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HYGIENIC ASSESSMENT OF THE PARTICULAR MATER CONTENT IN THE AIR OF ZAPORIZHZHIA CITY

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Relevance. The greatest threat to human health is provided by the suspended particular mater with an aerodynamic diameter of 10 мм or less. Since they can lead to an increase of frequency of respiratory and cardiovascular diseases and contribute to an increase in mortality from these diseases.

Objective. The research was aimed to carrying out a hygienic assessment of the particular mater content of the PM_4 and PM_{10} fraction in the atmospheric air and in the air of the working area of the metallurgical enterprises.

Materials and methods. It was performed the 4000 studies of PM_4 and PM_{10} concentrations in the atmospheric air and 1838 - at workplaces. The study was carried out using a piezo-balanced measuring instrument for mass concentration of respirable dust - KANOMAX 3521.

Results. Monitoring of atmospheric air showed that PM4 and PM_{10} are constant components of atmospheric air in the city of Zaporizhzhya. It was found that the maximum one-time concentrations of PM_{10} in the ambient air exceeded permissible concentration 20-minute mean only in sporadic cases, with the multiplicity exceeding 1.1-1.2 times. But daily average concentrations of these substances systematically exceeded recommended levels in 1.5 times. It was established that in the agglomeration, in the blast furnace guild and in the open-hearth guild departments the PM_{10} and PM_4 content in the air of the working area was 21.2 and 16.0 times, 31.8 and 24.4 times and 15.5 and 13.2 times more than at workers of factory management, respectively.

Conclusion. Organization of constant continuous monitoring of PM content in the air is a prerequisite for a correct assessment of their impact on the health of the population and workers.

Key words: particular mater, PM_4, PM_{10}, atmospheric air, working air, nanoparticles.

Relevance. The suspended particles, especially small ones, are classified by the World Health Organization as priority pollutants by the level of influence on human health. The danger of dust particles for human health is confirmed by the data of extended domestic and foreign researches. The greatest threat to human health is provided by the particles of the $PM_{2.5}$ fraction – the substances with an aerodynamic diameter of 2.5 mm or less and PM_{10} particles with an aerodynamic diameter of 10 мм or less. $PM_{2.5}$ and PM_{10} contain respirable particles that are as small as they can penetrate the thoracic part of the respiratory system. It has been proved that particular mater (PM) can be suspended for a long time in the air, transported long distances from the source of formation and have the ability to penetrate into the lower parts of the respiratory system, reaching the bronchi and alveoli. The effect of respirable PM on health is fully documented [4,5,10,12]. It is known that a short-term, and especially extended effect of these particles can lead to an increase of frequency of respiratory and cardiovascular diseases and contribute to an increase the mortality rate from these diseases.

In EU and US countries, constant monitoring of the PM content in the ambient air is carried out at the state level, emission and concentration of these substances are monitored, there are approved calculation methods for determining and estimating emissions of finely dispersed suspended particles; there are developed some steps for achieving the lowest concentrations of these pollutants in the air.

At the present, they are used the values, which are recommended by the WHO - average daily and average annual values, which are 25 мg/m^3 and 10 мg/m^3 for $PM_{2.5}$ and 50 мg/m3 and 20 мg/m^3 for PM_{10} [1] respectively, to estimate the exposure of the population with particular mater.

For the air of the working area, the maximum permissible concentrations of particular mater are not established, although it has been scientifically confirmed the presence of PM dust fraction in various processes in different sectors [6,10].

The research was aimed to hygienic assessment of the particular mater content of the PM_4 and PM_{10} fraction in the atmospheric air in different regions of the industrial city and in the air of the working area of one of the large metallurgical enterprises.

MATERIALS AND METHODS

It is studied the concentration of particular mater in the atmospheric air of a large industrial city and in the air of the working area of metallurgical enterprise. The study was carried out in accordance with a unified

procedure using a piezo-balanced measuring instrument for mass concentration of respirable dust - KANOMAX 3521.

The concentration of fine dust in the ambient air was estimated in the most polluted districts of the city of Zaporozhye – Zavodskiy, Shevchenkovskiy, Voznesenovskiy and conditionally clean area – Kommunarskiy district. Totally it was performed the 3,000 measurements of the concentrations of PM_4 and PM_{10}.

To assess the concentrations of particular mater at workplaces of the main guilds of the metallurgical enterprise, they were conducted the 1838 studies of PM_4 and PM_{10} concentrations. The control group consisted of employees of the department of plant management, where the total dust content does not exceed the maximum permissible concentration.

RESULTS AND THEIR DISCUSSION

In European cities, 74.5% and 94% of people were annually exposed to particular matter exceeding the WHO guidelines for PM_{10} and $PM_{2.5}$, respectively. In 2012, the maximum concentration of PM10 (40 мg/m3) in the EU was exceeded for 28.6% of the urban population [11].

In Ukraine, the system for rationing, monitoring and estimating the concentration of particular mater in atmospheric air is currently lacking, which does not allow us to correctly estimate the population exposure to these aerosols.

Therefore, we also organized a monitoring of the content of finely dispersed dust fractions (PM_4 and PM_{10}) for hygienic assessment of the state of atmospheric air pollution with these substances and predicting the adverse effects of their influence on the health of citizens.

Earlier, when it was the analysis of the gross emissions of PM fractions of suspended substances, we found that Zavodskiy (7249.02±389.5), Shevchenkovskiy (1524.4 ± 155.02) and Voznesenovskiy districts (511.88 ± 163.66) are the most contaminated in the city. In Zavodskiy district, the density of emissions from stationary sources was 172595.7 ± 9274.6 kg/m^2 on average for 5 years, in terms of 1 person this index was 134.34 ± 7.5 kg/person/year; in the Shevchenkovskiy district, the density of emissions was at the level of 23120.64 ± 2408.3 kg/m^2 and almost 10 kg/person/year; in Voznesenovskiy - 11127 ± 3557.8 kg/m^2 and about 5 kg/person/year, respectively [8]. Therefore, Zavodskiy, Shevchenkovskiy and Voznesenovskiy districts were selected as experimental, and Kommunarskiy became a control one, because, according to official statistical reports, the emissions of PM_{10} and $PM_{2.5}$ were not recorded.

The results of our work have shown that PM_{10} and PM_4 in different concentrations are constantly present in the air of both contaminated districts and in the control one. It was found that the maximum one-time concentrations of PM_{10} in the residential areas of the control district exceeded 0.3 mg/m^3, i.e. maximum permissible concentration 20-minute mean [9], only in sporadic cases, with the multiplicity exceeding 1.1-1.2 times. At the period of estimating daily average concentrations, it was found that PM_{10} systematically exceeded both the maximum permissible concentration 24-hour mean – 0.06 mg/m^3 [9], and the recommended levels of WHO (50 мg / m^3). For example, in the Voznesenovskiy region, the average daily concentrations of PM_{10} were from 0.029±0.002 mg/m^3 to 0.089 ± 0.01 mg/m^3, PM_4 -0.025±0.001 mg / m^3 to 0.042 ± 0.001 mg / m^3. It was established the seasonal dynamics of atmospheric air pollution. The highest concentrations of studied pollutants were established during the summer period of the year, especially in August (maximum $PM1_0$ concentration was 0.2 mg / m^3, PM_4 - 0.15 mg / m^3), and also in early September. The choice of period was connected with the prevailing wind direction in summer (northern, northeastern), an increase in the frequency of calm wind, surface inversions. In winter, atmospheric air in the Voznesenovskiy district is less polluted. The maximum values of PM_{10} concentration was identified at level of 0.07 mg / m^3, PM_4 - 0.05 mg / m^3 [7].

Bulk and granular materials are mainly used in many industries such as metallurgy, mining, construction materials, mineral fertilizer production. In the process of their recycling and transportation, air-dispersed systems are inevitably created [13]. Depending on the type of production, both the chemical and the physical composition of the dust can change, which requires systematic monitoring of the dispersion of dust and, of course, the PM fractions. The high content of PM_{10} and $PM_{2.5}$ fractions in the air of the working area allows one to assume the presence of finer dispersity particles.

But at this moment, it is difficult to do a correct assessment of the exposure of workers employed in various industries to PM and nanoparticles, due to the inadequate data on the dispersion composition of dust emissions of production processes, the lack of normative and methodological documents for controlling the content of PM and nanoparticles in the air of the work area [2].

Scientific researches of Ulanova T.S. et al. about the content of particular mater and the nanoscale particles in the air of the working area of the mining industry confirm a significant excess of nanoparticles from 5 to 68 times in the air of the working area during the production process in relation to the control group - the employees of the administrative building [10].

Conducted by us studies of PM concentrations in the air of the working area in the main guilds of the metallurgical enterprise showed that the dust level of the PM4 and PM10 fractions is significantly greater

than in the control group (workers of the plant management). It was established that the PM_{10} concentration in the sintering guild was 1.27 ± 0.04 mg / m^3, the PM_4 concentration was 0.79 ± 0.03 mg / m^3; in the blast-furnace guild the PM_{10} and PM_4 contents were 1.91 ± 0.11 and 1.22 ± 0.05 mg / m^3, respectively; in the open-hearth guild, the PM10 and PM4 contents were 0.93 ± 0.04 and 0.66 ± 0.05 mg / m^3, respectively. The concentration of PM_{10} and PM_4 in the plant at the workplace was 0.06 ± 0.006 mg / m3 and 0.05 ± 0.004 mg / m^3, respectively.

It was established that in the agglomeration department the PM10 and PM4 content in the air of the working area was 21.2 (p€0.001) and 16.0 times (p€0.001) greater than in the control area; in the blast furnace guild 31.8 and 24.4 times greater (p€0.001), respectively, and in the air of the working area of the open-hearth guild 15.5 times (p€0.001) and 13.2 times (p€0.001) than at workers of factory management. Also, the level of particular mater in the mechanical guild of metallurgical production exceeds 4.4 times (p€0.001) for the PM4 fraction and 3.3 times (p€0.001) for the PM10 fraction the level of particular mater in comparison with the control group [6].

In the concrete, all dust and gas emissions of explored metallurgical, engineering and mining industries contain PM fractions - up to 80% of PM10 and up to 40% of PM2.5. The dispersion composition of the dust depends on the specifics of the technological process, raw and materials. There are particles of the nanoscale range in emissions of many technological processes, which requires direct researches to study their impact on workers in particular and on the general population. Evaluation of the dust composition by fractions helps significantly in determining the area of influence of emission sources and estimating the exposure of the population to dangerous fractions of solid emissions. The introduction of an assessment of the fractional composition of dust in the procedures for justifying the standards for maximum permissible emissions and design of sanitary protection zones should be considered as a tool to increase the effectiveness of measures to ensure the sanitary and epidemiological welfare of the population [3].

One of the new topical directions in modern hygienic research is the determination of particles in a nanosized condition, which have the aerodynamic diameter less than 0.1 мм. In a nanoscale condition, any substances acquire new chemical, physical and biological properties that differ significantly from those in a macro condition [2]. It was established that the size of the particles is one of the important indicators of the influence on human health, along with the shape of the particles and their chemical composition.

An analysis of a large amount of scientific studies has shown that nanoparticles have a higher toxicity than conventional microparticles, they are able to penetrate with unchanged condition through cellular barriers, and also through the blood-brain barrier into the central nervous system. They are able to circulate and accumulate in organs and tissues, causing more pronounced pathomorphological lesions of internal organs, and also, having a long half-life, nanoparticles are extremely difficult to be excreted from the body [14].

CONCLUSIONS

1. Conducting atmospheric air monitoring showed that PM10 and PM4 are permanent components of the atmosphere in the city of Zaporozhye. Considering that the threshold level of atmospheric air pollution, below which PM10 does not affect health status has not yet been determined at present time, the problem of atmospheric air pollution with particular mater dust fractions requires a more detailed study to correctly assess of their impact on health of population.

2. It has been established that particular mater are determined in the air of the working area of the main and accessory guilds of the metallurgical enterprise, which level is significantly higher than in the air of the working area of the workers in the control group. To assess the degree of harmfulness of the impact of those particulars on the health status of workers, it is recommended that the PM4 and PM10 content should be monitored continuously in the air of the work area during hygienic assessment of working conditions.

3. It is necessary to control the content of particular mater and ultrathin particles because of their toxicity and their presence in the atmosphere and in the air of the working zone of industrial enterprises, which are formed in the process of production.

Конфлікт інтересів. Автори заявляють, що не мають конфлікту інтересів, який може сприйматися таким, що може завдати шкоди неупередженості статті.

Джерела фінансування. Ця стаття не отримала фінансової підтримки від державної, громадської або комерційної організацій.

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ГІГІЄНІЧНА ОЦІНКА ВМІСТУ ТВЕРДИХ ЧАСТОЧОК В ПОВІТРІ МІСТА ЗАПОРІЖЖЯ

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Актуальність. Найбільшу небезпеку для здоров'я людини становлять суспендовані тверді частки з аеродинамічним діаметром 10 мкм та менше. Оскільки вони можуть привести до збільшення частоти респіраторних і серцево-судинних захворювань і сприяти збільшенню смертності від цих захворювань.

Мета. Гігієнічна оцінка вмісту суспендованих твердих часток дрібнодисперсних фракцій PM_4 та PM_{10} в атмосферному повітрі та в повітрі робочої зони металургійного підприємства.

Матеріали та методи. Було проведено 4000 досліджень концентрацій PM_4 і PM_{10} в атмосферному повітрі і 1838 - на робочих місцях. Для визначення концентрацій респірабельних аерозолів був використаний метод п'єзобалансового зважування осадженої проби пилу за допомогою аналізатора аерозолю KANOMAX-3521.

Результати. Моніторинг атмосферного повітря показав, що PM_4 і PM_{10} є постійними компонентами атмосферного повітря в місті Запоріжжя. Було встановлено, що максимальні разові концентрації PM_{10} в навколишньому повітрі перевищують ГДК максимально разову тільки в спорадичних випадках, кратність перевищення становить 1,1-1,2 рази. Середньодобові концентрації цих речовин систематично перевищують рекомендовані рівні в 1,5 раз. Було встановлено, що в агломераційному, в доменному і мартенівському цехах вміст PM_{10} і PM_4 в повітрі робочої зони був в 21,2 і 16,0 разів, у 31,8 і 24,4 рази і в 15,5 і 13,2 рази більше, ніж у працівників заводоуправління, відповідно.

Висновок. Організація постійного моніторингу вмісту PM у повітрі є необхідною умовою для правильної оцінки їх впливу на здоров'я населення та працівників.

Ключові слова: тверді часточки, PM_4, PM_{10}, атмосферне повітря, повітря робочої зони, наночастки.

ГИГИЕНИЧЕСКАЯ ОЦЕНКА СОДЕРЖАНИЯ ТВЕРДЫХ ЧАСТИЦ В ВОЗДУХЕ ГОРОДА ЗАПОРОЖЬЕ

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Актуальность. Наибольшая угроза для здоровья человека представляют взвешенные твердые частицы с аэродинамическим диаметром 10 мкм или менее. Поскольку они могут привести к увеличению частоты респираторных и сердечно-сосудистых заболеваний и способствовать увеличению смертности от этих заболеваний.

Цель. Гигиеническая оценка содержания взвешенных твердых частиц мелкодисперсных фракций PM_4 и PM_{10} в атмосферном воздухе и в воздухе рабочей зоны металлургических предприятий.

Материалы и методы. Было проведено 4000 исследований концентраций PM_4 и PM_{10} в атмосферном воздухе и 1838 – на рабочих местах. Для определения концентраций респирабельных аэрозолей был использован метод пьезобалансного взвешивания осажденной пробы пыли с помощью анализатора аэрозоля KANOMAX-3521.

Результаты. Мониторинг атмосферного воздуха показал, что PM_4 и PM_{10} являются постоянными компонентами атмосферного воздуха в городе Запорожье. Было обнаружено, что максимальные разовые концентрации PM_{10} в окружающем воздухе превышают ПДК максимально разовую только в спорадических случаях, кратность превышения составляет 1,1-1,2 раза. Среднесуточные концентрации этих веществ систематически превышают рекомендуемые уровни в 1,5 раз. Было установлено, что в агломерационном, в доменном и мартеновском цехах содержание PM_{10} и PM_4 в воздухе рабочей зоны было в 21,2 и 16,0 раз, в 31,8 и 24,4 раза и в 15,5 и 13,2 раза больше, чем у работников заводоуправления, соответственно.

Вывод. Организация постоянного непрерывного мониторинга содержания PM в воздухе является необходимым условием для правильной оценки их влияния на здоровье населения и работников.

Ключевые слова: твердые частицы, PM_4, PM_{10}, атмосферный воздух, воздух рабочей зоны, наночастицы.