European Journal of Molecular & Clinical Medicine
ISSN 2515-8260 Volume 07, Issue 02, 2020

OCCUPATIONAL MORBIDITY OF WORKERS ENGAGED IN MINING OF DIFFERENT GRADES OF COAL

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Abstract.

This work aimed to analyze professional morbidity in the coal industry of Uzbekistan. The method of data copying from outpatient cards of professional patients and its statistical processing was used for analysis. The professional morbidity rate in the coal industry was 108 cases per 10 thousand workers and 6.8 times higher than in other industries. At surface coal mining in the open pit, as compared to underground mining in a coal mine, the number of cases of first detected occupational diseases was, on average, 2.6 times lower. Thus, the vibratory disease was most frequently met among workers of open-cast mining in comparison with underground mining 1.4 times, and professional bronchitis, bronchial asthma and pneumoconiosis - among workers of underground mining in comparison with open-cast mining in 2.3 times.Vibration disease is diagnosed among workers of underground mines at the work experience of 16 years, while among workers engaged in open-cast coal mining - 21 years and more. The analysis of results of medical and labor examination with professional diseases of coal industry workers showed that among 48.3 ‰ of workers, there were 30.4 ‰ disabilities of Group III and 17.8 ‰ disabilities of Group II. These indicators had differences depending on the brand of coal mined, so in the mining of brown coal (SiO2-10%), the disability of professional genesis amounted to Group II 7.5 ‰ and Group III 31.3 ‰, while in the mining of coal (SiO2-4%) 4.4 times more established Group II disability (73.3 ‰ workers) than Group III - (16.7 ‰). Conclusion: Coal dust of hard and lignite differ in chemical and physical properties and degree of dispersion, which affects the level of occupational morbidity and disability of workers.

Keywords: coal dust; working conditions; dispersion; professional disease; vibration; morbidity, length of service; disability.

Introduction.

Coal mining is characterized by working conditions that pose a risk to employees' health. Current working conditions are distinguished by the presence of complex and combined influence of factors of the production environment and the working process (dustiness of coal dust, noise, vibration, unfavorable microclimate, labor severity) with simultaneous influence on various systems and organs [1].

Dust, forming in the process of drilling, blasting, excavation, loading, crushing and transportation of coal, is one of the widespread unfavorable factors that harm the health of workers. The dispersion of dust determines the duration of the particles stay in the air of the

working zone, its physical and chemical activity, the possibility of penetration, deposits and accumulation of dust in the respiratory system of a person [2].

For workers engaged in underground coal mining, morbidity rate by cases and days of disability is estimated as "very high," and for workers involved in open-cast coal mining - "high" by cases and days of disability - "average."The average duration of the 1st case is 3 times more for workers of the underground mine in comparison with workers of open-cast mining [3].

Questions of influence of coal dust on indicators of professional morbidity in countries where the majority of the population is engaged in coal mining to have been studied, scientists are involved in problems of professionally conditioned morbidity and determination of initial forms of development of professional pathology 4, 5, 6, 7.

Scientific works devoted to health protection and provision of safe working conditions for miners are known in neighboring countries [8, 9, 10, 11, 12].

Several works have been carried out devoted to the influence of unfavorable factors of working conditions (noise, vibration, dustiness) in forecasting professional and professionally conditioned morbidity 13, 14, 15.

For the last 30 years in Uzbekistan, there has been no research on hygienic assessment of working conditions and the study of morbidity among coal industry workers. Scientific works of honest scientists are devoted to the study of assessment of the impact of chemical, physical and psycho-emotional factors on workers' organisms.

The approaches to prevention of occupational diseases existing in the Republic have some drawbacks, as up to now there is no normative and methodical basis for making measurements, determining the dose of exposure to harmful production factors and calculation of occupational risks; when assessing the indicators of dustiness, the dispersibility of respiratory dust is not taken into account; the efficiency of personal protective equipment and time of exposure to production factors in the dosage assessment is not taken into account; there is no register of occupational diseases [16].

The purpose of the research is to evaluate the indicators of professional disease incidence in the coal industry of Uzbekistan and the impact of dust dispersion on the health of workers, with different methods of coal mining.

Materials and methods.

Outpatient cards (f.25/u) of 6200 persons registered with the Scientific Research Institute of Sanitation, Hygiene and Occupational Diseases of the Ministry of Health of the Republic of Uzbekistan were studied, from which 134 cards of persons living in Tashkent and Surkhandarya regions of the Republic with professional pathology connected with coal mining were selected.

The analysis of the data of the dispensary accounting of occupational diseases was carried out following the methodological recommendation "Evaluation criteria and indicators

of production-related morbidity for complex analysis of the impact of working conditions on the health of workers" (Tashkent, 2017).

The objects of research for the study of working conditions were 2120 workers of basic occupations working in the coal industry: coal mine "Angren" (10 professions - 1600 people), underground coal mine № 9 "Angren" (14 professions - 320 people) and mine "Shargunkumir" (14 professions - 200 people).

Subject to inspection were coal mine "Angren" and underground coal mine № 9 "Angren," located in Tashkent region,is engaged in mining brown coal, underground coal mine "Shargunkumir," located in Sariasi district of Surkhandarya region is engaged in mining coal.

Research results.

The occupational morbidity rate in the coal industry of Uzbekistan is high (108 cases per 10 thousand workers) and 6.8 times higher than the level of identified occupational diseases among workers of other industries (16 cases per 10 thousand workers). During the last decade, the indicators of occupational diseases in the coal industry have tended to decrease and in the last 3 years only a few cases were registered.

The structure of occupational diseases was consistently represented by factors affecting health status and appeals to health care institutions (XXI class), respiratory diseases (X class), diseases of musculoskeletal system and connective tissue (XIII class), ear and mastoid (VIII class) (Fig. 1).

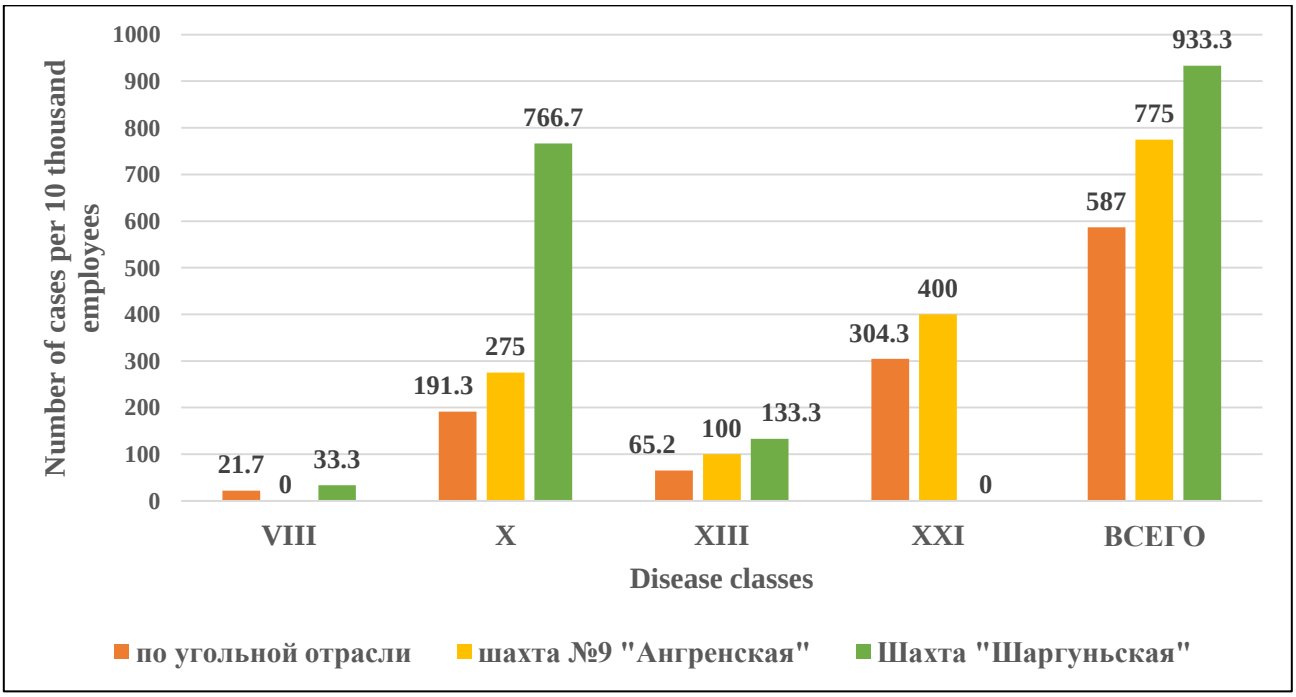

Figure 1: Structure of professional morbidity of coal industry workers in Uzbekistan, the number of cases per 10 thousand workers

The internal structure of respiratory diseases (X class), which took 1st place in the general structure of occupational diseases, was represented by professional bronchitis, professional bronchial asthma and pneumoconiosis.

The internal structure of the XXI class of diseases "Factors affecting the health status and appeals to health care institutions" in 100% of cases were represented by vibration disease.

The XIII class of diseases of the musculoskeletal system and connective tissue was mainly formed due to chronic lumbosacral radiculopathy and, in single cases, were registered such professional diseases of the musculoskeletal system as epicondillitis, shoulder-lobe periarthritis.

VIII class of diseases of the ear and mastoid process in 100% of cases was formed due to professional neurosensory hearing loss (bilateral cochlear neuritis of professional genesis).

In the structure of the professional sickness rate of coal industry workers, as a whole in the Republic, the greatest specific weight is vibration diseases (51.8%) and respiratory diseases (32.6%), which in the general structure of professional pathology is 84.4%. Whereas, a comparative analysis of these occupational diseases, registered among workers of the studied coal mining enterprises, showed a difference: vibration disease was most common among workers of the Angren mine (71.1%) and mine № 9 "Angren" (51.6%); professional bronchitis, bronchial asthma and pneumoconiosis - among workers of the Shargunkumir mine (82.1%) and mine № 9 "Angren" (35.5%).

The level of other nosological forms in the general structure of occupational disease workers mine "Shargunkumir" slightly different from the indicators of morbidity of workers mine № 9 "Angren."

In our opinion, the high frequency of vibration diseases in the Angren section and Angren mine No.9 is due to the start of modernization, technical and technological re-equipment of coal mining enterprises, worn-out and obsolete mining equipment and machinery was used for coal mining, which was accompanied by high levels of vibration parameters. The aggravating factors in the development of vibration disease are muscle overstrain, forced working position, cooling of hands and the whole body.

Indicators of professional pathology of respiratory organs among workers engaged in underground coal mining were high.

The structure of professional morbidity by professions of workers of underground coal mines and Angren open-pit mine is shown in figure 2.

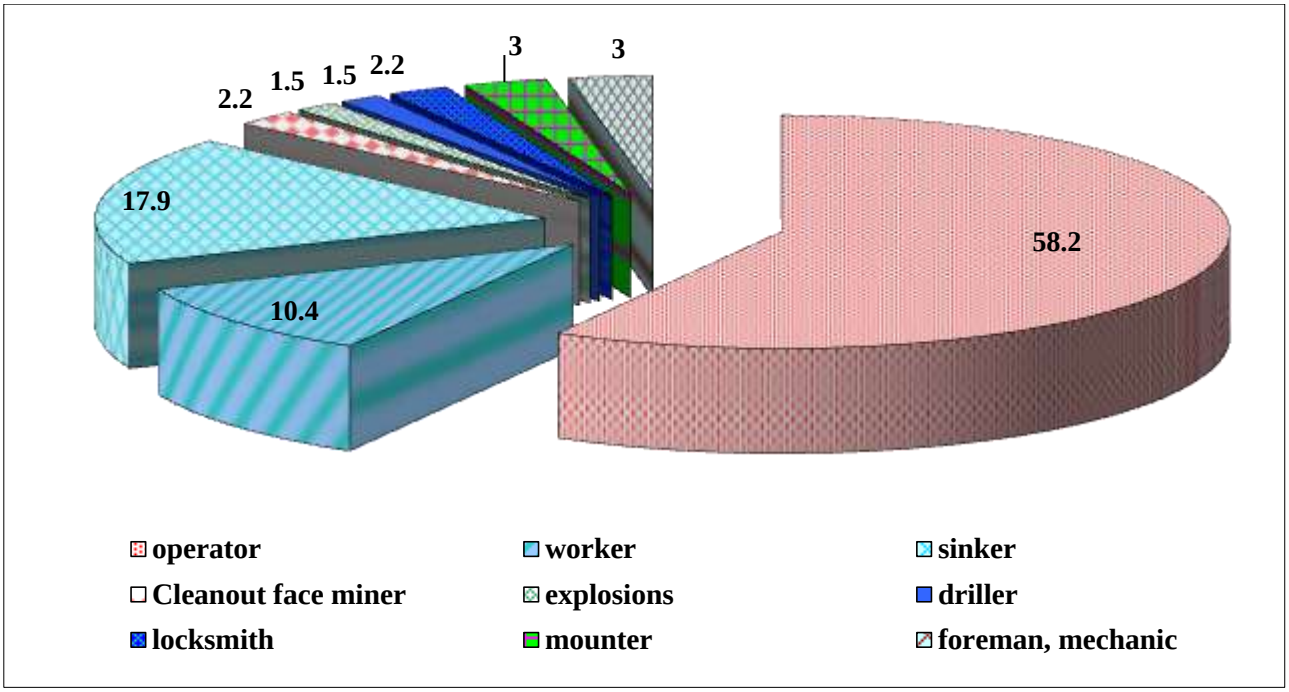

Figure 2: Distribution of occupational diseases by professions at coal mining enterprises of the Republic, %

Analysis of the data obtained shows that occupational diseases of various genesis are most common among mining machine operators (excavators, bulldozers, string and drill rigs, scrapers, roadheaders, digging and loading machines, etc.) and transport machine operators (locomotives, electric locomotives). Among workers of different professions engaged in open-cast and underground coal mining, the share of occupational diseases was different. Engineers accounted for 58.2% of all occupational diseases, sinkers - 17.9% and workers (miner, handyman, repair and mechanical shop, service and site) - 10.4%. The share of workers of other professions accounted for only 13.5% of all occupational diseases.

In the structure of professional pathology vibration disease, sensorineural hearing loss, chronic lumbosacral radiculopathies, bronchitis, asthma and pneumoconiosis were the highest among machinists and, from the number of detected cases of professional diseases, made respectively - 74.6, 60, 50 and 36.7% (Fig. 3).

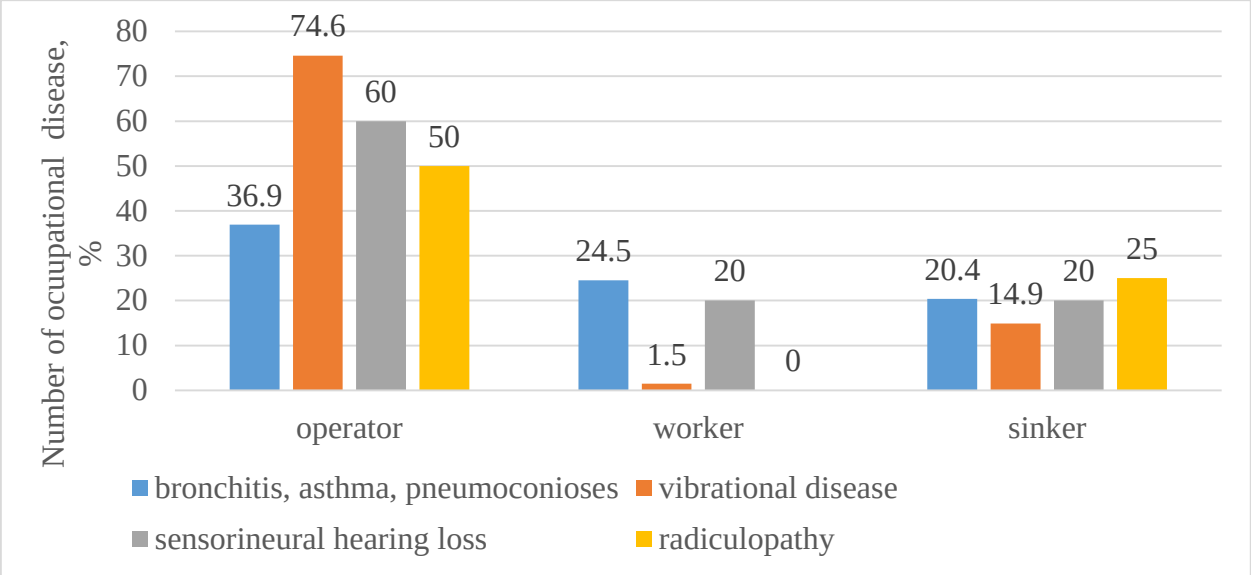

Figure 3 Distribution of occupational morbidity rate of employees by profession, %

In sinkers, compared to machinists, these diseases were less common: vibration disease - 5 times (14.9 vs. 74.6%), sensorineural hearing loss - 3 times (20.0 vs. 60.0%), chronic lumbosacral radiculopathies - 2 times (25.0 vs. 50.0%) and occupational respiratory diseases - 1.8 times rarer (20.4 vs. 36.7%). Vibration disease in machinists is associated with the impact of combined vibration, and in the sinkers, the development of vibration disease is mainly due to local vibration.

In the vast majority of cases, underground and surface workers of different specialties were diagnosed with neurosensory hearing loss (20.0%), as well as professional bronchitis, professional asthma and pneumoconiosis (24.5%).

The presented data on occupational morbidity in workers of different specialties of land mines and open-cut mines, divided into groups by professions, showed that their share of occupational diseases is the lowest, and the level of diseases of respiratory organs, ear and the mastoid process did not differ from that of sinkers.

In the analysis of occupational diseases of particular interest are the data characterizing the experience of persons with a first-time occupational disease.

Since in the general structure of professional pathology of coal industry workers 84.4% are vibration diseases, professional bronchitis, bronchial asthma and pneumoconiosis, the analysis of the frequency of registration of these diseases in the long-term dynamics with an interval of 5 years and depending on the length of service was carried out.

The length of service of underground and surface coal mining workers has some differences. So, at workers of underground mines, the vibratory disease is diagnosed at the work experience of 16 years, whereas workers occupied on open-cast coal mining - 21 years and more.

It is defined that for the 25 years, more cases of the first identified occupational diseases were observed in underground coal mines "Shargunkumir" and № 9 "Angrenskiy". While, in the open pit "Angren", compared with the coal mine "Shargunkumir", the number of first-time detected occupational diseases was on average 2.6 times lower: from 1.4 times (in 2004-2009) to 3.8 times (2010-2014).

The analysis of the distribution of professional diseases on all enterprises of the coal industry of the Republic showed that the share of coal-mining enterprises is 77,8% of professional diseases. It was found out that the share of workers engaged in the production of brown coal (Angren surface mine and mine № 9 "Angren"), accounts for almost 80% of occupational diseases, and the share of workers in the production of coal (Shargunkumir mine) - more than 20%.

The number of registered cases of occupational diseases in the coal industry of Uzbekistan for the last 25 years is shown in Figure 4.

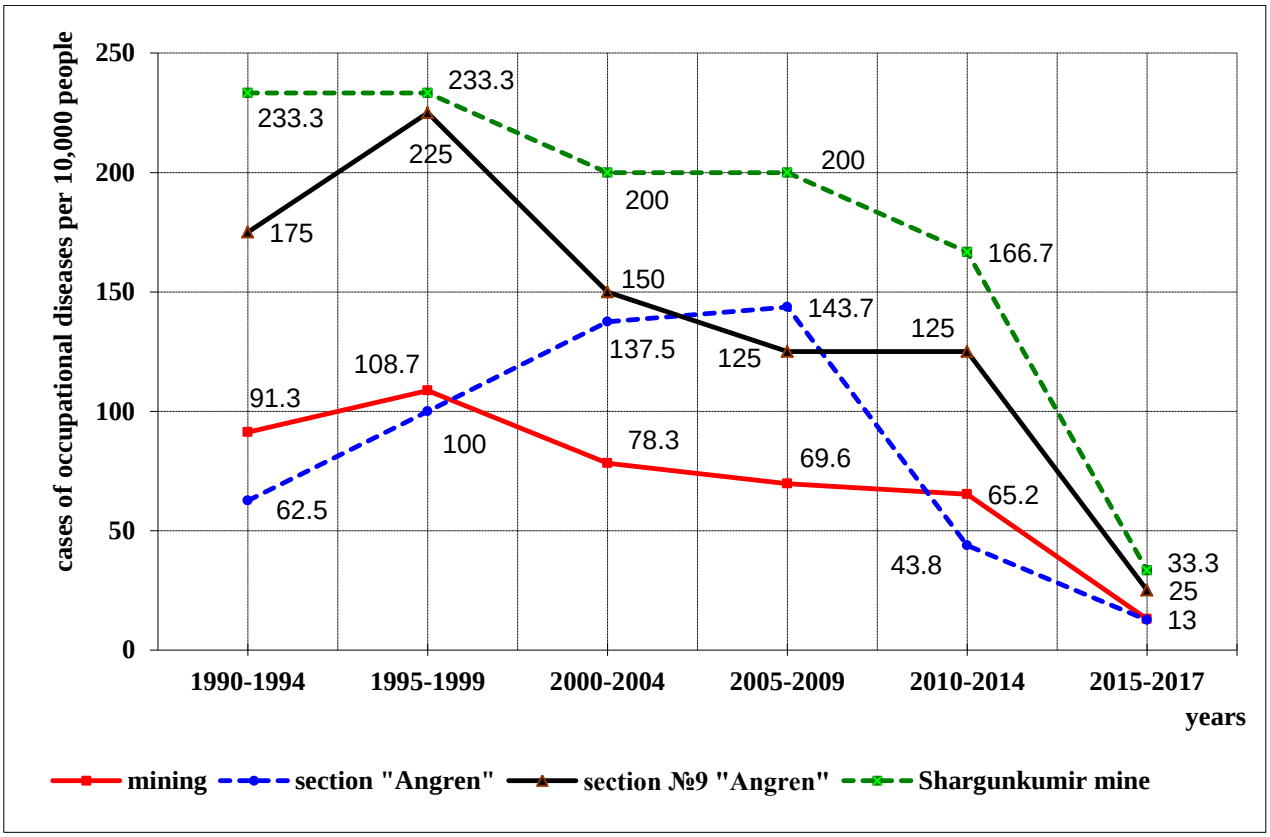

Figure 4. Dynamics of first-time occupational diseases in the coal industry of Uzbekistan, per 10 thousand workers

The presented graphic image in figure 4 shows that in 2015-2017, both for all studied coal-mining enterprises. As a whole for the coal industry of the Republic, there is a sharp decline of the first revealed cases of occupational diseases, the number of which for the 25

years has decreased in 7 times (91,3 - in 1990-1994 against 13,0 cases per 10 thousand workers - in 2015-2017).

Analysis of materials for the 25 years (1990-2017) shows that employees with vibratory disease have an average of 5 years less exposure time compared to employees whose work is associated with open coal mining. At work experience of 26-30 years, there is an increase in the number of cases of vibration sickness, reaching the maximum in the experience group of 31-35 years (147.8 cases per 10 thousand workers).

At coal mining by open-pit and underground methods, the length of service of persons with occupational diseases of respiratory organs made up to 16 years. Still, at workers of underground mines, diseases were registered 16 times more often than at open-pit mining in Angren mine (200 against 12.5 cases per 10 thousand workers).

The level of occupational diseases of respiratory organs and vibration disease, depending on the length of service at coal mining enterprises, is shown in Figure 5.

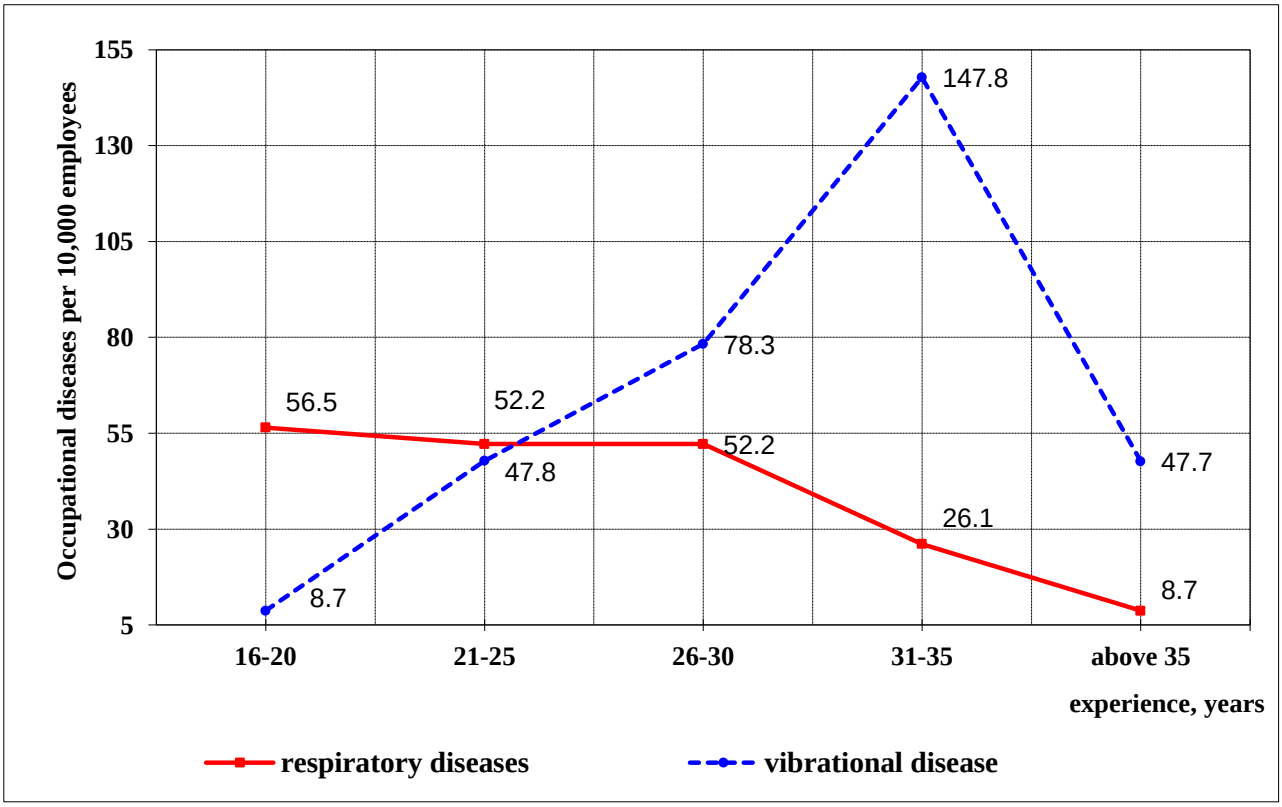

Figure 5: Occupational diseases rate per 10,000 employees, depending on work experience

Thus, dust and vibration influences are the main factors forming working conditions, professional risks and determining the level of professional pathology of respiratory and vibration diseases.

The analysis of results of medical and labor examination of coal industry workers showed that at the establishment of the diagnosis of professional genesis at the same time was established and disability. Thus, among 48.3 ‰ of workers of mines "Shargunkumir," № 9 "Angren" and surface mine "Angrenskiy" was established disability, the index of which was 82.2% of the total number of people with the first established occupational disease (58.7 ‰). Moreover, 30.4‰ of coal industry workers with professional pathology were diagnosed with Group III disability, and 17.8‰ - Group II disability.

At the same time, in the mine "Shargunkumir," with the detection of occupational disease of various etiologies 93.3 ‰ workers, in 96.4% of cases at the same time, they were diagnosed with a disability. The analysis of materials of medical and labor examination testifies to the fact that established to the workers of the group of disability in the mine "Shargunkumir" differed in severity not only from the open-cast mine "Angren" but also from underground mine №. 9 "Angren".

Figure 6 shows that in the Angren and Angren open-pit mines №9, the number of disabled workers in both Group II (10.0 vs. 7.5‰) and Group III (31.3 vs. 37.5‰) was almost the same.

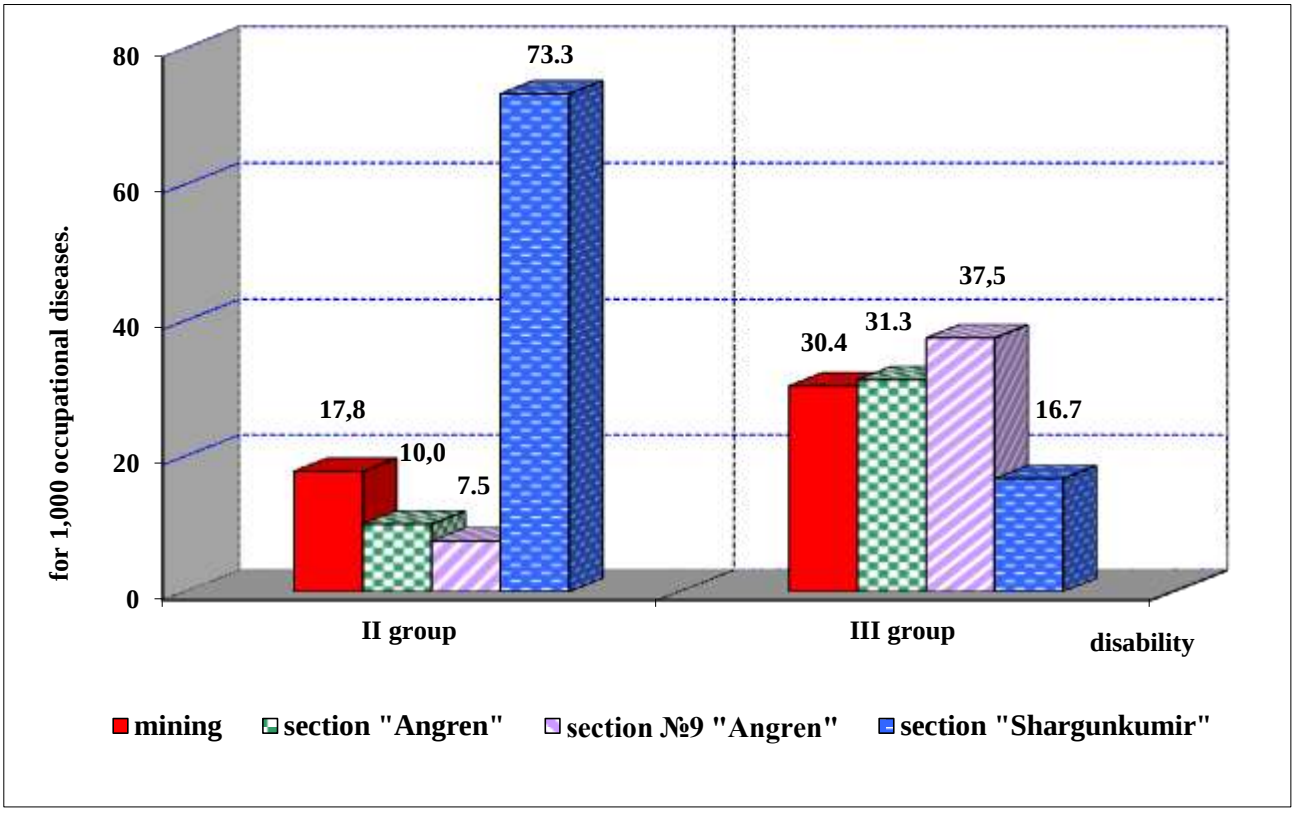

Figure 6. Distribution of persons with disabilities by professional pathology, per 1000 professional patients

The difference was that the employees of Shargunkumir mine, along with their occupational disease, were 4.4 times more likely to be in the Group II disability group (73.3‰ of employees) than in the Group III disability group (16.7‰).

Presented data on the frequency and severity of disability groups obtained in the establishment of primary occupational disease workers confirm that the underground mines "Shargunkumir" (hard coal) and № 9 "Angren" (brown coal), one of the most unfavorable production factors affecting the body is coal dust, which distinguishes the chemical and physical properties and degree of dispersion. This explains the higher rate of morbidity and severity of disability of workers of "Shargunkumir" mine, in comparison with workers of mine #9 "Angren."

As a result of studies, it was determined that the average concentration of coal dust at work places in the mine "Shargunkumir" 1.3 times higher than in the mine № 9 "Angren" (34.9 vs. 26.9 mg/m^3).

In the Republic, hygienic assessment of working conditions is based on the multiplicity of an excess of the actual concentration with the MPC. The assessment of working conditions showed that the multiplicity of the excess of MPC of hard coal (10 mg/m^3) exceeded 3.5 times, and of lignite" - 6.7 times (MPC - 4 mg/m^3). Despite the higher average dust concentration of hard coal, working conditions in it are estimated as less harmful due to the lower MPC exceedance multiple. But if we take into account that respiratory diseases are higher in hard coal mining as compared to brown coal mining by 2.3 times (82.1 vs. 35.5%), it is essential to take into account the degree of dust dispersion when the hygienic assessment of working conditions and justification of preventive dust control measures, as in contrast to brown coal mining, fine dust is formed by 25% more.

The analysis of materials made it possible to determine under which classes of working conditions occupational diseases were registered. It was found that in the underground mines "Shargunkumir" and № 9 "Angren," as well as in the section "Angren" the level of occupational diseases depended on the class of working conditions. It was determined that about 65% of occupational genesis diseases were registered in workers whose working conditions corresponded to the 3rd class of 3rd and 4th degree.

In order to establish actual classes of working conditions based on dust factor, we made calculations taking into account dust dispersion parameters.

Obtained data changed the picture of working conditions classes established by the traditional method. Taking into account dust dispersibility, the classes of working conditions of workers engaged in lignite mining decreased by 1 stage, whereas, in coal mining, the classes of working conditions for dust factor, on the contrary, increased by 1 stage. Thus, working conditions, taking into account dust dispersion, coal mining is presented as more harmful and, practically in all professions, corresponded to the 3rd class of 2-4 degrees, and in brown coal mining mainly - to the 3rd class of 2-3 degrees.

Consequently, in establishing the classes of working conditions for the dust factor and the calculation of dust load on the body of workers, it is necessary to take into account not

only the average values of the actual concentration of dust in the air of the working area, MPC, the average volume of pulmonary ventilation, exposure time per shift, the number of work shifts in a calendar year (worked in a dusty environment), the duration of the work shift, the coefficient of efficiency of the personal respiratory protection, but also the dispersion of dust.

Further, in work, we have made calculations and established classes of working conditions for the studied professions, taking into account the use of personal respiratory protection equipment and reduction of time of exposure to dust factor (Tables 1, 2).

Table 1

Working conditions classes(WCC) of employees according to the air dustiness indicators of work places taking into account the dispersion of coal dust(MPC of lignite dust - 4 mg/m3, of black coal - 10 mg/m^3)

Profession	**Cc, mg/m^3 common dust**	**WCC**	**Cc, mg/m^3 alveolar dust**	**MPC, mg/m^3**	**WCC**
brown coal mining					
String Machine operator	25,5	3.3	7,7	2,0	3.2
Executing machine operator	64,5	3.4	16,6	2,0	3.3
Electric locomotive and roadheader driver	17,4	3.2	5,3	2,0	3.2
Thunderstorm with chipping hammer	78,6	3.4	23,6	2,0	3.4
Thunderstorm on clearing of lava, the conveyor, the fastener	24,8	3.3	7,4	2,0	3.2
Transmitter	55,0	3.4	16,5	2,0	3.3
hard coal mining					
Executing machine operator	84,3	3.3	31,6	2,0	3.4
Electric locomotive and roadheader driver	22,3	3.1	8,4	2,0	3.2
Thunderstorm with chipping hammer	90,5	3.3	34,0	2,0	3.4
Fixer	38,0	3.2	14,3	2,0	3.3
Transmitter	83,7	3.3	31,4	2,0	3.4

Explosionist	62,5	3.3	23,5	2,0	3.4

When using personal respiratory protection equipment, in the form of filtering half masks of the 1st class (particulate matter aerosol capture: FFP1 - 80%), classes of working conditions according to the dust factor decreased by 1-2 stages, depending on the actual level of dust concentration at the workplaces of workers of the professions studied (Table 2).

Consequently, to reduce dust impact on organisms of workers engaged in underground coal mining, it is necessary to carry out individual selection of respiratory protection means, obligatory regular use in the process of work and evaluation of their efficiency.

Table 2

Working conditions classes (WCC) according to the indicators of air dustiness of working places before and after the application of personal respiratory protection equipment (PRPE), taking into account the dispersion of dust (at the efficiency of PRPE - FFR1 (80%)).

Profession	**before the use of PRPECc, mg/m^3**	**MPC, mg/m^3**	**WCC**	**after the use of PRPE Cc, mg/m^3**	**MPC, mg/m^3 dispersity**	**WCC**
brown coal mining						
String Machine operator	25,5	4	3.3	5,1	2,0	3,1
Executing machine operator	64,5	4	3.4	12,9	2,0	3.2
Electric locomotive and roadheader driver	17,4	4	3.2	3,5	2,0	3,1
Thunderstorm with chipping hammer	78,6	4	3.4	15,7	2,0	3.2
Thunderstorm on clearing of a lava, the conveyor, the fastener	24,8	4	3.3	4,96	2,0	3.1
Transmitter	55,0	4	3.4	11,0	2,0	3.2
hard coal mining						
Executing machine operator	84,3	10	3.3	16,9	2,0	3.3
Electric locomotive and roadheader driver	22,3	10	3.1	4,5	2,0	3.1

Thunderstorm with chipping hammer	90,5	10	3.3	18,1	2,0	3.3
Fixer	38,0	10	3.2	7,6	2,0	3.2
Transmitter	83,7	10	3.3	16,7	2,0	3.3
Explosionist	62,5	10	3.3	12,5	2,0	3.3

According to GOST 12.4.294-2015 (EN 149:2001+A1;2009), filter semimages of the 1st class (FFP1) have the following characteristics: low efficiency, protection factor up to 4 MPC, penetration factor -25%, allowable resistance on inhalation at 30 dm^3/min - 60 Ra, at 95 dm^3/min - 210 Ra and at exhalation at 160 dm^3/min - 300 Ra [17].

The volume of pulmonary ventilation depends on the level of energy consumption. It is for work category Ia-Ib (light physical labor) per shift - 4m^3, for work category IIa-IIb (average physical labor) per shift - 7 m^3 and work category III (heavy physical labor) - 10m^3. This fact indicates that increasing the severity of the work of an employee increases the frequency and volume of his breathing. This, in turn, increases the volume of inhaled and exhaled air, which in turn makes it difficult to breathe when the airflow resistance. Thus, the lower the resistance, the easier it is to breathe.

Filtering half masks hold large particles and fine particles smaller than 2 mkm penetrate under the mask into the employee's breathing zone. When filter semimages are used with high efficiency, their permeability coefficient is reduced and the resistance to inhalation and exhalation is increased.

As it was shown in Table 2 the working conditions of workers engaged in the extraction of brown coal, after the use of personal respiratory protection equipment, the class of working conditions decreased by 1-2 degrees, but high rates of mine air dustiness of coal particles, taking into account their penetration through the filtering mask practically class of working conditions did not change. The analysis of dust for dispersion showed that fine dust at coal mining is formed by 25% more in comparison with lignite mining.

Therefore, for the correct establishment of the class and degree of working conditions (in terms of harmfulness and danger), selection of effective collective and individual protection means, when studying production factors and conducting the hygienic assessment, we have developed methodical recommendations "Method of calculation of the respiratory dose of contamination with dirspersed fraction of air dust of working zone" [18] and "Method of reduction of working conditions class, taking into account efficiency of application of means of individual protection means by workers engaged in harmful production." [19].

Conclusions:

1. The level of professional sickness rate in the coal industry is 6,8 times higher than in other industries of Uzbekistan (10,8 against 1,6 cases per 10 thousand workers) and, during the last decade, has tended to a sharp decline. It was determined that during the 25 years,

more cases of first detected professional diseases were observed in underground coal mines "Shargunkumir" and №9 "Angren" and, in comparison with coal mine "Angren," the number of cases of first detected professional diseases was 2.6 times higher on average: from 1.4 times (in 2004-2009) to 3.8 times (2010-2014). During the last 25 years, for the coal industry of the Republic, the number of first detected cases of occupational diseases decreased 7 times (91,3 - in 1990-1994 against 13,0 cases per 10 thousand workers - in 2015-2017).

2. The leading classes of diseases in the structure of occupational diseases of the coal industry are consistent: factors affecting health (XXI class), diseases of the respiratory system (X class), musculoskeletal system and connective tissue (XIII class), ear and mastoid (VIII class).

3. In the general structure of the professional pathology of coal industry workers, 84.4% are occupied by vibration and respiratory diseases (51.8 and 32.6% respectively). Vibration sickness was most common among workers of the Angren mine (71.1%) and mine №9 Angren (51.6%), and professional bronchitis, bronchial asthma and pneumoconiosis - among workers of the Shargunkumir mine (82.1%), exposed to fine dust of coal.

4. Employees of coal underground mines and Angren open-pit mine have occupational diseases of various genesis most common among machinists, who accounted for 58.2%, sinkers - 17.9% and workers of different specialties - 10.4%. The development of vibration disease depends on the method of coal mining and exposition work experience: workers of underground mines are diagnosed with work experience of 16 years, and those engaged in open-cast coal mining - 21 years; respiratory diseases, regardless of the method of coal mining, were registered in the senior group - up to 16 years and in underground mines 16 times more often than in open-cast coal mining (200 vs. 12.5 cases per 10 thousand workers).

5. Analysis of materials of medical and labor examination of coal industry workers showed that in 82.2% of cases among persons with first established occupational disease (58.7 ‰), disability was established (48.3 ‰, including 30.4 ‰ - Group III and 17.8 ‰ - Group II). In the mine "Shargunkumir," with the detection of occupational disease of various etiologies, in 96.4% of cases simultaneously was found out disability, and 4.4 times more was found.

Group II (73.3‰ of employees) rather than Group III (16.7‰).

6. The level of occupational diseases in underground mines "Shargunkumir" and №9 "Angren" and in the section "Angren" depended on the class of working conditions: 65% of diseases were registered in workers whose working conditions correspond to Class 3 and Class 4 working conditions. Working conditions, taking into account dust dispersion, coal mining was presented as more harmful and, practically for all professions, corresponded to class 3 of 2-4 degrees, and for brown coal mining - mainly - to class 3 of 2-3 degrees.

7. Working conditions of workers engaged in brown coal mining, after the application of respiratory protection equipment, the class of working conditions decreased by 1-2 degrees. Still, the high rates of the dustiness of mine air by coal particles, taking into account their penetration through the filtering mask practically class of working conditions did not change.

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