Journal of Environment and Sustainable Mining Vol.1 No.1 (2025) 33-43

Journal of
Environment and Sustainable Mining

University of Sistan and Baluchestan

Iranian Society of Mining Engineering (IRSME)

Evaluation of Pulmonary Function Capacity and Respiratory Disorders Caused by Dust in The Workers of Building Stone Mines of Nehbandan City

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ARTICLE INFO

Article type:
Research Article

Article history:
Received: 2025-01-05
Received in revised form: 2025-02-29
Accepted: 2025-03-22
Available online: 2025-03-29

Keywords:
Steam Methane Reforming (SMR),
TriMethane Reforming (TMR),
Sensitivity analysis,
Gas-to-Liquids (GTL).

ABSTRACT

Miners are exposed to different pollution in mineral environments. This study aimed to investigate the pulmonary function and respiratory disorders in the workers of Nahbandan city caused by dust and dirt. The semi-experimental study was conducted on 30 workers with occupational exposure to dust (exposure group) and compared them with 30 workers without it. Two rounds of spirometry were performed for them after they completed a standard respiratory questionnaire. Data were analyzed using paired t-test and one-way ANOVA at a confidence level of $p<0.05$ in SPSS-22 software. The clinical symptoms of pulmonary in the exposure group were significantly higher than those in the group without exposure ($p<0.05$). Pulmonary function was significantly lower in the exposure group than in the non-exposure group ($p<0.05$). The second Spirometry showed that the average of all parameters at the end of the work shift was decreased compared to the corresponding values before exposure. These values were not considerable ($p>0.05$), but the average inhalable dust in mines was 1.75 times the allowable occupational contact in Iran. Stone mine dust is associated with irreversible chronic changes in pulmonary function parameters and respiratory symptoms. Consequently, all workers must wear unique masks, and the daily work schedule should be reduced.

Cite this article: Hosseini Nasab, M. and Mohammaddoost, O. (2025). Evaluation of Pulmonary Function Capacity and Respiratory Disorders Caused by Dust in The Workers of Building Stone Mines of Nehbandan City. *Journal of Environment and Sustainable Mining*, 1(1), 33-43. https//doi.org/10.22111/jesm.2023.44103.1001

Publisher: University of Sistan and Baluchestan.
DOI: https//doi.org/10.22111/jesm.2023.44103.1001

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1 .Introduction

On the one hand, mining provides the necessary materials for human life and advancement. Still, on the other hand, it is responsible for causing significant pollution that negatively impacts the environment [1]. The mining process spreads a considerable number of materials that cover the stone dust. Depending on the mineral type, it can leave pollution in water, air, and soil. As a result of the severe harm caused by exploration, diseases, and fatalities that result from mining, mines are considered one of the most dangerous places in many countries. The mineral environment contains various pollutants and toxic elements, such as chromium, mercury, etc., to which mine workers are continuously exposed [2].

As dust causes certain diseases that bother humans, it occupies a significant position in professional health care. Previously, researchers believed that dust caused pulmonary illness but did not realize there was a real connection between these diseases. Furthermore, despite what is prevalent, dust alone does not cause illness. Other factors are important to consider, including particle size, type, and combination of particles, as well as individual sensitivity and time of exposure [3].

Whether the dust causes advanced disease or not, dust can be divided into ineffective and toxic dust. There is no fibrosis effect associated with feeble dust. X-rays can detect the remaining dust in the lymphatic tissues of the lungs. These types of weak dust include carbon, calcium carbonate, cement, and gypsum [3].

After prolonged exposure to toxic dust, disease symptoms may appear in the individual, depending on the dust type. Time duration of contact leads to severe pulmonary side effects, the respiratory capacity is reduced gradually, and certain clinical symptoms appear [3-6]. The disease does not cause death, but it can cause severe suffering until the end of a person's life and ultimately cause disability [3].

Two types of toxic dust are caused by free silica and silicates [3, 4]. X-rays can be used to diagnose fibrosis nodes or nodules that occur in the lungs following the inhalation of silica frequently. The disease resulting from inhaling silica dust is a type of Pneumoconiosis, which is known as Silicosis. Inhaling silica dust causes Pneumoconiosis, commonly referred to as Silicosis. It is necessary to deal with silica or silicon dioxide in several vocations. Various industries generate silica dust, including glass manufacturing, road construction, tunnel construction, and the extraction of zinc, tin, gold, decorative stones, and building stones [3].

Dust pollution poses a particular threat to mine workers, regardless of whether they work in an open space or a closed facility. Discharge and mineral loading regions, mineral deposits, tailing dams, screens, rock crushers, and transportation roads are the main sources of dust generation. The impact of dust depends on its density [7].

In this regard, increasing mineral moisture and using water and chemical spray or a dust catcher are common in regions with dust. The infrastructure of the path, frequent water spraying, and using hooded vehicles are practical but costly [7].

The nature of the work in mineral activities makes accidents, injuries, and occupational diseases inevitable. One of these pathogens is harmful dust [8].

As occupational diseases rarely occur suddenly, it is difficult to determine the exact number of fatalities and the amount of time wasted due to occupational diseases. Occupational diseases are believed to be underreported in the mining industry. Studies have not proven this issue, however [8].

Dust is one of the chemical factors that enter the respiratory environment, residues in a part of the respiratory system in relation to the particle size, and finally, causes illness. Zenker, 1866, was the first person who named lung diseases Pneumoconiosis. It means "a lung containing dust." According to the ILO definition, Pneumoconiosis is dust accumulation in the lungs and tissue reaction to its presence [9]. The term pneumoconiosis describes a set of lung diseases caused by frequent inhalation of small particles, in which long-term retention is the primary cause. The damage location inside the lung is a function of the size and toxicity of inhalable dust, gas, or fiber [10].

Pulmonary function tests are a group of tests that measure breathing and how well the lungs are functioning. Spirometry is a painless study of air volume and flow rate within the lungs. It is the most frequently used measure in assessing the physiological lung function of a patient, and can help differentiate the etiology of the patient's symptoms [11, 12]. Spirometry is a simple and quick procedure to perform: patients are asked to take maximal inspiration and then to forcefully expel air for as long and as quickly as possible (a forced vital capacity maneuver- Fig. 1). Measurements that are made include:

- Forced expiratory volume in one second (FEV1)
- Forced vital capacity (FVC)
- The ratio of the two volumes (FEV1/FVC) [12].

Spirometry and the calculation of FEV1/FVC allow the identification of obstructive or restrictive ventilatory defects. An FEV1/FVC < 70 % where FEV1 is reduced more than FVC, signifies an obstructive defect (Fig. 2). Common examples of obstructive defects include chronic obstructive pulmonary disease and asthma [12].

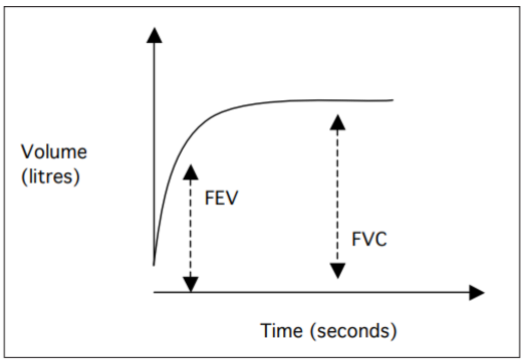

Fig. 1. Normal Spirometry [12].

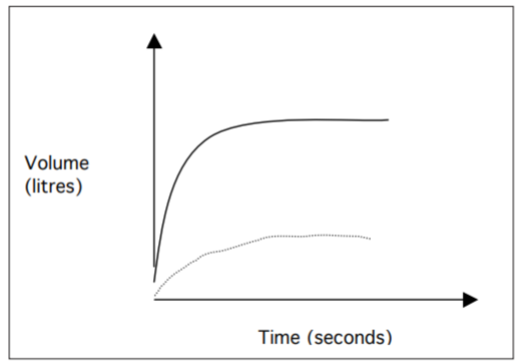

Fig. 2. Spirometry in obstructive lung disease [12].

The pulmonary function of building workers exposed to dust in the workplace was studied, which verified the assumption of the absence of respiratory symptoms in workers due to working with building materials [13]. In other studies, a meaningful relationship between chronic respiratory symptoms and the reduction of pulmonary function capacity and dust exposure was observed [14-16]. While in some studies, this relationship was not found [17].

Alizadeh et al. studied the pulmonary capacities of coal miners and concluded that those exposed to coal dust have lower pulmonary capacities than those not exposed. In addition, work experience has a significant effect on the reduction value of pulmonary capacities in individuals exposed to dust [18].

An investigation of exposure to dust was conducted on workers in the cement industry in Shiraz. Eighty-eight workers exposed to cement dust were randomly selected in the study, along with 80 administrative staff without current or previous exposure to dust, and these individuals were considered the reference group. The respiratory symptoms questionnaire was provided, and the study community underwent X-ray tests of the chest and pulmonary function. There was a significant prevalence of symptoms such as chronic cough, rhonchi, and shortness of breath among workers exposed to dust. Similarly, the thorax radiography of these workers showed signs of a regular inflammatory process. However, the radiography of the reference group did not change considerably. Furthermore, the pulmonary function parameters of these workers were significantly lower than those of their reference matches. As a result, exposure to cement dust was related to respiratory symptoms and functional disorders [19].

In another research, the relationship between the time of exposure to dust and respiratory disorders in coal miners in West Bengal was studied. This study aimed to investigate the epidemic of pulmonary function disorder and determine a relationship between the time of exposure to dust and pulmonary function indices. A considerable difference was observed in pulmonary function between the group exposed to dust and the group not exposed to dust, according to the results. A significant reduction in pulmonary capacity was also observed in dust-exposed individuals. Also, a high negative correlation was found between the spirometry results and the time of exposure to dust compared to those not exposed to dust groups. Consequently, this study showed a positive relationship between the time of exposure to dust and worsening pulmonary function [20].

A similar result was observed that the respiratory symptoms and pulmonary function among iron miners in Iran, who were exposed to occupational dust, were reduced. Sibilant rhonchi, short breathing, and cough were epidemics among these workers. Occupational exposure to inhalable dust reduces workers' vital capacity, quick expiratory volume, and the ratio of their forced expiratory volume in one second to their forced vital capacity as they age. In addition, smoking reduces forced vital capacity and forced expiratory volume in one second by approximately 5 to 9 units [21].

Other research on the pulmonary function capacities of workers in the steel industry. The results indicated that workers with occupational exposure to dust and pollutants are at risk of developing advanced respiratory symptoms and dropping spirometry indices [22]. A study on the workers of sanitary ware factories exposed to dust concluded that there is a meaningful relationship between reducing pulmonary function capacity, short breathing, respiratory complications, and the type of work [23].

Saha et al., in 2011, studied the miners' fitness in terms of determining the maximum aerobic capacity using an indirect method after finding a protocol for standard-level tests before going to the mine by considering heartbeat and oxygen consumption. It showed that the oldest miners (50-59 years) had the minimum oxygen absorption compared to the youngest group (20-29 years). It was found that the VO2max of Indian miners is lower than their mineral-matched counterparts outside India and other non-mineral jobs in India [24].

Around 10% of workers in two coal mines of Damghan suffered from pulmonary diseases due to inhaling pollutant air [25]. Considering the argument between researchers about the ability of dust to cause pulmonary function disorders and stable chronic respiratory side effects, the authors focused on designing a controlled study to obtain information that can be used to remove the above ambiguities and answer the scientific question. Therefore, the present study was designed and implemented aiming to evaluate dangers due to occupational contact with dust and determine the respiratory and functional disorders. There is a significant amount of dust generated during the exploration of these mines due to the use of a wire saw.

2. Materials and methods

The research is semi-empirical, and the statistical community is all workers in the building stone mines (Shah Kouh mining area located in Nahbandan city) in 2020. The main part of the granitoid mass of Shah Koh consists of two units of monzogranite-granodiorite and syenogranite. Greisen granites are limitedly outcropped in the eastern part of the mass, and a small number of dacite, andesite, and aplite dykes, as well as mineralized quartz-tourmaline veins, have interrupted this granite mass. The presence of magnetite and amphibole minerals and the absence of muscovite, aluminosilicates, and pegmatite veins indicate the similarity of mineralogy and lithology of this intrusive mass with I-type granites.

Sixty individuals were selected using the categorized random sampling method. They were classified into two groups (30 persons): exposed (workers of the exploration section (rock-excavation, coring, and wire saw device) and loading section) and without exposure (administration and transportation drivers). There was no history of respiratory disease, chest surgery, or respiratory injuries. Based on age, height, weight, work experience, smoking addiction, economic and social status, education, and place of residence, individuals were divided into two groups. No history of dust exposure has been reported in the group of people without exposure.

Study participants signed the written consent for this research, and the standard Respiratory Questionnaire of the Lung Institute of America [26] was completed. Each individual is asked about respiratory symptoms (cough, rhonchi, short breathing, etc.), tobacco consumption, and medical and family history. Respiratory chronic symptoms were defined as cough and phlegm at each time of day and night for at least three months of the year for two successive years. The obtained information from the questionnaire was used for the determination of the amount of respiratory disease symptoms epidemic among the exposed and non-exposed groups. Pulmonary Function Test (PFT) was conducted based on the standard guideline [27] by using the spirometer, two rounds for the exposed group and once for the non-exposed group. The measured parameters were Forced Vital Capacity (FVC), Forced Expiratory Volume in one second (FEV1), the ratio of Forced Expiratory Volume in the first second to their Forced Vital Capacity (FEV1/FVC), and Peak Expiratory Flow (PEF). Based on the standard protocol of the spirometer manufacturer, the device was calibrated twice a day by using a one-liter syringe. The spirometer device is adjusted to predict an average percent value for each pulmonary function based on age, weight, height while standing, gender, and race of each person [28].

The maneuvering process was taught to workers before spirometry, and they were asked not to smoke and not to shower before the procedure. The weight and standing height of the persons were measured when they wore their usual uniforms for work.

Participants rested for 4 minutes before the spirometry test began. The test was performed in a standing position using a nose clamp. Each individual underwent at least three acceptable tests. If there was a significant difference between the obtained results from different tests, the tests were repeated five times. Then, the maximum values obtained from tests were selected for analysis. To calculate the predicted percentage for pulmonary function parameters, the obtained values from tests were divided by the predicted values (based on age, weight, height, work experience, body mass index, and smoke addiction) by the spirometer device, multiplied by 100.

The Shapiro–Wilk test was conducted to investigate normality tests, paired t-test inferential statistics for in-group comparison, and variance analysis test for one-way intergroup comparison. Data were analyzed using SPSS-22 software with a confidence level of $p<0.05$.

Forty inhalable dust samples were collected using method number 7500 of the NISOH institute [29]. A Fredi sampling pump model 224-PCXR3 from SKC of Germany, 10 mm sampling nylon silicon, and 25 mm diameter PVC filters were used for sampling in this study. Before and after sampling, filters were placed in a desiccator for 24 hours. The sampling pump was calibrated using a rotameter in the discharge of 1.8 lit/min, and sampling was conducted using nylon silicon at the respiratory height of the workers (1.5-1.8 m). An X-ray diffusion method was used to decompose the sample. Initially, a stock solution was provided, followed by practical standard solutions within 20 to 100 µg. Then, the calibration curve was drawn between the pure quartz value and diffraction intensity.

The filtration device, consisting of a Büchner funnel with filter, special clamp, and aspirator pump, was then utilized to pass the standard quartz solution from the silver membrane filters with a 37 mm diameter and 0.8µm porosity. In addition, for the preparation of principal samples, the PVC filters containing samples were digested in tetrahydrofuran solution, and the transportation dust sample was collected on the silver membrane filter. After preparation, the diffusion intensity of the standard and principal specimens was recorded using an X-ray diffusion device. For sample decomposition, the X-ray Powder Diffraction model D5000 of the Siemens company of Germany was used.

SPSS-22 software and linear regression t-tests were used to analyze information obtained from the measurement statistically. To compare the density of the inhalable dust and the Occupational Exposure Limits (OEL) in Iran, equation 1 was used to specify the Occupational Exposure Limits values [30]:

$$OEL = \frac{10}{\%SiO_2+2}\ (mg/m^3) \quad (1)$$

3. Results and discussion

3.1. Results

Table 1 indicates the average and standard deviation of age, weight, height, and work experience for exposed and non-exposed persons. There were no significant statistical differences in the properties of the two groups.

Table 2 shows the clinical pulmonary symptoms based on the studied groups. Compared to the non-exposed group, the exposed group displayed more respiratory symptoms, such as cough, phlegm, and rhonchi.

Table 3 shows the results of pulmonary function tests in the different studied groups. Compared to the non-exposed group, some pulmonary function parameters, such as forced vital capacity, forced expiratory volume in the first second, the ratio between forced expiratory volume in one second and forced vital capacity, and peak expiratory flow, are lower in the exposed group. The susceptible persons were examined by spirometry at the end of the 8-hour shift work to explore the intense variation of pulmonary functions. As compared to the beginning of the shift, all pulmonary functions were reduced. There was no statistical significance in these differences.

The results of the statistical test presented in Table 4 showed that the average dust particle density of 43.56 mg/m3 is related to the respiratory region of exposed workers, and 6.14 mg/m3 was associated with the respiratory area of non-exposed workers. Table 5 compares the time-weighted average (TWA) of the inhalable dust with the OEL of Iran in building stone mines of Nahbandan city. The results of the statistical test showed that there is a considerable difference between the time-weighted average and the inhalable dust in the respiratory region of exposed workers and the OEL of Iran (P-Value=0.004).

3.2. Discussion

The purpose of this study was to evaluate the acute and chronic pulmonary effects of dust exposure among building stone miners in Nahbandan city. According to the comparison between exposed and non-exposed individuals, there was no significant difference between the two groups. Respiratory symptoms and reduction of pulmonary function parameters were considerably higher in the exposed group than in the non-exposed one. Despite similar income and dwelling, none of them had medical records related to chronic pulmonary diseases, injuries, or chest surgeries. Therefore, dust exposure is the primary difference between them.

Findings of the test of the respiratory symptoms epidemic in the two groups indicate that symptoms such as cough, phlegm, and rhonchi are higher in the exposed group.

The findings of the pulmonary function test in the present study show that the predicted percentage average of parameters such as forced vital capacity, forced expiratory volume in the first second, the ratio between forced expiratory volume in the first second and forced vital capacity, and peak expiratory flow in the exposed group is considerably lower than the non-exposed group.

In this study, the respiratory disorder of the exposed worker is in a way that spirometry changes show evidence of obstructive pulmonary disease. The FVC value is standard or ascending in obstructive pulmonary disease, but the main symptom of this disorder is the reduction of the FEV1 value. Therefore, the ratio of FEV1 to FVC is reduced significantly [31]. It can be concluded that exposure to dust can lead to chronic obstructive pulmonary disease. These results are similar to the findings of other studies in this field. For example, reduction of pulmonary function parameters, such as FEV1, FVC, rhonchi, and short breathing in workers of the cement industry caused by exposure to dust has been reported [32, 33].

In some case studies, contact with dust has been accompanied by diffuse bronchiolitis and pulmonary function disorder (obstructive pulmonary symptoms) [34, 35]. Another study specified the relationship between chronic contact with overspending dust and pulmonary fibrosis, emphysema, obstruction of the airway, and reduction of respiratory capacity [36]. It was found in a study on the gold miners of South Africa that contact with siliceous dust, especially in smoke persons, increases fatality due to obstructive pulmonary diseases [37].

Table 1. Comparison of general characteristics of two groups of exposed and non-exposed workers.

Groups	Height (cm) Average ± standard deviation	Age (year) Average ± standard deviation	Weight (kg) Average ± standard deviation	Body Mass Index ($^{kg}/_{m^2}$) Average ± standard deviation	Work experience (year) Average ± standard deviation	History of smoking (year) Average ± standard deviation
Exposed workers N=30	175.40±3.25	30.7±3.45	72.40±5.42	23.66±2.14	8.40±3.44	2.20±1.24
Non-exposed workers N=30	176.24±2.45	32.4±4.33	70.40±4.25	22.78±2.25	7.55±4.15	3.55±2.13
Significance level	0.11	0.24	0.38	0.11	0.13	0.10

*Significance level: $p< 0.05$

Table 2. The epidemic percentage of two groups of exposed and non-exposed workers.

Respiratory symptoms	Exposed workers N=30	Non exposed workers N=30	Significance level
ough	29	3	*p= 0.000
Sputum or phlegm	33	5	*p= 0.000
Wheezing	18	2	*p= 0.02
Asthma	31	3	*p= 0.000
Cough and sputum	15	1	*p= 0.03

*Significance level: $p< 0.05$

Because pulmonary function can be related to individuals and spirometers, each participant underwent a spirometry test before beginning the study. The pulmonary function parameters showed oscillations, but these differences did not appear to be statistically significant. After the work shift, the spirometry test was performed. During this period, lung parameters were lower than usual, but this difference was insignificant. This implies that exposure to dust for the duration and density of the present study cannot cause severe pulmonary effects.

Cohort studies, such as the present study, cannot prove cause-and-effect relationships. Although it is true, there is evidence that dust exposure causes these consequences. First, the exposed group before employment did not experience any kind of respiratory disease. Second, workers did not experience chemical exposure before occupation or during their duty. Third, even though the reference group was older than the exposed group (on average, two years) and the reference group individuals had, on average, two more years of smoke addiction compared to the susceptible group, respiratory disorders and respiratory symptoms in them were significantly lower than in the susceptible group.

In addition, it is expected that the age impact will result in a reduction in the difference between the two groups in terms of respiratory symptoms and respiratory disorders, given that, other than the age and smoking addiction factors, the distribution of confounding variables is similar between the two groups. On the other hand, IBM was standard for both exposed and non-exposed groups. Therefore, it is not an effective parameter in respiratory disorders and respiratory symptoms (Table 1).

The average total density of dust in the vicinity of the pollution resources was 43.56 mg/m3, and the average inhalable dust particle density was 1.75 times the OEL of Iran. It indicates the excessive amount of inhalable dust in building stone mines due to the absence of proper control systems to reduce pollution.

Therefore, it can be concluded that respiratory symptoms and pulmonary disorders in the exposed group are due to their contact with dust.

Table 3. Comparison of pulmonary function in two groups of exposed and non-exposed workers.

Parameter	Before starting the daily work of exposed workers (Average ± standard deviation)	After the daily work of susceptible workers (Average ± standard deviation)	Significant level before and after daily work	Non-exposed workers	Significant level before daily work of exposed workers compared to non-exposed workers	Significant level after daily work of exposed workers compared to non-exposed workers
Forced Vital Capacity (FVC)	91.74±8.42	91.33±9.42	p= 0.33	94.04±9.42	p= 0.17	p= 0.11
Forced Expiratory Volume in one second (FEV1)	86.80±7.32	82.40±6.42	p= 0.44	91.31±7.42	*p= 0.002	*p= 0.000
FEV1/FVC	93.13±9.44	90.34±7.42	p= 0.13	97.03±8.42	*p= 0.000	*p= 0.001
Peak Expiratory Flow (PEF)	86.30±8.45	82.40±8.42	p= 0.10	92.47±9.42	*p= 0.004	*p= 0.001

*Significance level: $p< 0.05$

Table 4. Total dust distribution in the building stone of Nehbandan city.

	Number of samples	The average concentration of total dust mg/m^3	Standard deviation mg/m^3
Breathing zone of workers without exposure to dust	20	6.14	0.44
Breathing zone of workers exposed to dust	20	43.56	0.7

Table 5. The time-weighted density of the inhalable dust based on the daily work hour (8 hours)

	Time-weighted average of inhalable dust concentration (C) mg/m^3	Occupational Exposure Limit (OEL) mg/m^3	C/OEL (⁄)
Breathing zone of workers without exposure to dust	0.116	0.1	1.16
Breathing zone of workers exposed to dust	0.175	0.1	1.75

4. Conclusions

Occupational inhalation of low-density dust, over a long period, has been shown to be a significant risk factor for chronic pulmonary disease. In this regard, the results indicate that health and engineering actions (for example, respiratory protection programs) are required to reduce dust density and contact, prevent possible side effects, and confirm the need to stop smoking among workers, particularly those exposed to dust. In addition, individuals exposed to the side effects of dust should undergo active periodic examination, rather than daily and routine examination.

As the inhalable dust of stone mines contains a high level of free silica, it is critical to implement complementary management measures, improve work environments, and train mine employees continually to prevent their exposure.

Water consumption during the extraction process, the use of wire saw devices, and loading are the most effective ways of preventing the creation of dust in mines. A suitable method should be adopted for water consumption to ensure that all dust created by different operations is thoroughly mixed with water and does not enter the air.

A variety of dust control methods, including confining and personal protection tools such as masks and Respirators, may be employed if this method is ineffective.

Acknowledgment

The authors of this research sincerely thank the University of Sistan and Baluchistan for the financial support of this study.

Ethical Considerations

The authors avoided data fabrication, falsification, and plagiarism, and any form of misconduct.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of Interest

The authors declare no conflict of interest.

References

[1] Hamidian, H., Moradzadeh, N., Espahbodi, M. (2012). Environmental study of methane emissions from coal mining operations. *Mines Development Monthly*. April, 25: 69. (In Persian).

[2] Saffari, M., Dargahi, M., Mozdian Fard, M.R., Kashani, M. (2006). Effects of Mineral Extraction on Environmental Pollution and Diseases of Miners. Fifth Student Conference on Mining Engineering; Isfahan. (In Persian).

[3] Saffari, M. (2006). Study the effects of mineral extraction on environmental pollution and diseases of miners. The first specialized conference on environmental engineering; 2-8 (In Persian).

[4] Poursaeidi, M., Azimzadeh, H.R., Sodaizadeh, H.R. (2012). Effects of Toxic and Non-Toxic Dust on Human Health. First National Conference on Desert (Science, Technology and Sustainable Development); Tehran; (In Persian).

[5] Imam Hadi, M.A., Nouraie, M., Tahbaz, M.O., Bakhshayesh Karam, M., Zahirifar, S., Bahadori, M.(2005). Curtain plate next to the primary pulmonary manifestation in contact with asbestos: a study on miners and chrysotile asbestos factory in Hajat-Nehbandan. *Journal of Medical Studies*. 16 (3): Fall (In Persian).

[6] Shojaei Borjoui, S., Azimzadeh, H.R., Mosleh Arani, A., Kuchakzadeh, M.R. (2019). Occupational monitoring and assessment of health hazards of respiratory exposure to dust in an industrial unit of Chinese soil production. *Journal of Occupational Medicine*. 11(3): 14-25, (In Persian). http://dx.doi.org/10.18502/tkj.v11i3.2584

[7] Taheri, A., Rahnama Rad, J., Judaki, V., Barzegari, T. (2011). Investigation of pollution caused by decorative stone mines in Aligudarz city. 7th Iranian Conference on Engineering Geology and Environment. p. 6 (In Persian).

[8] Kazem Nouri, M. (2009). Events and diseases caused by work in mining activities. *Journal of Mining Engineering*. 3: Summer (In Persian).

[9] Jahangir Blourchian, M. (2012). Toxicology of Organic Dust of Pneumoconiosis. Faculty of Health, Medical Sciences University of Gilan; (In Persian).

[10] Masroor Rudsari, D., Rafiei, F., Fadaei Aghdam, N., Hosseini Agha, F. (2012). Health-related quality of life in patients with chronic obstructive pulmonary disease. *Journal of Nursing Care Research Center of Tehran University of Medical Sciences (Iranian Journal of Nursing)*. 25 (76): p. 19-27 (In Persian).

[11] Sewa, D.W., Ong, T.H. (2014). Pulmonary function test: spirometry. Proceedings of Singapore Healthcare. 23(1), pp.57-64. http://dx.doi.org/10.1177/201010581402300110

[12] Ranu, H., Wilde, M., Madden, B. (2011). Pulmonary function tests. *Ulster Medical Journal*, 80(2), 84-90.

[13] Khazraei, T., Zamanian, Z., Zare, R., Mubasheri, F. (2015). Comparative study of pulmonary function test of construction workers and a group of food industry workers. *Journal of Fasa University of Medical Sciences*. 5 (3) (In Persian).

[14] Mwaiselage, J., Bratveit, M., Moen, B., Mashalla, Y. (2004). Cement dust exposure and ventilatory function impairment: an exposure–response study. *Journal of occupational and environmental medicine*. 46(7): 658-667. http://dx.doi.org/10.1097/01.jom.0000131787.02250.79

[15] Neghab, M., Chobine, A. (2007). The relationship between occupational exposure to cement dust and prevalence of respiratory symptoms and disorders. *Journal of Kermanshah University of Medical Sciences*. 11(2): 215-226. http://dx.doi.org/10.1097/01.jom.0000083036.56116.9d

[16] Kakui, H., Ghulami, A., Qasem Khani, M., Hosseini, M. (2012). Occupational exposure of workers to cement dust and its effects on respiratory function in a cement plant. Ofogh Danesh, *Quarterly Journal of Gonabad University of Medical Sciences and Health Services*. Spring; 18 (1) (In Persian).

[17] Fell, A.K.M., Thomassen, T.R., Kristensen, P., Egeland, T., Kongerud, J. (2003). Respiratory symptoms and ventilatory function in workers exposed to Portland cement dust. *Journal of occupational and environmental medicine*. 45(9): 1008-1014.

[18] Alizadeh, A., Nasle Seraji, G., Kakui, H. (2000). Study of pulmonary capacities of Central Alborz-Mazandaran coal miners. *Journal of Yazd Shahid Sadoughi University of Medical Sciences and Health Services*. 8 (4): (Special Issue of Health 2): 58-63 (In Persian).

[19] Neghab, M., Choobineh, A. (2007). Work-related respiratory symptoms and ventilatory disorders among employees of cement industry in Shiraz. Iran. *Journal of occupational health*. 49(4): 273-278. http://dx.doi.org/10.1539/joh.49.273

[20] Prasad, S.K., Singh, S., Bose, A., Prasad, B., Banerjee, O., Bhattacharjee, A. (2021). Association between duration of coal dust exposure and respiratory impairment in coal miners of West Bengal, India. *International Journal of Occupational Safety and Ergonomics*, 27(3): 794-804. http://dx.doi.org/10.1080/10803548.2020.1742463

[21] Gholami, A., Tajik, R., Atif, K., Zarei, A.A., Abbaspour, S., Teimori-Boghsani, G. (2020). Respiratory symptoms and diminished lung functions associated with occupational dust exposure among iron ore mine workers in Iran. *The open respiratory medicine journal*. 14(1): 1-7. http://dx.doi.org/10.2174/1874306402014010001

[22] Giahi, O., Darwishi, E., Sarabi, M., Shahsavari, S. (2014). Study of the relationship between exposures to inhaled pollutants and lung function capacity of workers in steel industry. *Scientific Journal of Kurdistan University of Medical Sciences*. 19: 135-145 (In Persian).

[23] Halwani, Gh. H, Ebrahimzadeh, M., Hoboubati, H., Jafari Nodooshan, R. (2011). Investigation and Evaluation of Respiratory Complaints and Pulmonary Performance Capacities of Workers in Yazd Chinese health Factories. *Journal of Occupational Medicine*. 3 (2): 46-53 (In Persian).

[24] Ratnadeep, S., Netai Chandra, D., Amalendu, S., Rajib, B. (2011). Maximum Aerobic Capacity of Underground Coal Miners in India. *Journal of Environmental and Public Health*. 6 pages, http://dx.doi.org/10.1155/2011/232168.

[25] Delkhosh, M.B., Seif Aghaei, F. (2003). Investigate the number of charcoal particles emitted in the working air of two Damghan coal mines. *Scientific Journal of Semnan University of Medical Sciences*. 2 (1 and 2) (In Persian).

[26] Ferris, B.G. (1978). Epidemiology Standardization Project (American Thoracic Society). The *American review of respiratory disease*. 118 (6 Pt 2):1-120.

[27] Statement ATS. (1979). Snowbird workshop on standardization of spirometry American Thoracic Society. *American Review of Respiratory Disease*, 119(5): 831-838. http://dx.doi.org/10.1164/arrd.1979.119.5.831

[28] Hnizdo, E., Churchyard, G., Dowdeswel, R. (2000). Lung function prediction equations derived from healthy South African gold miners. *Occupational and environmental medicine*. 57(10): 698-705. http://dx.doi.org/10.1136/oem.57.10.698

[29] National Institute for Occupational Safety and Health. (2003). Silica, crystalline, by XRD (respirable): Method 7500. In: NIOSH Manual of Analytical Methods, 4t h ed., 3rd Suppl. Cincinnati, OH: DHHS (NIOSH), Publication No. 127.

[30] Occupational Safety and Health Administration. (1996). Quartz and cristobalite in workplace atmospheres: Method ID-142. Salt Lake City, UT: U.S. Department of Labor. Occupational Safety and Health Administration.

[31] Kumar, V., Cotran, R., Robbin, S. (1997). Basic pathology. 6th. Philadelphia (PA): WB Saunders Company; 393-425.

[32] Zelekem Z.K., Moenm B.E., Bratveit, M. (2010). Cement dust exposure and acute lung function: a cross shift study. *BMC Pulmonary Medicine*, 10: 19. https://doi.org/10.1186/1471-2466-10-19

[33] Poornajaf, A.H., Kakooei, H., Hosseini, M., Ferasti, F., Kakaei, H.A. (2010). The effect of cement dust on lung function in a cement factory, Iran. *International Journal of Occupational Hygiene*. 2: 74-78.

[34] National Institute for Occupational Safety and Health (NIOSH). (1984) Manual of the analytical method. 3rd ed.

[35] Enarson, D.A., Maclean, L., Dybuncio, A., Chan-Yeung, M., Grzybowski, S., Johnson, A. (1984). Respiratory health at a pulp mill in British Columbia. *Archives of Environmental Health: An International Journal*. 39(5): 325-330. https://doi.org/10.1080/00039896.1984.10545858

[36] Sripaiboonkij, P., Phanprasit, W., Jaakkola, M.S. (2008). Respiratory effects of occupational exposures in a milk powder factory. *European Respiratory Journal*, 31(4): 807-814. https://doi.org/10.1183/09031936.00106407

[37] Hnizdo, E. (1990). Combined effect of silica dust and tobacco smoking on mortality from chronic obstructive lung disease in gold miners. *British Journal of Industrial Medicine*. 47(10): 656-664. https://doi.org/10.1136/oem.47.10.656