RISKS AND SPECIFIC FEATURES OF BRONCHOPULMONARY PATHOLOGY IN APATITE-NEPHELINE ENTERPRISE WORKERS IN KOLA HIGH ARCTIC

S.A. Siurin, V.V. Shilov

Northwest Public Health Research Center; Russia, 191036, Saint Petersburg, 2-aya Sovetskaya st., 4.
The study was carried out in Kirovsk, Murmansk oblast, Russia

A medical examination of 3871 employees of mining and chemical industry engaged in the production, transportation and processing of apatite-nepheline ore in the Kola High Arctic showed the worst state of respiratory health in open pit miners. They have higher risk of chronic bronchopulmonary diseases than miners of underground mines (RR = 1.30), enrichment plant workers (RR = 1.81) and the rail shop workers (RR = 3.80). The findings stress the need for improved working conditions and more effective personal respiratory protection devices in this group of workers.

Key words: apatite-nepheline production, bronchopulmonary pathology, Kola High North.

The largest apatite-nephelinic ore deposit in Russia is located in the Kola Peninsula which determines harsh production conditions due to the arctic climate and poor infrastructure. Most of the workers involved in the production, transportation and processing of apatite-nephelinic ore in the Kola High Arctic are exposed to harmful working conditions including general and local vibration, noise, lower temperature, dust-gas mixture, and uncomfortable working position [2, 4, 5]. Exposure to those factors is known to create a higher risk of musculoskeletal diseases, nervous disorders and impaired hearing [1, 3, 7]. There is also evidence to a high rate of chronic bronchopulmonary diseases (CBPD) among such workers the medical and social significance of which is underestimated [8, 9].

The purpose of the research is to analyze the risk factors, structure and prevalence of chronic bronchopulmonary diseases (CBPD) in the workers involved in the production, transportation and processing of apatite-nephelinic ore in the Kola High Arctic.

Materials and methods. Within the course of the research, we conducted an in-depth medical examination of 1,777 underground miners and 503 workers of open-pit apatite-nepheline mines, 790 workers of the rail shop (RS) and 801 workers of apatite-nepheline dressing plants (ANDP) comprising “Apatit” open joint-stock company. The research program included a medical examination by a pulmonologist and assessment of the respiratory function using the method of spirometry and bronchodilatory test (400 µg of salbutamol). The diagnostics of chronic bronchitis (CB), chronic obstructive pulmonary diseases (COPD) and bronchial asthma (BA) was conducted in accordance with the acknowledged international criteria. The persons with individual symptoms of a respiratory pathology which were not sufficient to diagnose any specific CBPD were referred to the CBPD “risk group”. The persons with no clinical, functional or radiographic symptoms of a CBPD were referred to the “healthy group”.

The obtained data was processed with Epi Info, v. 6.04d recommended by the WHO; we measured the relative ratio (RR), 95% confidence interval (95% CI), goodness-of-fit test, and Student’s t-test. The differences were considered significant at p<0.05.

Results of the research. Assessment of the workplace conditions [6] showed that apatite
ore extraction, loading and hauling in the underground mines are carried out in a relatively stable cooling microclimate: subnormal temperature (3-80°C in summer and 5-120°C in winter), high humidity (up to 100%) and air motion (up to 2.0-4.0 m/s). The microclimate in the open-pit mines is characterized by rapid changes in meteorological factors. Thus, the air temperature in winter ranges from 0°C to -30°C, and in summer - from +50°C to +25°C. The air in the working area of open-pit mines is affected by the calm air and inversion frequently observed in the North; these conditions increase the level of contamination of the surface layer of the atmosphere. [10].

Drilling, blasting and load-haul operations using self-propelled drilling, loading and delivery of diesel equipment result in high concentrations of toxic components of gaseous and particulate aerosols. The level of nitrogen oxides in the air exceeds the MAC by 5.5 times, carbon monoxide and TNT – by up to 1.5-2.0 times. Mean shift concentrations of dust are in the range of 2.45-8.65 mg/m³ (MAC = 6.0 mg/m³), though during drilling, the dust levels may reach 30.8 mg/m³ (exceeding the MAC by 5.1 times). The main components of the dust (in weight %) are SiO₂ – 30.2; CaO – 18.2; Al₂O₃ – 15.2; P₂O₅ – 12.7; Na₂O – 7.7; Fe₂O₃ – 3.7.

The rail shop workers are exposed to the cooling microclimate with alternating parameters (air temperature from -30°C to +25°C, relative air humidity up to 100%, air mobility – up to 18 m/s). During railway repairs and cooling, the maximum exceedance of the permissible concentration of dust totals 9.3.

During ore processing at the apatite-nepheline dressing plants, dustiness (exceedance of the MAX by up to 4-5 times) is one of the main harmful industrial factors. The highest dust content is faced by crush operators, assembly line operators at the crushing plant, concentrate shipmen, mill and assembly line operators at the shipping department.

The analysis of the demographic indicators revealed significant differences in the above groups of workers. Among the underground and open-pit deposit workers, there are less women than at the rail shop or dressing plants (p<0.01-0.001). The mean age of the underground miners is lower (p<0.05), and the length of service of the open-pit deposit workers is higher (p<0.05) as compared to other divisions of “Apatit” (see Table 1 below).

A clinical and instrumental examination showed that the symptoms of bronchopulmonary pathology were not registered in 57.2-73.5% of the examined patients. The number of healthy workers among the rail shop workers was higher than among miners (p<0.001) and ANDP workers (p<0.01). Individual symptoms of respiratory pathology were registered in 19.6-23.8% of workers who constituted the “risk group” for CBPD. The most frequently diagnosed disease was CB (4.3-16.1%). The incidence of CB among open-pit deposit workers was higher than among underground workers (p<0.05), rail shop workers and ANDP workers. The incidence of CB among the workers involved in underground mining was also higher as compared to the rail shop workers (p<0.001) and ANDP (p<0.05).

CBPD and BA were registered less frequently since they are not determined by the labor conditions. All the cases of BA were mild and characterized with high sensibility to the household and/or animal allergens, not related to employment at “Apatit” (see Table 2 below).

Table 1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Underground mines</th>
<th>Open-pit deposits</th>
<th>Rail shop</th>
<th>ANDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender: men, %</td>
<td>88.9</td>
<td>94.8</td>
<td>76.6</td>
<td>67.5</td>
</tr>
<tr>
<td>women, %</td>
<td>11.1</td>
<td>5.2</td>
<td>23.4</td>
<td>32.5</td>
</tr>
<tr>
<td>Age, years</td>
<td>38.8±0.3</td>
<td>39.7±0.8</td>
<td>40.7±0.4</td>
<td>40.4±0.4</td>
</tr>
<tr>
<td>Length of service, years</td>
<td>12.0±0.4</td>
<td>15.1±0.8</td>
<td>12.5±0.3</td>
<td>12.0±0.5</td>
</tr>
</tbody>
</table>

Table 2

Respiratory health parameters among apatite-nepheline workers (%)
The risk of CB among open-pit deposit workers was higher than among underground miners (RR=1.30; 95% CI = 1.03–1.65; $\chi^2=4.80; \ p=0.02854$), ANDP workers (RR=1.81; 95% CI = 1.34–2.43; $\chi^2=15.6; \ p=0.00008$) and rail shop workers (RR=3.80; 95% CI = 2.59–5.58; $\chi^2=54.4; \ p=0.0000001$).

Respiratory health of the workers involved in open-pit mining is impacted by the time of exposure to harmful industrial factors (length of service). In the first 10 years, CB develops in 9.3% of employees, CBPD – in 3.1% of employees; according to the results of a preliminary medical examination, those employees were considered healthy. With every 10 years of service, the number of employees without any respiratory pathology is decreasing, and the number of people in the CBPD risk group (with the growth from ≤ 10 years to 11-20 years) and the number of employees with CB are growing. The incidence of CBPD does not change depending on the length of service, and the number of employees with BA, unlike employees with CB, has significantly decrease with longer service (see Table 3).

With the length of service of 11-20 year, the risk of CB increased to 1.59 (95% CI 1.21–2.09; $\chi^2 = 11.5; \ p = 0.00068$), with the service of 20 and longer – up to 2.01 (95% CI 1.56–2.59; $\chi^2 =30.2; \ p = 0.0000001$) as compared to the length of service of 10 years and less. No connection between the length of service and the state of health was revealed in the rail shop and ANDP employees, as compared to the miners.

The respiratory health indicators in the rail shop and ANDP workers are significantly better due to the lack of combined exposure to the dust-and-gas mixtures and cooling microclimate. It is important to keep in mind that there are more men

<table>
<thead>
<tr>
<th>Clinical group</th>
<th>Underground mines</th>
<th>Open-pit deposits</th>
<th>Rail shop</th>
<th>ANDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthy workers</td>
<td>59,0</td>
<td>57,2</td>
<td>73,5</td>
<td>66,9</td>
</tr>
<tr>
<td>Risk group</td>
<td>23,8</td>
<td>22,5</td>
<td>19,6</td>
<td>20,7</td>
</tr>
<tr>
<td>Workers with CB</td>
<td>12,3</td>
<td>16,1</td>
<td>4,3</td>
<td>9,0</td>
</tr>
<tr>
<td>Workers with CBPD</td>
<td>3,1</td>
<td>3,2</td>
<td>1,5</td>
<td>2,4</td>
</tr>
<tr>
<td>Workers with BA</td>
<td>1,8</td>
<td>1,0</td>
<td>1,1</td>
<td>1,0</td>
</tr>
</tbody>
</table>

Table 3

The impact of the length of service on the respiratory health of employees

<table>
<thead>
<tr>
<th>Clinical group</th>
<th>Length of service</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤ 10 years (n=1502)</td>
<td>11–20 years (n=1159)</td>
<td>&gt; 20 years (n=1210)</td>
</tr>
<tr>
<td>Healthy workers</td>
<td>954 (63.5%)</td>
<td>594 (51.3%)$^1$</td>
<td>578 (47.8%)$^{1, 3}$</td>
</tr>
<tr>
<td>Risk group</td>
<td>315 (21.0%)</td>
<td>352 (30.4%)$^1$</td>
<td>355 (29.3%)$^2$</td>
</tr>
<tr>
<td>Workers with CB</td>
<td>139 (9.3%)</td>
<td>176 (15.2%)$^1$</td>
<td>230 (19.0%)$^3$</td>
</tr>
<tr>
<td>Workers with CBPD</td>
<td>47 (3.1%)</td>
<td>28 (2.4%)</td>
<td>46 (3.8%)</td>
</tr>
<tr>
<td>Workers with BA</td>
<td>47 (3.1%)</td>
<td>9 (0.8%)</td>
<td>1 (0.1%)</td>
</tr>
</tbody>
</table>

Note: $^1$ – differences (p<0.05) between the groups of employees with the length of service of ≤ 10 years and 11-20 years;
$^2$ – differences (p<0.05) between the groups of employees with the length of service of ≥ 10 years and 20 years;
$^3$ differences (p<0.05) between the groups of employees with the length of service of 11-20 years and > 20 years.

The highest incidence and risk of CBPD were revealed in open-pit apatite miners as compared to the rest of “Apatit” employees which can be explained to the highest level of exposure to dust, explosive gases, diesel fuel combustion products, and unfavorable microclimate [5, 8]. Additionally, underground miners work in the conditions of cooling microclimate but it is stable [4]. Exposure to the dust-and-gas mixtures is lower due to a wide use of electrically-powered loading-and-delivery equipment. The length of exposure to harmful industrial factors (length of service) significantly increases the risk of CB.
among miners, consequently, higher exposure to
tobacco smoke – the main non-industrial risk fac-
tor contributing to the development of CB and
CBPD [8]. Decreased number of workers with BA
among the employees in training is related to cease-
ing the career in the mining and chemical industry
due to medical reasons.

It is critical to emphasize that no cases of
pneumoconiosis, a common disease among this
type of workers, were revealed before the switch
from dry drilling to wet dust suppression systems
[7].

**Conclusion.** The impact of combined harmful
industrial factor significantly increases the risk of
CBPD among the apatite-nepheline workers. CB is
the most common among the respiratory diseases
developing among the open-pit miners. The ob-
tained results indicate the necessity to improve the
labor conditions and individual protection gear to
protect the respiratory health of the employees

**References**

1. Karnachev I.P., Skripal’ B.A., Rocheva I.I. i dr. Professional’naja zabolovaemost’ i proiz-
vodstvennyj travmatizm pri dobyche i pererabotke apatit-nefelinovyh rud [Occupational morbidity and
traumatism in the extraction and processing of the apatite-nepheline ore]. Nauchnye podhody k resheniju

dobychi i pererabotki apatito-nefelinovyh rud Kolskogo Zapoljar’ja [Harmful production factors in the
technology of the extraction and processing of the apatite-nepheline ore of Kola Arctic Circle]. Izvestija
Tuľ’skogo gosudarstvennogo universiteta. Estestvennye nauki. – 2012. – Issue # 1. – Ch. 2. – P. 95–100.

patologii na predprijatijah gorno-himicheskogo kompleksa Kol’skogo Zapoljar’ja [Prevalence of the
chronic pathology on the mining-and-chemical industry of Kola Arctic Circle]. Jekologija i ohrana zdor-
ov’ja rabochih promyshlennyh predprijatij v Barenc-regione. Materialy simpoziuma. – Kirovsk, 14–16

4. Profilaktika zabolovaenij, svyazannyh s uslovijami truda, u rabotnikov gorno-himicheskoy pro-
myshlennosti Krajnego Severa: Informacionno-metodicheskoe pis’mo [Disease prevention connected
with the employment terms of workers on the mining-and-chemical industry of the High North: Informa-

5. Rukovodstvo po gigienicheskoy ocenke faktorov rabochej sredy i trudovogo processa. Kriterii i
klassifikacija uslovij truda: Rukovodstvo 2.2.2006-05 [Guidance on hygienic assessment of the working
environment and process factors. Criterions and classification of the employment terms: Guidance

metallurgicheskoy i gorno-himicheskoy promyshlennosti Kol’skogo Zapoljar’ja: Avtoref. dis. ... kand.
med. nauk [Hygienic assessment of the employment terms and preventive measures of the occupational
deseases on the metallurgic and mining-and-chemical industry of Kola Arctic Circle: synopsis of a thesis,

7. Skripal’ B.A. Professional’naja zabolovaemost’, ee osobennosti na predprijatijah gorno-
himicheskogo kompleksa Kol’skogo Zapoljar’ja [Occupational morbidity and its features on the mining-

8. Sjurin S.A., Burakova O.A. Bronholegochnaja patologija u rabochih apatit-nefelinovyh rudn-
ikov Kol’skogo Zapoljar’ja [Bronchopulmonary pathology of the apatite-nepheline mines workers of Kola

9. Sjurin S.A., Burakova O.A. Osobennosti obshhej i profession’al’noj patologii gornjakov aparti-
tovych rudnikov Krajnego Severa [Features of the general and occupational pathology of the miner work-

10. Chashhin V.P., Dedenko I.I. Trud i zdorov’e cheloveka na Severe [Labour and human health on