of chrysotile asbestos dust on the JSC «Kostanai minerals.»

Materials and methods

The study was conducted according to the type of retrospective cohort clinical trial. The study was conducted at the National Center for Occupational Hygiene and Occupational Diseases, and was based on a survey of workers of JSC «Kostanai minerals». To study the influence of unfavorable factors of chrysotile asbestos production assessed the immune status of 106 male workers of JSC «Kostanai minerals» with industrial exposure to dust factor. The control group consisted of 20 males who do not have contact with asbestos dust. Analysis of the age structure of the surveyed showed that the vast majority of workers — those over 30 years of age 31–40 years, 29.4 % and 31.8 % were working 41 to 50 years. At the age of 50 years were 18, 6 % of men. All subjects depending on the duration of the production experience were divided into five groups in increments of 5 years, the largest number of workers have worked on this production of 6–10 years — 38.1 %, 16–20 years of experience have 21.9 % of people directly exposed to chrysotile asbestos dust.

To study the immune status of the surveyed population and determined the major subpopulations of lymphocytes: T cells, B cells, T helper, T suppressor cells and zero — 0-cells. Immunophenotyping of lymphocytes was performed using a «shortened» the panel of monoclonal antibodies (mAbs) to identify the following CD-markers: CD3 (T lymphocytes), CD4 (T helper), CD8 (T suppressor), CD20 (B lymphocytes), CD56 (natural killer cells). To assess humoral immunity held definition of serum immunoglobulins (IgA, IgM, IgG), secretory immunoglobulin A (SIgA) by ELISA according to the standard procedure [12, 13].

Statistical analysis of the results of the study was carried out using the software package Microsoft Office Excel 2003 and «Statistic 6,0» Windows'HR in the operating system, using the variational statistical analysis (mean values and their deviations — M ± m) with an estimate of the reliability of the results with respect to Student's t-test [14].

Results and discussion

Analysis of the cellular immunity system (Table 1) showed a significant difference in the content of CD3 (T lymphocytes) decrease in workers of the main group (59,1 ± 0,43 %) compared with controls (71,2 ± 0,52 %). There is also a significant gradual decrease in CD3 in workers with increasing length of service, so with 0–5 years experience — 70,1 ± 0,31 % ($p < 0.01$), and more than 20 years — 58,7 ± 0,41 % ($p < 0.01$).

Table 1

Indicators of T-managers the immune system surveyed in depending on the length (M ± m)

Indicators	Control=20	Experience				
		0–5 years (n=21)	6–10 years (n=19)	11–15 years (n=21)	16–20 years (n=23)	More than 20 years (n=22)
CD3, %	71,2±0,52	70,1±0,31	58,9±0,75	57,5±0,37*#	56,7±0,85*#	58,7±0,41*#
CD4, %	45,2±0,26	49,2±0,23*	44,9±0,45	42,8±0,25*	41,9±0,72*#	40,9±0,85*#
CD8, %	20,6±0,73	22,5±0,37	23,7±0,62*	24,1+0,57*	26,3±0,71*#	27,1±0,53*#
CD4/CD8	2,17±0,11	2,19±0,11	1,95±0,15	1,83±0,14	1,61±0,11*#	1,53±0,1*#

Notes: * — reliability of differences in indicators compared with the control, $p < 0.01$; # — reliability of differences in indicators compared to healthy workers with experience of 0–10 years, $p < 0.01$.

No significant differences in the content of CD-4 (T-helper cells) in the examined and control group is not found (43,8 ± 0,54 % and 45.2 0.26 %, respectively). Changing the contents of CD-4 from employees of chrysotile asbestos production, depending on the duration of exposure to industrial pollutants was complex: at the experience of 0–5 years, the relative abundance of CD 4 cells (49,2 ± 0,23 %, p <0.01) was significantly higher than controls, suggesting that activation of the immune system working under the impact of dust agent. Then have a CD4 workers with 6–10 years experience normalized 44,9 ± 0,45 %), which characterized the immune system to adapt to the conditions of the working environment.

Then there is a tendency to decrease their content in workers with experience of 16–20 years compared with not enough trained workers (41,9 ± 0,72 % and 49,2 ± 0,23 % (p <0.01), respectively). We work more than 20 years are set even lower rates as compared with the control group, and with short experienced workers — 40,9 ± 0,85 % (p < 0.01). This indicates a decompensation of the protective mechanisms of the immune system, manifested by a lack of activation of macrophages in the event that affected T-cells that perform the function of helper type 1, on the one hand, on the other hand, is the activation of humoral immunity (activation of specific B-lymphocytes to pro -induction of the anti-immunoglobulin) if affected by T-helper type 2.

No significant differences in the content of CD8 (T suppressor) in those basic and control groups could not be detected, but attention is drawn to increase their production levels with increasing seniority. So at the experience of 5 years CD8 figures were 22,5 ± 0,37 %, while at the experience of more than 20 years — 26,3 ± 0,71 % (p <0.01). Cytotoxic lymphocytes (CD 8) cells carry tumor immunity, therefore, takes place in the examined voltage killer lymphocyte function, which represents a risk in the development of cancer. The most efficient cells in the immune defense will probably be tested in B-lymphocytes, responsible for representation of allergens, peptides and other soluble antigens.

Comparative analysis of immunoregulatory index (CD4/CD8) showed a gradual decrease of this index (2,19 ± 0,11 — at the experience of 5 years, and 1,53 ± 0,1 — at the experience of more than 20 years, p < 0.01), which indicates an increase in cytotoxicity with increasing seniority in contact with chrysotile asbestos.

Significant reduction in the functional activity of T cells was observed in persons who have been working more than 20 years compared with short experienced workers, which confirms the hypothesis that the stage of decompensation, observed in the immune system in many years of contact with chrysotile asbestos.

Content analysis of CD20 (B lymphocytes) in the plasma revealed a decrease in performance with increasing seniority (Table 2). So in the group with experience of 5 years showed a trend toward lower CD20 (11,92 ± 1,7 % and 12,7 ± 1,09 %, respectively). Significant reduction in B-cells found at the experience of 11–15 years (8,89 ± 1,32 %, p <0.01) and lowest in comparison with the control group and not enough trained workers registered at the experience of more than 20 years (6.1 0.39 %, p <0.01).

T a b l e 2

Indicators of B-lymphocytes and null cells of the immune system tested, depending on the length (M ± m)

Indicators (%)	Control (n=20)	Experience				
		0–5 years (n=21)	6–10 years (n=19)	11–15 years (n=21)	16–20 years(n=23)	More than 20 years (n=22)
CD20	12,7±1,09	11,92±1,7	10,51±1,1	8,89±1,32*#	8,4±0,47*#	6,1±0,39*#
CD56	18,97±0,45	34,25± 1,17*	37,3±1,67*	32,5±1,94*	32,7±0,96*	31,5±1,32*#

Notes: * — reliability of differences in indicators compared with the control, p <0.01; # — reliability of differences in indicators compared to healthy workers with experience of 0–10 years, p <0.01

In analyzing the parameters of CD56 (null cells) found a sharp increase in performance in the first years of contact with chrysotile asbestos, and there was an increase of 1.8 times (18,97 ± 0,45 % and 34,25 ± 1,17 % — respectively, p < 0.01). At the experience of 6–10 years of on-cell number increased to 37,3 ± 1,67 %, then tended to decrease. In highly trained workers (over 20 years experience) the number of zero cells decreased in comparison with the experience of 6–10 years.

The study revealed changes in the immune system, depending on length of service. In cellular immunity found significant reduction in CD3 rate in the intervention group (59,1 ± 0,43 %) compared with controls (71,2 ± 0,52 %). Depending on length of service options CD3 significantly decreased slowly, so at the experience of 0–5 years — 70,1 ± 0,31 % (p <0.01) and more than 20 years — 58.7 0.41 % (p < 0.01). CD4 count in the subjects of the main group was not significantly different from controls. Changing the content of CD4 in chrysotile asbestos workers produce, depending on the duration of exposure to asbestos dust was complex: at the experience of 0–5 years, the relative content of CD4-cells (49,2 ± 0,23 %, p <0.01) significantly higher than controls. CD4 in workers with experience of 6–10 years to normal (44,9 ± 0,45 %), which characterized the immune system to adapt to the conditions of the working environment. Then there is a tendency to decrease their content in workers with experience of 16–20 years, compared with not enough trained workers (41.9 0.72 % and 49,2 ± 0,23 % (p <0.01), respectively). In workers with experience more than 20 years are set even lower rates — 40,9 ± 0,85 (p <0.01).

Analysis of the concentrations of different immunoglobulin classes revealed significant depending on the length of the study group (Table 3). Indicators of immunoglobulin A in the first years tend to increase (2,95 ± 0,54 g/l), the workers at the experience of more than 11 years was significantly reduced (1,85 ± 0,53 g/l), as compared to the control group (2,85 ± 0,27 g/l), and indicators of not enough trained workers (2,95 ± 0,54 g/l). The same trend is observed in the parameters of secretory IgA, where in the early years of contact with dust revealed an increase of almost 2-fold (0,64 ± 0,15 g / l, p <0.01), and a group of workers with experience of more than 20 years reduction target of 2 times (0,16 ± 0,03 g / l, p <0.01) compared with the control and 4-fold compared with not enough trained workers.

Table 3

Analysis of the concentrations of different immunoglobulin classes

Indicators	Control (n=20)	Experience				
		0–5 years (n=21)	6–10 years (n=19)	11–15 years (n=21)	16–20 years (n=23)	More than 20 years (n=22)
IgA, g/l	2,85 ± 0,27	2,95±0,54	2,21±0,72	1,85 ±0,53#	1,72±0,34*#	1,35±0,57*#
IgM, g/l	1,12 ± 0,56	1,98±0,61	1,91±0,53	1,28 ±0,24	1,45±0,78	1,17±0,81
IgG, g/l	11,27±0,14	15,35±0,86	13,27±0,54	17,25 + 0,12*	17,92±0,84*	19,27±0,57*
S IgA, g/l	0,34±0,07	0,64±0,15*	0,29±0,06#	0,23±0,06#	0,21±0,05*#	0,16±0,03*#

Notes: * — reliability of differences in indicators compared with the control, p <0.01; # — reliability of differences in indicators compared to healthy workers with experience of 0–10 years, p <0.01.

In the analysis revealed increased IgM parameters at the experience of 0–5 years (1,98 ± 0,61 g/l) and 6–10 years (1,91 ± 0,53 g/l) and nonsignificant reduction in the further work in contact with chrysotile asbestos in comparison with the indicators of short experienced workers.

Immunoglobulins IgG in all groups of workers increased in proportion to length of service. If the group were 0–5 years — 15,35 ± 0,86 g/l in the group over 20 years — 19,27 ± 0,57 g/l and had a significant difference only with the control group.

Thus, the characteristic feature of the humoral response of the body core working group was a significant decrease in the content of IgA and S IgA, increased IgM and IgG.

Correlation analysis of cellular immunity among workers with the experience of 0–5 years revealed a moderate negative relationship between the pH of the nasal cavity, and IgM (r = -0,51, p <0.05).

In conducting the correlation analysis within the established parameters of cellular immunity expected strong, medium level of communication. Moderate positive relationships found between experience and CD3 (r = 0,54, p <0.01), pH, and nasal sIgA (r = 0,58, p <0.01). Workers with 11–15 years experience of the main indicators of cellular immunity when correlations are determined: CD3, CD4, CD56, Ig G, sIg A.Moderate negative relation between age and identified IgG (r = -0,59, p <0.01), experience, and CD8 (r = -0,52, p <0.01).

Analysis of the correlation parameters in workers with 16–20 years experience within the set of the immune system strong ties between the average degree of relationship: age and CD20, CD56 (r = 0,6, p <0,01; r = -0,5, p < 0.01). The correlation parameters in the relationship highly trained workers with experience of more than 20 years, found an average degree of the relationship between age and IgA, IgM (r = 0,53, r = 0,57, p <0.01).

Conclusions

A risk factor in the development of pathology of the upper respiratory tract is altered immunoreactivity of the body work, manifesting by inhibition of cellular immunity: decrease in the content of CD3

(58,7 ± 0,41 %), CD4 cells (40,9 ± 0,85 %) and functional T-lymphocyte activity, decreased the content of CD20 cells (6,1 ± 0,39 %), humoral: a decrease in the concentration of IgA (1,35 ± 0,57 g/l), increased IgM, IgG.

Exposure to chrysotile asbestos dust leads to disruption of mucosal barrier and reduce the local immunity of the mucous membranes of the upper respiratory tract, in nasal secretions is a decrease in the concentration of secretory IgA (0,16 ± 0,03 g/l).

References

1. *Fedin I.N.* A condition of ENT organs at miners of coal mines // Safe habitat — pledge of health of the population: Scientific works of FNCH of F.F.Erisman. — Voronezh, 2004. — Iss. 12. — P. 602–604.
2. *Piskunov S.Z.* Physiology and pathophysiology of a nose and nose bosoms // Russian rinology. — 1995. — № 1. — P. 19–20.
3. *Syneva E.L., Ustyushin B.V., Aydinov G.V.* Working conditions and occupational diseases of ENT organs / under the editorship of Academician of the Russian Academy of Medical Science, professor A.I.Potapov. — M., 2001. — 308 p.
4. *Vorland L.H.* Antimicrobial peptides as part of the innate immune defense system // Folia Otorhinolaryng et Pathol Respiratoriae. — 1996. — Vol. 2. — № 1–2. — P. 13–21.
5. *Henkin R.I.* Why we breathe through our nose and our mouth: it's biochemistry, not only anatomy // Folia Otorhinolaryng et Pathol Respiratoriae. — 1997. — Vol. 3. — № 3–4. — P. 7–24.
6. *Bykova V.P.* Lymphatic-epithelial bodies in system of local immunity of mucous membranes // Pathology Archive. — 1995. — № 1. — P. 11–16.
7. *Eccles R.* Rhinitis as a mechanism of respiratory defence // Eur. Arch. Otorhinolaryng. — 1995. — Vol. 252. — P. 2–7.
8. Galaktionov of Century Evolutionary immunology. — M.: Academbook, 2005. — 408 p.
9. *Dueva L.A.* Immunological aspects of clinic professional bronchial-pulmonary diseases // Medicine of work and industrial ecology. — 2003. — № 6. — P. 5–9.
10. *Ljubchenko P.N., Massarygin V.V. et al.* Markers of influence of asbestos at workers // Medicine of work and industrial ecology. — 2005. — № 5. — P. 29–33.
11. *Kosarev V.V., Zhestkov A.V., Lebedin Ju.S.* Diagnostics of inhalation influence of industrial aerosols // Pulmonology. — 2003. — № 3. — P. 21–24.
12. *Kovalchuk L.V., Gankovskaja L.V., Meshkova R.Ja.* Clinical immunology and allergology with bases of the general immunology. — M.: GEOTAR-MEDIA, 2011. — 640 p.
13. *Rolf Ts.* Foundations of immunology. — M.: The World, 2008. — 135 p.
14. *Junkerov V.I., Grigoriev S.G.* Mathematics-statistical data processing of medical researchers. — St.-Petersburg: VMedA. — 2002. — 272 p.

UDC 677.511

Investigation of the chrysotile cement roofing sheets properties of various operation term

Хризотилцементтен жасалған әр түрлі мерзім қолданылған жамылғы табақтардың қасиеттерін зерттеу

Neumann S.M.[1], Popov K.N.[2], Mezhov A.G.[2]

[1]*Non-profit Organization «Chrysotile Association», Moscow;*
[2]*Moscow State University of Civil Engineering, Russia (E-mail: svetamark@yandex.ru)*

Мақалада 40 және одан да көп жыл бойы пайдаланған хризотилцементтік адыр-бұдырлы төбе жабындысы құрамын зерттеудің нәтижелері көрсетілген. Ұсынылған мағлұматтар хризотилцементтік өнімдердің қалыңдығы жұқармайтыны және атмосфераға зияны келмейтінін көрсетті. Өткізілген зерттеулер басқа төбе жабатын материалдар мен өнімдермен салыстырғанда хризотилцементтік адырбұдырлы төбе жабындының экологиялық, экономикалық артықшылығын растады.

В статье приведены результаты исследований свойств хризотилцементных волнистых листов со сроком эксплуатации в кровлях от 30 до 60 лет. Впервые экспериментально установлено, что в процессе длительной эксплуатации хризотилцементных листов их свойства не ухудшаются. Из результатов испытаний следует, что с возрастом не уменьшается толщина хризотилцементных листов, и, следовательно, волокна асбеста не выделяются в атмосферу, как это бездоказательно утверждается в некоторых зарубежных источниках. Авторы отмечают, что в микроскопических исследованиях, как и в ранее проведенных работах, показано, что волокна асбеста есть в цементной матрице.

The modern market of the roofing materials is very wide. Choice of this or any other roofing material requires an integrated approach. Many factors should be considered. Among them design and aesthetic requirements as well as the environmental conditions of its operation and last but not least, the financial capacity of a building contractor.

According to the price-quality trade-off chrysotile cement sheets are top-ranked among the industrial manufactured products for pitched roofs. These products, with more than a century of history, are used practically all over the world. They are simple in manufacturing and r*oofing installation*, light (14 kg/m² comparing to the ceramic tiles — up to 70 kg/m²), whereas, not expensive and durable.

The most active period of the chrysotile cement production around the world was in the 50–70s of the XX century due to the necessity of the housing stock restoration and the infrastructure rehabilitation of the participating countries in the Second World War. A large number of enterprises appeared in the USSR. 58 plants worked in the country by the end of 1990-ies. Currently, the age of the roofs on some buildings, built in that period, is more than 60 years. There are examples of a much longer term of the successful chrysotile cement roofs operation. In the west of Russia and in Ukraine even now there are the roofs made of thin flat tile 4 mm thick, which were manufactured at the first slate plant in Russia (launched in 1908) in Fokino town, Bryansk region [1]. The exact date of the tiles manufacturing is unknown, but it is known that the production of the flat roofing tiles was discontinued in the late 20-ies of the 20^{th} century, when the production of the corrugated sheets was adjusted. Therefore, chrysotile cement «tiles» on these houses are more than 80 years old. The houses under these tiles were rebuilt 2 — 3 times, and the tiles were restored to the roof.

After decades of the operation term chrysotile cement roofing sheets are still on the roofs in many regions of Russia and other countries in different climatic zones and retain their main properties: to hold water, to withstand snow loads and to protect from UV light and radiation. The real long-term operation of the chrysotile cement products give an evidence of the actual retention of their physical and mechanical characteristics during the whole term of operation. At that the operating life of chrysotile cement is not limited after the sheet is removed from the roof or after the passage of its main crack.

In the literature the information about the physical and mechanical characteristics of the tiles and sheets after such a long period of operation is not found. Their size is regulated by the normative documents only for the production aged 7–28 days and during the receiving of the production consignment by the project owner. At the same time, the investigation of changes in the chrysotile cement roofing sheets building performance in the process of long-term operation are of a considerable interest. Supporters of an *antiasbestos campaign*, which began about 30 years ago, are speaking about the air pollution by the fibers, which, as they claim, are allocated from the surface of the chrysotile cement sheets in the process of the operation. In the western literature there is even a calculation data on the exit velocity of the fibres from the sheet products. At the specified speed of the exit velocity of the fibres the chrysotile cement sheets would have simply dissolved into thin air within the space of 50 years after their installation on the roof. However, in the literature there is no experimental data on the change of the sheet thickness and other physical and mechanical properties of the material.

To obtain the information about the degree of the chrysotile cement roofing sheets integrity, including their thickness in the process of the long-term operation in the present study we tested the VO roofing sheets (corrugated roofing sheets), manufactured by the plant «Krasny Stroitel» in Voskresensk. VO roofing sheets are no more commercially available for more than 30 years; sheet size — 1200×686 mm, thickness not less than 5.5 mm (in accordance with GOST 378–76 «Asbestos-cement corrugated sheets of standart profile and details for them»). Operated products were on the roofs of private houses in the Shifernyj town, Moscow region. The age of the sheets is 30, 40 and 60 years as it was subjectively defined on the basis of the data with which the buildings owners furnished us. Some roofing sheets by the time of sampling after being removed from the roofs were kept outdoors by the owners. The surface of the sheets was contaminated with dust, they were partly covered by the moss growth. For testing we took sheets without any visible damages of the surface.

On account of the small number of selected sheets we failed to spend statistically reliable test. For preliminary testing we sawed out one sample from each roofing sheet to determine the bending stress and two to determine the fracture toughness and density.

Physical and mechanical tests of the selected sheets are performed in accordance with the current GOST 8747–88 «Asbestos-cement sheet products. Methods of testing» in August 2010 in the industrial laboratory of the plant «Krasny stroitel» Ltd. The results are shown in the Table.

Table

The results of the physical and mechanical testing of the VO roofing sheets in comparison with the GOST 378–76 regulations

Sheet #	Term of operation, years, no less than	Parameters of the samples				
		Thickness, mm	Bending strength, MoR, MPa	Thickness, mm	Fracture toughness, kJ/m^2	Density γ, g/sm^3
Indicators in accordance with GOST 378–76		5,5	16	5,5	1,5	1,6
1	30	5,9	17,6	5,5	1,6	1,76
				6,1	1,6	1,72
2	40	5,9	16,1	5,8	1,6	1,75
				6,2	1,7	1,72
3	40	6	16,3	5,8	1,9	1,54
				6,2	2	1,55
4	40	5,7	21,4	5,7	1,8	1,7
				5,7	2,1	1,69
5	60	5,7	15,9	5,4	1,8	1,74
				5,2	2	1,71
6	60	5,9	19,3	6	1,8	1,71
				5,7	1,8	1,72

Given the fact that there was small number of tested specimens, for greater reliability of the findings index listed in the table is not average, but includes all the subproduct test results: bending strength — 6 samples, other indicators — 12. As a comparison in the top row of the table there are normative indicators of the products according to GOST 378–76.

The given data shows that the thickness of the roofing sheets as well as their physical and mechanical characteristics are within the requirements of the standards for almost all tested samples. Only 2 samples out of 18 have thickness that is 2–5 % below normal, density of two samples out of 12 is lower by 3–4 %. There under we can conclude that during the entire operation period within 30–60 years in the climatic conditions of Moscow region the physical and mechanical properties of the VO chrysotile cement roofing sheets comply with the requirements of the GOST (the initial parameters), applicable at the time of the roofing sheets manufacture.

In this case, it is important to note the complicated ecological mode of operation of the sheets in Voskresensk district, Moscow region, with a large number of the changes of temperature and humidity extremes, which are typical for the region, the sheets were also effected by the pollution from the operation of the chemical plant being once the most powerful in the Soviet Union (26 production lines) and cement plants.

Whereas the adopted regulations for the ultimate bending strength, density and fracture toughness as to the SV-40 corrugated roofing sheets, which are manufactured at the present time according to GOST 30340–95 «Asbestocement corrugated sheets. Technical requirements» are consistent with the requirements of GOST 378–76 to VO roofing sheets, there is no reason for assumption of another mode of modern products behavior in the process of their operation.

The record of properties invariance of the chrysotile cement sheets samples with the term of operation up to 60 years under natural conditions have not revealed any deviations from the regulations, which once again proved the reputation of the chrysotile cement roofing sheets as a long-lasting material. High physical-mechanical properties of the chrysotile cement are determined by unique properties of a natural fibrous mineral chrysotile, as well as unique and layer-by-layer press-filter technology with the reinforcement of thin films by the chrysotile fibers [2, 3], as a result of which a multi-layered composition of the portland cement and chrisotile fibers is formed.

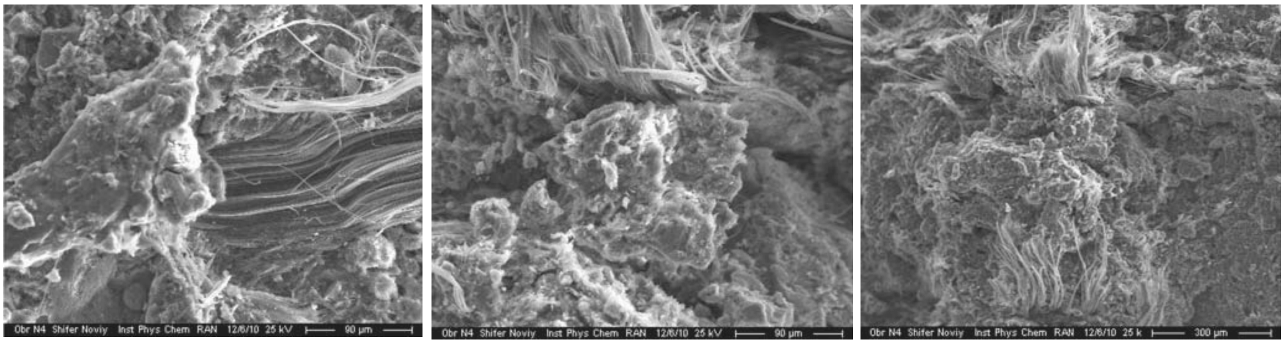
During the test we revealed the immutability of the chrysotile cement sheets thickness in the process of their operation, which allows to refute reliably the allegations of the possibility of the chrysotile fibres allocation, because in order to release the fibres from the cement matrix one layer after another must be destroyed, that would just lead to a decrease in the thickness of the products.

Also in the course of the test we studied the condition of the surface of the chrysotile cement samples taken from the sheets of various age and the character of chrysotile fibers allocation on the surface. For comparison, samples were taken from the SV-40 sheets of about six months and VO sheets being in use for about 60 years.

Fresh spall of the samples was studied using scanning electron microscope JSM-U3, JEOL company (Japan) and x-ray spectrometer with the energy dispersion of the GETAC company (Germany). The test was carried out in the Russian academy of sciences A.N.Frumkin Institute of Physical chemistry and Electrochemistry RAS (IPCE RAS). Samples were fastened onto a graphite substrate with the help of a double-sided conductive adhesive tape. To provide the conductivity to the object we applied a layer of carbon with thickness of a few nanometers by vacuum thermal evaporation method. The objects were viewed at an accelerating voltage of 25 kV and current of the electron beam in about 10^{-9}A.

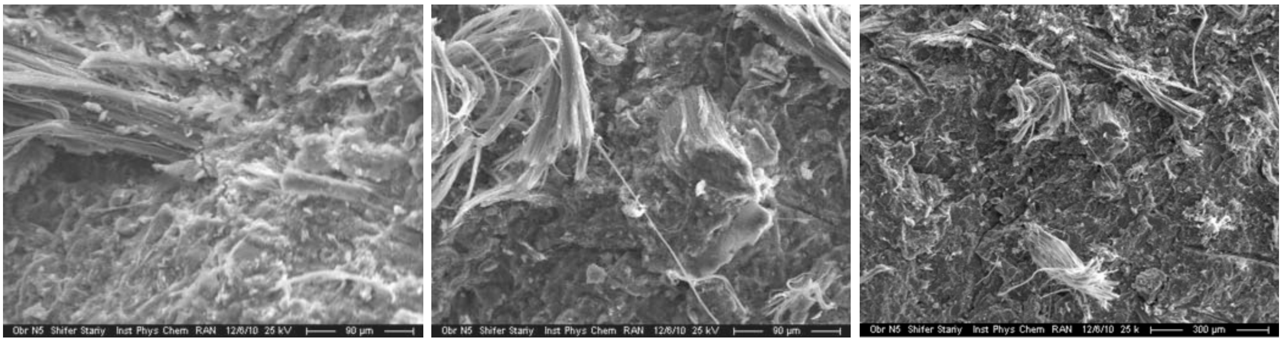
From the given pictures (fig. 1, 2) we can see that the structure of the surface of the chrysotile cement samples, which have substantially different terms of operation, is close as to the outline of the cement matrix grains, but there is a difference of its density degree: as for the samples of 6 months, their structure is looser, it has more substancial breaches of continuity in the form of long and wide gaps than the one of the 60 years samples, wich has more extensive violations of the continuity as long and wide cracks.

This clearly shows that with ageing of the chrysotile cement products the degree of the chrysotile fibers consolidation in the cement matrix is increasing at the expense of the porosity reducing of the material, increase of the fibres reduction strength by the matrix and, obviously, at the expense of the more active cooperation between the hardening portland cement and chrysotile fibers. There is no difference between the samples of different age in the location of the chrysotile beams and of individual fibers in the matrices of the hardened portland cement. In all the pictures there are tight bundles of chrysotile and fibres, visible as separate. The ends of some of the beams remained in the matrix after the samples spalling (fig. 1*a*, 2*a*), the other are «sticking out» of the matrix (fig. 1*b*, *c*; 2*b*, *c* — are made at a different magnification). In our opinion, the lack of differences in the arrangement and consolidation of fibres gives an evidence of the chrysotile fibres retention in the cement matrix during the entire period of the product operation.



a b c

Fig. 1. Micrographs of the chrysotile cement at the age of about 6 months



a b c

Fig. 2. Micrographs of the chrysotile cement at the age of 60 years

Thus, the data obtained in the physico-mechanical testing of chrysotile cement roofing sheets with a significantly different operation and microscopic studies of their surface, shows immutability of the chrysotile cement properties during a long operation period. This data also serves as a refutation of the available in the publications statements that in the process of operation thickness of chrysotile cement products is reduced and chrisotile fibers are allocated from them into the atmosphere. The research has confirmed the advantages of the chrysotile cement roofing products from environmental, operational and economic points of view in comparison with many other roofing materials and products.

References

1. *Burnham I.I.* The theory of forming asbestos-cement sheets and pipes. — M.: Stroiizdat, 1988.
2. *Komarov Y.T.* 100-year anniversary of the Bryansk asbestos factory // Build. Materials. — 2008. — № 9. — P. 34–35.
3. *Sokolov P.N.* Technology of asbestos-cement products. — M., 1960.

«ҒАЛАМДЫҚ ӘЛЕМДЕГІ УНИВЕРСИТЕТ: ӨЗАРА ӘРЕКЕТ ЖОЛДАРЫ МЕН ТҮРЛЕРІ» ХАЛЫҚАРАЛЫҚ ФОРУМЫНАН МАТЕРИАЛДАР

МАТЕРИАЛЫ С МЕЖДУНАРОДНОГО ФОРУМА «УНИВЕРСИТЕТ В ГЛОБАЛЬНОМ МИРЕ: ПУТИ И ФОРМЫ ВЗАИМОДЕЙСТВИЯ»

УДК 631.35

Активное управление качеством зерна риса при уборке

Active control of rise grain quality at harvest

Есполов Т.И., Умбаталиев Н.А.,Садыков Ж.С., Альпейсов Ш.А.

Казахский национальный аграрный университет, Алматы (E-mail: nuhtar.u@mail.ru)

Мақала авторлары күріш жинаудың технологиялық үрдісінің ағымды желісіне комбайндағы бастыру-сүзгілеу құрылғысының тұрақтылығы мен жүктелу біркелкілігін қамтамасыз ететін қосымша операциялар енгізуді ұсынады. Сонымен қатар күріш дестесінің биомассасын жинау, оны бастыру-сүзгілеу құрылғысына беру мен толықтай таратудың технологиялық операцияларын орындаудағы келіссіздік комбайнның тарату-тасымалдау құрылғысының конструктивтік кемшіліктерінің нәтижесі болып табылатыны анықталды. Нәтижесінде сүзгілеу төмендейді, зақымдау артады, бастыру режимінің артық жүктелуі мен қатаңдығы бәсендейді, дәнің тауарлық шығыны артады.

For the decision of this problem it is suggested to include additional operations, providing stability and evenness of loading threshing separator devices combine by the change of form of roller of biomass of rice into the production line of technological process of cleaning up. Thus, it is set that by investigation of structural defects distributive — transporting devices of combine are inconsistency of implementation of technological operations of selection, serve and valuable distribution of biomass of roller of rice to the threshing separator device. As a result a separation goes down of it, traumatize increases appear, overloads, hard mode of threshing, the losses of commodity grain increase.

Решение проблемы качества продукции связано не только с синхронностью функциональных действий технических устройств и механизмов, контактирующих с биомассой риса, но и со стабильностью параметров, определяющих ее исходное состояние (размеры валка, плотность и влажность, степень созревших зерен и др.).

Исследование эффективности использования рисоуборочных комбайнов на подборе и обмолоте валков позволили обнаружить в их работе ряд недостатков, отражающихся на качестве зерна и его урожае. Причины снижения качества — механические повреждения, дробление и микротрещины, обусловленные режимами работы и конструктивными недоработками технологических систем, устройств и механизмов, осуществляющих подачу биомассы в молотильно-сепарирующее устройство (МСУ). Нами установлено, что по ширине молотильный барабан загружается не полностью из-за неравномерности вороха по толщине и в работе барабана возникают неустойчивые режимы, нередко приводящие к его остановке и отрицательно сказывающиеся на качестве обмолота.

Устойчивость технологического процесса работы узлов, устройств и механизмов комбайна занимает основное место в концепции управления обмолотом биомассы риса. Управление ходом технологического процесса обмолота является важнейшей функцией рисоуборочных комбайнов и всех машин в комплексе. Несмотря на то, что содержание устройств и методы управления, меняются в зависимости от уровня сложности механизмов (подборщик валков, активатор биомассы, транспортер, наклонная камера, грохот, очистка, МСУ и.т.д.), принцип управления и характер воздействий имеют общую для всех цель — достижение качественного обмолота урожая риса.

Внедрением систем автоматического регулирования (САР) загрузки комбайнов занимаются российские и зарубежные [1–3] ученые. За основной управляющий параметр принимается толщина слоя урожайной массы под планками плавающего транспортера наклонной камеры. Согласно данным, полученным Г.Ф.Лукиных, К.Г.Колгановым, Г.Г.Нахамакиным, В.И.Михайловым, В.Д.Шеповаловым [4] и другими, слой стеблей, поступающий в молотильное устройство, оставался неравномерно распределенным по ширине молотилки, а его толщина зависит от скорости движения комбайна. Исследования показали, что колебания подач в работе происходят с частотами, превышающими допустимые для функционирования САР. При этом существующие системы автоматизации загрузки не обеспечивают эффективной стабилизации подачи биомассы.

Наиболее сложным этапом в движении биомассы является прохождение через наклонную камеру, поскольку в ней окончательно устанавливаются не только параметры потока вороха попадающего в МСУ, но и его нормализация по качеству.

Анализ результатов исследований названных выше ученых показал, что проблему повышения эффективности уборочной техники большинство из них предлагали решать совершенствованием технологий и изменением конструкции комбайнов. Исследованиям процессов управления биомассой риса в дообмолотный период практически не уделялось достаточного внимания.

Что касается кардинальных решений проблем повышения качества зерна при уборке, то оно связано с управлением технологическим процессом обмолота, совершенствованием технологий и модернизацией комбайна. Предлагается объединить в единый комплекс все управляющие параметры, направив их действия в активное управляющее устройство технологическим процессом, воздействующим на формы валков, образованных из различных сортов и урожайности риса. Отметим, что по такой постановке решения проблемы снижения потерь зерна риса исследования не проводились.

Технологический процесс возделывания и уборки урожая риса изучен, однако, с учетом зональных условий работы исследован недостаточно.

Разработаны и составлены карты операционной технологии, но товаропроизводители продолжают нести ощутимые потери по недобору зерна, качеству и затратам на единицу продукции.

Операционная технология возделывания и уборки риса описывает каждую операцию и вид полевых работ, в том числе основную и предпосевную обработку почвы, планировку чеков, посев, условия и приемы по внесению и заделке минеральных удобрений, борьбу с вредителями и уборку риса.

Практика механизации процессов возделывания и уборки риса, а также результаты исследований [5] показали, что основу рационального выбора ресурсосберегающего технологического процесса составляют управляющие факторы по каждой операции, с учетом оптимизации потребления материальных, трудовых и энергетических ресурсов.

Оптимальный выбор, содержание и условия реализации управления операцией в комплексе представляют собой сложную задачу. Используя оперативный метод познания в его комбинированном виде (сочетание информации, полученной на моделях, и сопоставление её с данными производственных экспериментов) определяем оптимальные параметры не только рабочих органов технических устройств, но и режимы воздействия их на зерна риса. Оперативный метод позволяет максимально использовать рациональные возможности управляющих факторов технологических операций по снижению потерь и повышению качественных показателей, т.е. практически «по-хозяйски» управлять технологическими процессами.

Представленная схема в общем виде отображает воздействия на основные производственные процессы возделывания и уборки риса, множество изменяющихся факторов (рис.). Соблюдение влияния этих факторов в допустимых пределах может быть обеспечено при условии подхода к этим процессам с позиции системного управления.

Управление — процесс обеспечения того, что каждая операция действительно достигает поставленной цели. Управление ходом выполняемых производственных операций основывается на сопоставлении фактических результатов функционирования производственного процесса и отдельных его составляющих с предусмотренными показателями различных уровней и определении величины расхождения. Использование такого подхода позволяет оперативно вмешиваться в производственный процесс и с помощью управляющих параметров создавать условия, при которых технологические процессы стабилизируются и обеспечивают нормальное функционирование всех механизмов.

Рассмотрим систему управления производственного процесса «возделывание» как упорядоченную совокупность взаимосвязанных и взаимодействующих операций, направленных на достижение поставленной цели — получение товарного зерна риса. Исключение какого-либо элемента из этой совокупности отрицательно скажется на функционировании всей системы управления. Наличие эффективной системы управления, как показала практика, является условием качественного выполнения всех операций агротехнических процессов возделывания и уборки риса.

Рис. Модель управления технологическими процессами возделывания и уборки риса

Изменяя факторы, влияющие на агротехнические показатели в допустимых пределах, в конечном итоге, можно добиться получения определенной высоты стеблестоя риса, максимальной одновременности созревания зерна в метелках, полноту его наполнения и снизить осыпание, т.е. управлять урожаем.

Аналогичные признаки и свойства характерны для производственного процесса «уборка урожая».

Управляя процессом формирования срезанных стеблей риса и укладкой их в валки, получаем оптимальные параметры валка по высоте, ширине и направленности расположения в нем метелок. В конечном итоге, это положительно отражается на качестве его подбора и последующем обмолоте.

Одним из эффективных средств решения проблемы по обеспечению стабильно-равномерной подачи подобранной биомассы в молотильно-сепарирующее устройство является усовершенствованная конструкция наклонной камеры [5]. Оснащенная набором комплектов рабочих органов наклонная камера комбайна превратилась в активно действующее управляющее устройство для поступающего потока биомассы. Измененная, по нашему предложению, геометрия наклонной камеры с рабочими органами за короткий промежуток времени движения внутри нее вороха биомассы эффективно воздействует на стебли, метелки с рисом — разравнивает слой и приводит биомассу в режим колебательного движения, т.е. способствует активному отделению созревших зерен риса до молотильного барабана. Колебательной характер (подбрасывание) движения биомассы создает идеальные условия для прохождения сквозь стебли свободных зерен риса к днищу наклонной камеры.

Таким образом, установлено, что следствием конструктивных недостатков распределительно-транспортирующих устройств комбайна является несогласованность выполнения технологических операций подбора, подачи и полноценного распределения биомассы валка риса к молотильно-сепарирующему устройству. В результате этого снижается сепарация, увеличивается травмированность, появляются перегрузки, наблюдается жесткий режим обмолота, возрастают потери товарного зерна.

Поэтому решение проблем связанных с управлением перемещающимися потоками биомассы позволит оперативно реагировать и своевременно корректировать режимы работы уборочных процессов.

References

1. *Guk J.M., Galnin E.V.* To the problem of creation of researches combine of the training setting // Tractors and agricultural machinery. — 1971. — № 10. — P. 24–26.
2. *Nath S., Sohnson W.H., Milliken G.A.* Combine lose model and optimization of the machine system. — TransASAE, 1982. — Vol. 25. — № 2. — P. 308–312.
3. Loss models for foraqe harvest // Trans ASAE, St. Joseph (Mich). — 1995. — Vol. 38. — № 6. — P. 1621–1631.
4. *Shepovalov V.D.* Automatic regulator of serve of panary mass // Technique in agriculture. — 1967. — № 6. — 46 p.
5. *Umbataliyev N.A.* Perfection of technological process of threshing and construction of rice fields combine: Abstract of thesis of dis. … doctor of engineering sciences. — Almaty, 2010.

УДК 631.354:633.1

Результаты исследования усовершенствованной наклонной камеры зерноуборочного комбайна

Results of the study advadced to tilt the camera combine harvester

Тойлыбаев М.С., Садыков Ж.С., Альпейсов Ш.А., Тойлыбаев Н.С.

Казахский национальный аграрный университет, Алматы (E-mail: meiram_61@mail.ru)

Мақалада жайылым өсімдіктер тұқымын жинауда өнімділікті жоғарылату үшін дән жинайтын машинаның жаңа ұрпақтағы перспективалы көлбеу қондырғысы жетілдірілді және игерілді. Бұл қондырғының ұтымды параметрлері дәлелденіп, тәжірибелер өткізуде қажетті және жеткілікті тиісті дәлдікпен қойылған есеп шешімдері үшін тәжірибе жоспарлары қолданылды.

To improve performance, harvesting seed pasture plants we have developed and refined a promising new generation of camera tilt grain-harvesting machines. To study the optimal parameters improved feeding channel for harvesting seeds of pasture plants, in particular, methods of wheatgrass our experimental design, which consists in choosing the number and the experimental conditions, necessary and sufficient for the task with the required accuracy.

Для повышения пропускной способности зерноуборочных комбайнов необходимо изыскание новых рабочих органов, принципиально отличающихся от существующих или обеспечивающих обработку материалов с максимальным сохранением его качества. Анализ современного состояния и тенденций развития ведущих мировых компаний комбайностроения, теоретических и экспериментальных работ, выполненных в области основных рабочих органов и регуляторов загрузки, показывает, что для решения важнейшей народнохозяйственной задачи повышения производительности зерноуборочных комбайнов необходимо решить проблему интенсификации процесса обмолота и сепарации в них.

Для обоснования оптимальных параметров усовершенствованной наклонной камеры для уборки семян пастбищных растений, в частности житняка, нами применялись методы планирования экспериментов, которые состоят в выборе числа и условий проведения опытов, необходимых и достаточных для решения поставленной задачи с требуемой точностью. Используя общий вид квадратичной модели и оценки b-коэффициентов, запишем уравнения множественной регрессии в развернутом виде для каждого выходного показателя $\mu = Z_1$, $\lambda = Z_2$ и $\nu = Z_3$, характеризующего применяемый способ разрушения двойчатки колосьев житняка. В соответствии с данными и структурой модели получены следующие регрессионные уравнения второго порядка:

полнота разрушения двойчаток колосьев, %:

$$Z_1 = 84{,}51 + 1{,}33333\,x_1 - 5{,}8125\,x_1^2 - 2{,}21667\,x_2 - 9{,}1625\,x_2^2 + 0{,}81111\,x_3 - 5{,}6125\,x_3^2 - 1{,}32222\,x_4 - 6{,}9125\,x_4^2 - 0{,}8\,x_1x_2 - 0{,}85\,x_1x_3 - 2{,}3875\,x_1x_4 - 2{,}2625\,x_2x_3 - 1{,}875\,x_2x_4 + 1{,}3\,x_3x_4; \quad (1)$$

отрыв колосьев, %:

$$Z_2 = 3{,}55 + 0{,}255556\,x_1 - 0{,}197917\,x_1^2 + 1{,}027778\,x_2 + 2{,}352083\,x_2^2 + 0{,}45\,x_3 + 1{,}6521\,x_3^2 + 0{,}34444\,x_4 + 1{,}40208\,x_4^2 - 0{,}28125\,x_1x_2 - 0{,}29375\,x_1x_3 + 0{,}66875\,x_1x_4 - 0{,}35625\,x_2x_3 + 0{,}15625\,x_2x_4 - 0{,}45625\,x_3x_4; \quad (2)$$

степень разравнивания биомассы, %:

$$Z_3 = 82{,}14 + 1{,}05\,x_1 - 4{,}44375\,x_1^2 - 1{,}71111\,x_2 - 6{,}99375\,x_2^2 + 0{,}62778\,x_3 - 4{,}34375\,x_3^2 - x_4 - 5{,}29375\,x_4^2 - 0{,}60625\,x_1x_2 - 0{,}65625\,x_1x_3 - 1{,}84375\,x_1x_4 - 1{,}73125\,x_2x_3 - 1{,}44375\,x_2x_4 + 1{,}00625\,x_3x_4. \quad (3)$$

Уравнения (1)–(3) описывают взаимосвязь полноты разрушения двойчатки, отрыва колосьев и разравнивания биомассы житняка с независимыми параметрами разравнивающего устройства.

Имея квадратичное уравнение регрессии четырех независимых переменных, можно преобразовать его к канонической форме и проанализировать вид многомерной поверхности отклика в исследуемой области факторного пространства, а также найти зоны параметров, в которых отклик имеет экстремальное значение.

На следующем этапе регрессионного анализа были выявлены статистически значимые эффекты факторов. Значимость компонентов полученной регрессионной, характеризующая существенность влияния исследуемых параметров устройства на степень полноты разрушения двойчатки колосьев $\mu = Z_1$, определялась по рассчитанным значениям *t*-критерия Стьюдента, абсолютные величины которых упорядочены по степени их убывания и представлены в виде диаграмм Парето. Диаграмма Парето является эффективным средством определения того, какие эффекты имеют наибольший вклад в формирование интересующей нас зависимой переменной, например, степень разравнивания биомассы житняка Z_3.

Наибольшее влияние на полноту разрушения двойчатки колосьев житняка оказывают, в первую очередь, квадраты (*Q*) переменных $x_2(Q)$ — длины зоны разрушения и $x_4(Q)$ — высоты гофр. Затем следуют парное взаимодействие x_1x_4 (1*L*by4*L*) подачи биомассы и высоты гофр, линейный (*L*) или так называемый главный эффект x_2 — длина зоны разрушения и др. Соответствующие им полосы пересекают вертикальную линию, которая представляет 90 %-ную доверительную вероятность [1–5].

Таблица 1

Дисперсионный анализ регрессионных моделей для показателей разрушения колосьев житняка

Источник изменчивости	Число степеней свободы *df*	Сумма квадратов *SS*	Средний квадрат *MS*	Отношение средних квадратов *F*	p-уровень значимости для *F*
Полнота разрушения двойчаток колосьев житняка Z_1, %					
Регрессия (*R*)	14	2726,615	194,7582	8,399924	0,001504
Остаток (*E*)	9	208,6714	23,18571		
Полная сумма (*T*)	23	2935,286			
Отрыв колосьев Z_2, %					
Регрессия (*R*)	14	129,874	9,276711	5,469177	0,007338
Остаток (*E*)	9	15,26563	1,696181		
Полная сумма (*T*)	23	145,1396			
Степень разравнивания биомассы Z_3, %					
Регрессия (*R*)	14	1603,802	114,5573	8,526813	0,00142
Остаток (*E*)	9	120,9145	13,43495		
Полная сумма (*T*)	23	1724,716			

Сумма квадратов, обусловленная регрессией (SS_R) для полноты разрушения двойчатки колосьев μ и степени разравнивания биомассы житняка ν, составляет около 93 % от полной суммы квадратов (SS_T), а для степени отрыва колосьев λ — 89,5 %.

Оценка качества разработанных регрессионных моделей для показателей обмолота житняка, полученных по лабораторно-полевым данным, проверялась коэффициентами множественной корреляции R, детерминации R^2, а также F-критерием Фишера и критерием Дарбина-Ватсона d. Перечисленные статистические характеристики и критерии для оценки качества уравнений регрессии, рассчитанные компьютерными статистическими программами *SPSS* 16 и *Statistica* 7.0, приведены в таблице 2.

Таблица 2

Проверка качества аппроксимации регрессионных моделей для показателей обмолота житняка

Статистический показатель	Значение для критерия обмолота		
	$\mu = Z_1$	$\nu = Z_2$	$\lambda = Z_3$
Множественная корреляция R	0,964	0,946	0,964
Коэффициент детерминации R^2	0,929	0,895	0,930
Скорректированный (на df) R^2	0,818	0,731	0,821
Стандартная ошибка	4,815	1,302	3,665
Число степеней свободы df: k_1; k_2	14; 9	14; 10	14; 11
Критерий Фишера F	8,400	5,469	8,527
Уровень p для значимости F	$1{,}5\cdot10^{-3}$	$7{,}3\cdot10^{-3}$	$1{,}4\cdot10^{-3}$
Критерий Дарбина-Ватсона d			
Сериальная корреляция			

Примечание. k_1 и k_2 — число степеней свободы для числителя и знаменателя, соответственно.

Приведенные в таблице 2 значения коэффициента множественной корреляции значимы, достаточно высоки (0,964; 0,946; 0,964) и близки к предельной величине ($R \le 1$), что свидетельствует о достаточно высокой тесной взаимосвязи исследуемых параметров с разрушением двойчаток и отрывом колосьев житняка, а также разравниванием биомассы житняка.

Рассчитанные модели позволили определить в дальнейшем оптимальную область регулируемых параметров активатора, вне которой улучшение показателей полноты разрушения двойчатки колосьев житняка не принесет пропорционального эффекта.

Наличие отрицательных коэффициентов (b_{11}, b_{22}, b_{33}, b_{44}) при квадратах переменных в уравнении для полноты разрушения двойчатки колосьев житняка $\mu = Z_1$ показывает, что для каждой из этих переменных существует оптимальный уровень.

Аналогичный вид поверхностей отклика и линий равных уровней был получен для степени отрыва колосьев ($\lambda = Z_2$) и степени разравнивания растительной массы житняка ($\nu = Z_3$) усовершенствованной наклонной камерой.

Исследование поверхностей отклика с помощью канонического преобразования приводит к следующим уравнениям:

$$\begin{aligned} Z_1 - 84{,}838 &= -4{,}38166\xi_1^2 - 5{,}78731\xi_2^2 - 7{,}47413\xi_3^2 - 9{,}8569\,\xi_4^2; \\ Z_2 - 3{,}432 &= 2{,}41328\xi_1^2 + 1{,}78422\xi_2^2 + 1{,}29105\xi_3^2 - 0{,}280227\xi_4^2; \\ Z_3 - 82{,}398 &= -3{,}35959\xi_1^2 - 4{,}44959\xi_2^2 - 5{,}73273\xi_3^2 - 7{,}53309\xi_4^2. \end{aligned} \qquad (4)$$

Как следует из первого уравнения (4), поверхность отклика $\mu = Z_1$ для полноты разрушения двойчаток колосьев житняка имеет максимум, равный 84,8 %, поскольку знаки всех коэффициентов этого канонического уравнения отрицательны. Поверхность отклика для отрыва колосьев житняка $\lambda = Z_2$ имеет седловидную точку, в которой отклик равен 3,4 %, так как коэффициенты второго канонического уравнения (4) разных знаков (три коэффициента положительны, один отрицательный). Отклик для степени разравнивания растительной массы житняка $\nu = Z_3$ в стационарной точке также имеет максимум, равный 82,4 %, поскольку все коэффициенты третьего уравнения (4) отрицательны.

Таким образом, все координаты особых точек откликов Z_1, Z_2, Z_3, лежат в области эксперимента и незначительно отличаются между собой по величине для полноты разрушения двойчаток колосьев $\mu = Z_1$ и степени разравнивания биомассы житняка $\nu = Z_3$. Поэтому, приняв эти координаты за оптимальное решение и преобразовав их в натуральный масштаб, получим следующие параметры усовершенствованной наклонной камеры:

– подача биомассы q = 2,57 кг/пм;
– длина зоны разрушения L = 58,73 см;
– угол атаки гофр α = 25,76 град.;
– высота гофр h = 19,62 мм.

При них выходные показатели качества обмолота житняка принимают следующие значения: полнота разрушения двойчаток колосьев $\mu = Z_1$ = 84,8 %; степень отрыва колосьев $\lambda = Z_2$ = 3,5 %; степень равномерного распределения растительной массы житняка $\nu = Z_3$ = 82,4 %.

Предлагаемая технология уборки семян пастбищных растений, реализуемая посредством усовершенствованной наклонной камеры к уборочной машине, является ресурсосберегающей и экологически чистой, она может найти широкое применение в частных сельскохозяйственных производствах (как в мелких, так и средних и крупных крестьянских хозяйствах). Кроме эффекта от снижения потерь урожая, технология позволяет также уменьшить количество уборочных агрегатов на операциях скашивания и обмолота семян растений; снизить потребную мощность двигателя комбайна на обмолот; снизить потребность ГСМ для проведения уборочных работ; уменьшить энергопотребление, трудовые и материальные затраты в процессе послеуборочной обработки семян.

References

1. *Sadykov Zh.S.* New technologies and machines for harvesting seed of crops // KazNIINKI. — 1992. — 88 p.
2. *Toilybaev N.S.* By the way education roll pasture plants at combine harvesting // International Scientific Conference: Prospects for the agricultural and automotive engineering in the Republic of Kazakhstan. — Almaty, 2006.
3. A.S. № 1687078. The USSR. Tilting the camera combine harvester. Publ. 10/30/91.
4. *Sadykov Zh.S., Toilybaev N.S. et al.* The method of determining the coefficient of biomass and leveling device for its implementation // Patent for the invention № 19 509, «NIIS» from 25.03.2008.
5. *Sadykov Zh.S, Toilybaev N.S. et al.* Accelerator for harvesters threshing // Summary for Innovative patent number 027 636, from 20.12.2010.

АВТОРЛАР ТУРАЛЫ МӘЛІМЕТТЕР
СВЕДЕНИЯ ОБ АВТОРАХ

Agafonova M.V. — Russian oncological scientific center of N.N.Blochin of the Russian Academy of Medical Science, Moscow, Russia.

Alipeysov Sh.A. — the Vice-rektor of the KazNAU, Doctor of Agricultural Sciences, Kazakh National Agrarian University, Almaty.

Amanbekova A.U. — Republican state public enterprise «National center for occupational hygiene and occupational diseases» Ministry of Health of the Republic of Kazakhstan, Karaganda.

Amanzhol I.A. — Director of National center of occupational health and occupational diseases Ministry of Health of the Republic of Kazakhstan Doctor of Medicine, Professor, Karaganda.

Azhimetova G.N. — Republican state public enterprise «National center for occupational hygiene and occupational diseases» Ministry of Health of the Republic of Kazakhstan, Karaganda.

Bekpan A.Zh. — Candidate of Medical Sciences, Regional diagnostic center, Astana.

Berzin S.A. — Professor of the Department of oncology and radiology, Doctor of Medical Sciences, Professor, State budget educational institution of high professional development «Ural State Medical Academy», Yekaterinburg, Russia.

Bourmistrova T.B. — Head of the Department of roentgenological studies and tomography, Research institute of occupational health of the Russian Academy of Medical Sciences, Moscow, Russia.

Chernyuk V.I. — Vice-director on science of Institute of occupational medicine of AMC of Ukraine, Doctor of Medicine, Professor, Kiev.

Chuy T.S. — Institute of occupational medicine of AMS of Ukraine, Kiev

Demetskaya A.V. — Chief of the Laboratory for toxicology of aerosols of SI «Institute of occupational health of NAMS of Ukraine», the Candidate of Biological Sciences, Kiev, Ukraine.

Duzbaeva N.M. — Candidate of Biological Sciences, Y.A.Buketov Karaganda State University.

Gazizov O.M. — Doctor of Medicine, Karaganda State Medical University.

Grinberg L.M. — Head of the Department of anatomical pathology, Doctor of Medical Sciences, Professor, the Chief pathologist of Yekaterinburg, State budget educational institution of high professional development «Ural State Medical Academy»; the Chief of the Pathologic department of the Pulmonological medical center, Yekaterinburg, Russia.

Goudkova E.A. — Senior teacher of chair of the general chemistry, Candidate of Chemical Sciences, Belgorod State University.

Ibraev S.S. — Chief of SR sanitary and hygienic laboratories, Doctor of Medical Sciences, Professor, SRC Karaganda State Medical University MH RK.

Ibrayeva L.K. — Head of laboratory of dust pathology, Associate professor, Doctor of Medicine, National center of occupational health and occupational diseases, Ministry of Health of the Republic of Kazakhstan, Karaganda.

Izmerov N.F. — Director of the Research institute of occupational health of the Russian Academy of Medical Sciences, Academician of the Russian Academy of Medical Sciences, Moscow, Russia.

Karakashyan A.N. — Head of laboratory of physiology and occupational health of women and teenagers, Candidate of Medical Sciences, Institute of occupational medicine of AMC of Ukraine, Kiev.

Kashanskiy S.V. — Chief of the Laboratory of branch hygiene of labor, Senior research assistant, Candidate of Medical Science, National State Institution «Yekaterinburg medical research center for prophylaxis and health protection of industrial workers» of Federal supervision agency for customer protection and human welfare, Yekaterinburg, Russia.

Kochelayev V.A. — Chairman of the Expert Council of the Non-profit Organization «Chrysotile Association», Asbest, Sverdlovsk Region, Russia.

Kucheruk T.K. — Institute of occupational medicine of AMS of Ukraine, Kiev.

Kundiyev Yu.I. — Director of Institute of occupational medicine of AMS of Ukraine Doctor of Medicine, Professor, Academician of AMC of Ukraine, Kiev.

Leonenko O.B. — Principal Researcher of the Laboratory of toxicology of aerosols of SI «Institute of occupational health of NAMS of Ukraine», Kiev, Ukraine.

Martynovskaya T.Yu. — Institute of occupational medicine of AMS of Ukraine, Kiev.

Mezhov A.G. — Postgraduate student, Construction material department, National Research University, Moscow State University of Civil Engineering, Russia.

Moshkovsky V.E. — Junior Researcher of the Laboratory of toxicology of aerosols of SI «Institute of occupational health of NAMS of Ukraine», Kiev, Ukraine.

Movchan V.A. — Junior Researcher of the Laboratory of toxicology of aerosols of SI «Institute of occupational health of NAMS of Ukraine», Kiev, Ukraine.

Mukasheva M.A. — Professor of physiology department Doctor of Biology, Y.A.Buketov Karaganda State University.

Neumann S.M. — PhD, Non-profit Organization «Chrysotile Association», Moscow, Russia.

Otarov E.Zh. — Leading research scientist SR sanitary and hygienic laboratories, Doctor of Medicine, Professor, SRC Karaganda State Medical University MH RK.

Plukhin A.E. — Head of the Department of occupational and noncommunicable diseases of internal organs induced by exposure to industrial aerosols, Research institute of occupational health of the Russian Academy of Medical Sciences, Moscow, Russia.

Popov K.N. — PhD, Professor, Construction Material Department, National Research University, Moscow State University of civil engineering, Russia.

Pyatnitsa-Gorpinchenko N.K. — Institute of occupational medicine of AMS of Ukraine, Kiev.

Pylev L.N. — Head of Laboratory of natural carcinogens Doctor of Medicine, Professor, Russian oncological scientific center of N.N.Blochin of the Russian Academy of Medical Science, Moscow, Russia.

Sadykov Zh.S. — Director of the KazNAU Institute, Doctor of Technical Sciences, Kazakh National Agrarian University, Almaty.

Salnikova N.A. — Institute of occupational medicine of AMS of Ukraine, Kiev.

Smirnova O.V. — Research officer, the Russian oncological scientific center of N.N.Blochin of the Russian Academy of Medical Science, Moscow, Russia.

Surzhikov D.V. — Head of laboratory of applied hygienic researches, Doctor of Biology, Scientific research institute of complex problems of hygiene and occupational diseases Siberian branch of the Russian Academy of Medical Science, Novokuznetsk.

Tkachenko T.Y. — Senior Researcher of the Laboratory of toxicology of aerosols of SI «Institute of occupational health of NAMS of Ukraine», Kiev, Ukraine.

Toylybaev M.S. — Candidate of Technical Sciences, Assistant professor, Kazakh National Agrarian University, Almaty.

Toylybaev N.S. — Senior teacher, Kazakh National Agrarian University, Almaty.

Umbataliyev N.A. — Chief of the chair, Doctor of Technical Sciences, Kazakh National Agrarian University, Almaty.

Vasilyeva L.A. — Leading research officer, Candidate of Biological Sciences, Russian oncological scientific center of N.N.Blochin of the Russian Academy of Medical Science, Moscow, Russia.

Vezentsev A.I. — Head of the Department of general chemistry, Doctor of Engineering, Professor, Russian oncological scientific center of N.N.Blochin of the Russian Academy of Medical Science, Moscow, Russia.

Yespolov T.I. — Rector of the KazNAU Academician, Doctor of Economical Sciences, Kazakh National Agrarian University, Almaty.

Zhumabekova G.S. — Station of the emergency help, Karaganda.

Правила оформления статей

Для публикации в журнале «Вестник Карагандинского университета» принимаются статьи на казахском, русском и английском языках, содержащие результаты фундаментальных и прикладных исследований в области естественных и гуманитарных наук.

Объем статьи, включая библиографию, не должен превышать 10 страниц текста, набранного на компьютере (редактор Microsoft Word), минимальный объем статьи для гуманитарных направлений 6 страниц, естественных — 4 страницы. В издательство необходимо представить электронную версию статьи в полном соответствии с распечаткой. Страницы статьи должны быть пронумерованы.

К оформлению статей предъявляются следующие требования:

Поля рукописи должны быть: верхнее и нижнее — 25 мм, левое и правое — 20 мм; шрифт — Times New Roman, размер — 11 пт; межстрочный интервал — одинарный; выравнивание — по ширине; абзацный отступ — 0,8 см.

В верхнем левом углу дается УДК статьи.

По центру приводятся:

- название статьи (полужирное написание) на русском и казахском языках. Для серий «Математика», «Физика», «Химия» дополнительно дается название на английском языке.
- фамилии и инициалы авторов;
- полное название учреждения, которое представляет автор (с указанием города). Если авторы из разных учреждений, то соответствие между автором и учреждением устанавливается надстрочными индексами, например:

Иванов И.В.[1], Крылов С.П.[2]
[1]Карагандинский государственный университет им. Е.А.Букетова;
[2]ТОО «Институт органического синтеза и углехимии НАН РК», Караганда

- электронный адрес;
- аннотации на казахском, русском и английском языках, отвечающие требованиям информативности, содержательности и качества перевода (7–8 строк).

Далее идет текст статьи, в конце которой — список использованной литературы с полным библиографическим описанием.

Список использованной литературы для серий «Математика», «Физика», «Химия» оформляется на английском языке (обязательно).

Например:

Для книг: Фамилии и инициалы авторов. Заглавие. — Сведения о повторности издания. — Место издания: Издательство, Год издания. — Количество страниц.

Например: *Ильин В.А., Позняк Э.Г.* Линейная алгебра. — 3-е изд. — М.: Наука, 1984. — 294 с.

Для статей из журналов: Фамилии и инициалы авторов. Название статьи // Заглавие издания. Серия. — Год издания. — Том. — Номер. — Страницы.

Например:

Панчук Д.А., Садакбаева Ж.К., Пуклина Е.А. и др. О структуре межфазного слоя на границе металлическое покрытие–полимерная подложка // Российские нанотехнологии. — 2009. — Т. 4. — № 5–6. — С. 114–120.

Омарова Г.К. Влияние деформирования на скорость отверждения олигомеров // Вестн. Карагандинского ун-та. Сер. Химия. — 2010. — № 2(58). — С. 17–20.

Для материалов конференций, сборников трудов и т.д.: Фамилии и инициалы авторов. Название статьи // Заглавие издания: Вид издания. — Место, год издания. — Том. — Номер. — Страницы.

Например:

Бакиров Ж.Б. Исследование закритического прогиба пластин с учетом случайных факторов // Строительство: Тр. КарГТУ. — Вып. 1. — Караганда: Изд. КарГТУ, 1996. — С. 171–174.

Касенов Б.К., Ашляева И.В. О термодинамических свойствах арсенатов щелочноземельных металлов // Физико-химические исследования строения и реакционной способности вещества. — Караганда, 1988. — С. 124–131.

Иностранная литература оформляется по тем же правилам.

Первая ссылка в тексте на литературу должна иметь номер [1], вторая — [2] и т.д. по порядку. При ссылках на результат из книги указывается ее номер из списка литературы и (через точку с запятой) номер страницы, на которой опубликован этот результат. Например: [8; 325]. Ссылки на неопубликованные работы не допускаются.

В статье нумеруются лишь те формулы, на которые по тексту есть ссылки.

В таблицах, рисунках, формулах не должно быть разночтений в обозначении символов, знаков. Рисунки должны быть четкими, чистыми. На рисунки и таблицы в тексте должны быть ссылки.

Сведения о каждом из авторов включают следующую информацию: Фамилия Имя Отчество (полностью), должность, звание, ученая степень, место работы, город. Для серий «Математика», «Физика», «Химия» сведения об авторах даются на английском языке.

Обязательно приводятся контактные данные (телефон, e-mail) автора (или авторов).

При наличии источника финансирования исследования по направлениям «Математика», «Физика», «Химия» (гранты, госбюджетные программы) указывается информация о нем.