Investigation of fine dust pollution during hard and soft works in warehouse complexes

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Abstract. The dust dispersed composition in various types of hard and soft works is under study. The dust emissions indoors concentration data is obtained. The dust concentration on distance dependence is constructed. The impact assessment of hard and soft works in warehouses and residential premises on environmental pollution by dust emissions is given. The concentration and ratio of PM2.5 to PM10 particles were calculated in order to determine the dustiness and the negative impact on the environment.

Introduction
The main sources of suspended particles in the atmospheric air of large cities are: vehicle emissions, ferrous and nonferrous metallurgy enterprises, mechanical engineering, building materials production (this is associated with such technological processes as mechanical grinding of solid materials, as well as transportation of bulk materials, blasting) processes of burning liquid fuels (diesel fuel, oils), open storage sites for building and bulk materials (sand, salt, etc.), garbage handling stations, crushing and sorting complexes for construction waste recycling, construction sites, building demolition work, excavation works, unheeded soil areas [1].

Purpose of the study
The dust impact assessment on the environment quality and human health during hard and soft works. The study of the dust dispersed composition in the working zone air. Calculation of the concentration and ratio of PM2.5 to PM10 particles to determine dustiness and negative environmental impact.

Theoretical part
One of the urban air pollutants is construction dust, which is emitted from under construction, reconstructed, or repaired buildings and structures. Hard and soft works (leveling of concrete and other coatings for plaster and putty; flooring structures preparation for flooring; creating holes in vertical and horizontal structures, chipping, fastening, etc.) related to the mechanical impact on concrete and reinforced concrete structures.

Hard and soft works are a necessary stage of using the premises (warehouse, residential part, museum, university, etc.). The dust formed during these works corresponds to a different degree of dispersion and is characterized by the greatest amount of discharge. In this case, it is necessary to take into account the physical, chemical and morphological dust characteristics. It is important to consider the ability to absorb (absorb) harmful impurities, and as a result, the dust toxicity. The suspended
particles total flow is divided by size. It consists of PM\textsubscript{10} particles (less than 10 microns) and PM\textsubscript{2.5} (less than 2.5 microns) [2].

All over the world and, in particular, in Russia, the standards for the content of PM\textsubscript{2.5} and PM\textsubscript{10} dust particles in the ambient air have been adopted. Particles of these sizes have a negative effect on the health and condition of the person as a whole. At the same time, particles of smaller sizes of 2.5 microns are more harmful than larger 10 microns causing pulmonary and cardiovascular diseases [3].

Hard and soft works are a source of enormous formation of dust particles. At the moment there is no single standard for these types of work for the content of fine suspended particles PM\textsubscript{10} and PM\textsubscript{2.5} in the working zone air. Also, there are no systems and assessments of the dispersed composition and concentration control.

**Experimental part**

In the fine dust formation study, three operations were considered during the hard and soft works: wall cleaning; walling; leveling the walls after plastering.

As an experimental environment, the warehouse complex in the Moscow region in the Lyubertsy district in the working village of Tomilino was investigated as a zone with a large number of new warehouse premises under construction.

Air sampling was carried out near the workplace at a height of approximately 1.5 meters from the floor level (respiration level) using AFA filters an aspirator. The sampling sites number was chosen at the rate of one point per 1 m\textsuperscript{2} of production area. Two samples were taken at one point in parallel. For statistical processing of the results and identifying the changes dynamics in dust content in the air, at least three consecutive samples were taken with predetermined time intervals.

During the experimental study, the measurements inside the premises (during the working shift), in which hard and soft works were carried out, accompanied by dust emission, were taken.

The microscopic method was used to study the dust dispersed composition [4]. The technique was used with the help of computer programs Dust, SpotExplorer, PhotoShop for editing and presenting the obtained data, allowing to determine the different diameters particles size as a percentage. At the beginning of the pictures with a microscope were taken. After that, they were processed in a graphic editor. Only light and contrast settings were changed. Then the processed photos were loaded into the program and converted into points on a logarithmic grid. At the end of the whole process - an approximating line was drawn and the images of various processes of hard and soft works were superimposed on a single logarithmic grid.

By analogy with the studies of studying and presenting a dispersed composition, it was decided to visually present the study results in the particle diameters mass distribution integral functions form on a log-normal grid (Figure 1). Each function corresponds to a certain operation type during hard and soft works.

The disperse analysis results graphic image, presented in the particles mass distribution integral curves form over the diameter in Figure 1, shows that the dispersed composition of the dust generated during construction works is described by a log-normal distribution [5 - 7].
Figure 1. The particles mass distribution integral functions by diameter for dust generated during the hard and soft works: 1 - cleaning the walls; 2 - stroking; 3 - alignment of the walls after plastering.

Also, the dust concentration dependences on distance (Figure 2), particle size (Figure 3), room area (Figure 4) and working time (Figure 5) were experimentally obtained. The fine particles PM$_{10}$ PM$_{2.5}$ concentrations ratio is presented in the considered operations of hard and soft works (Figure 6). A general table of concentrations from each type of operation is summarized and the ratio of PM$_{2.5}$ to PM$_{10}$ is revealed (Table 1).

Figure 2. The concentration dependence of dust generated during hard and soft works on the distance from the place of operation: 1 - cleaning the walls; 2 - stroking; 3 - alignment of the walls after plastering.

The analysis, which showed that the dust concentration selected at different distances, decreases, can be explained by the particles’ aggregation into larger ones.
Figure 3. The concentration dependence of dust generated during hard and soft works on the particle size: 1 - cleaning the walls; 2 - stroking; 3 - alignment of the walls after plastering.

Figure 4. The concentration dependence of dust generated during hard and soft works on the floor space: 1 - cleaning the walls; 2 - stroking; 3 - alignment of the walls after plastering.

Figure 5. The concentration dependence of dust generated during hard and soft works on the time of the working process: 1 - cleaning the walls; 2 - stroking; 3 - alignment of the walls after plastering.
Due to the new warehouse complexes construction high rates, a new air pollution level is emerging. Starting from the soil development stage and ending with construction and installation work, accompanied, as a rule, by tremendous dust formation, in spite of the fact that these types of dust are of organic nature, they significantly affect the ecological situation.

**Table 1.** Concentration of PM10 and PM2.5 particles during building finishing works

| Operation no. | Operation type | Concentration, [mg / m$^3$] | The ratio of PM$_{2.5}$ to PM$_{10}$ [%] |
|---------------|----------------|-----------------------------|-----------------------------------------|
|               |                | Average | PM$_{2.5}$ | PM$_{10}$ |          |
| 1             | Grooving       | 1.72    | 0.0052     | 0.2924   | 0         |
| 2             | Plastering     | 1.52    | 0.0062     | 0.4464   | 0.003     |
| 3             | Stopping       | 1.24    | 0.023      | 1.2464   | 0.006     |

**Figure 6.** The fine dust particles concentrations PM$_{10}$ and PM$_{2.5}$, formed during the finishing and construction works: 1 - PM$_{10}$ concentration when cleaning walls; 2 — PM$_{2.5}$ concentration during wall cleaning; 3 — PM$_{10}$ concentration during grooving; 4 — PM$_{2.5}$ concentration during grooving; 5 - PM$_{10}$ concentration when leveling after plastering; 6 - PM$_{2.5}$ concentration when leveling after plastering.

Taking the dust high fine fractions percentage into account, it can be concluded that even at concentrations of suspended solids in atmospheric air corresponding to TLV, there is an excess of PM$_{10}$ and PM$_{2.5}$ concentrations according to Hygienic Rating 2.1.6.2604-10 [8]. Therefore, it is necessary to carry out the measures to improve the atmospheric air quality in the urban environment.

**Summary**

Various types of hard and soft works (cleaning walls, walling, leveling after plastering) are considered, and the particle size ranges during their technological process, which range from 1.5 microns to 30 microns, are determined.

The dust particles concentration dependences during hard and soft works on the distance from the place of work, on the dust particles size, on the room area, on the working process time were obtained.

It was determined that the dust highest concentration when cleaning the walls (18 mg / m$^3$) and the lowest when leveling after plastering (8 mg / m$^3$). At the same time, the fine dust share when cleaning the walls is less than when leveling after plastering.

The ratio of particle sizes D (PM$_{2.5}$) to D (PM$_{10}$) as a percentage was obtained and presented in graphical form.
An assessment of pollution and dust particles distribution during hard and soft works in warehouses was given.

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