MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

NATIONAL TECHNICAL UNIVERSITY
«KHARKIV POLYTECHNIC INSTITUTE»

METHODICAL INSTRUCTIONS

for laboratory work

"DETERMINATION OF DUST CONTENT OF

ATMOSPHERIC AIR"

for the discipline "Ecology"
for students of all specialties and all forms study

Kharkiv
NTU "KhPI"
2026

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

NATIONAL TECHNICAL UNIVERSITY
«KHARKIV POLYTECHNIC INSTITUTE»

METHODICAL INSTRUCTIONS

for laboratory work

"DETERMINATION OF DUST CONTENT OF

ATMOSPHERIC AIR"

for the discipline "Ecology"
for students of all specialties and all forms study

Approved by the editorial
and publishing department
protocol № 1 of 19.02.26

Kharkiv
NTU "KhPI"
2026

Methodical instructions for laboratory work "Determination of dust content of atmospheric air " in the discipline "Ecology" for students of all specialties and all forms of study/ compiled by L. A.Vaskovets, N. S. Yevtushenko, N.Ye. Tverdokhliebova – Kharkiv: NTU “KhPI”, 2026. – 50 p.

Compiled by: L. A. Vaskovets
N. S. Yevtushenko
N.Ye. Tverdokhliebova

Reviewed by S.O. Vambol

Department of "Occupational and environmental safety"

INTRODUCTION

Air quality characterizes the suitability of chemical, physical and biological factors of the air environment for the vital activity of living organisms. A change in the composition and properties of atmospheric air as a result of the entry or formation of physical, biological factors and (or) chemical compounds in it, which can adversely affect human health and the state of the natural environment, indicates its pollution and deterioration of quality [1].

The results of studies published in the European Heart Journal assure that in Europe the impact of various sources of atmospheric air pollution leads to 790 thousand additional deaths, of which 659 thousand deaths occur in the 28 countries of the European Union (EU) and 8.8 billion - worldwide. Studying individual countries, researchers found that air pollution causes additional mortality. The highest number of such cases (more than 200 per 100 thousand population) is in Bulgaria, Ukraine, Croatia and Romania (life expectancy (LE) in these countries is 3 or more years lower). In Germany – 154 thousand per 100 thousand population (LE – 2.4 years lower); in the UK – 98 respectively (LE – 1.5 years). The best air quality is in Norway, where the level of atmospheric pollution is significantly lower than the safety standards set by the WHO, which are stricter than the EU standards [2].

The European Alliance of Independent and Non-Governmental Organizations, Doctors, Environmentalists and Activists European Public Health Alliance (EPHA) has calculated the losses of residents of 432 EU cities due to air pollution. In total, they amount to €166 billion annually - an average of €1,276 per inhabitant. WHO experts emphasize the particular seriousness of health problems of residents of large cities due to air pollution with dust, especially fine particles. Today, most deaths are explained by the impact of microscopic dust with a diameter of less than 2.5 microns (PM2.5), which settles in the lungs and causes changes in the respiratory and circulatory systems. In 1990, about 1 million people died prematurely in Europe from its effects. According to forecasts, 70% of residents of European cities will live in areas where hygienic standards for dust are exceeded. The situation with atmospheric air pollution is also difficult in Ukraine. The pollution level of many cities of Ukraine is characterized by an increased content of suspended solid particles that enter the atmosphere during the combustion of organic fuels (coal and fuel oil), garbage at city landfills, industrial production, construction of structures and transport roads [6].

From stationary sources of pollution into the atmospheric air of Ukraine in 2018–2019, 316–310 thousand tons of solid particles entered the atmospheric air. Of these, microscopic dust with a diameter of more than 2.5 microns and less than 10 microns – 54–66 thousand tons, with a diameter of less than 2.5 microns – 24–2.5 thousand tons, soot – 5.9–5.8 thousand tons [3, 4].

To determine the danger of dust pollution of atmospheric air to human health and the environment, the concentration of suspended solid particles is measured in it. For this purpose, various methods and devices are used that take into account the dispersion of these particles.

Purpose of work – to get acquainted with the principles of assessing dust pollution of atmospheric air, methods and devices for measuring its levels; to master the weight method of determining air dustiness; to conduct an experimental determination of dust content in the air.

The terms used in the work and their definitions are given in Appendix A.

1. AIR QUALITY CRITERIA AND FACTORS DETERMINING THE DEGREE OF HARMFULNESS OF AEROSOL AIR POLLUTION

Dust is one of the most common atmospheric pollutants, along with nitrogen and sulfur dioxides, carbon monoxide, and hydrocarbons.

Dust – these are solid particles of various substances ranging in size from micron particles to tenths of a millimeter, which are capable of remaining suspended in the air for a long time. An aerodynamic dispersed system in which the dispersed medium is air and the dispersed phase is dust particles is called an aerosol.

By size, dust particles are classified into visible to the naked eye (over 10 microns), microscopic (0.25–10 microns) and ultramicroscopic (less than 0.25 microns).

By dispersion, the following size fractions of microscopic particles are distinguished:

PM_{10} – particles with an aerodynamic diameter of less than 10 µm;

- $PM_{2,5}$ – particles with an aerodynamic diameter of less than 2.5 µm;
- PM_1 – particles with an aerodynamic diameter of less than 1.0 µm;
- coarse fraction – size fraction between 2,5 i 10 µm;
- • nanoparticles – particles with an aerodynamic diameter less than 0,1 µm.

«PM_{10}» denotes particulate matter passing through a size-selective air sampler as defined in the reference method for the sampling and measurement of PM_{10} with a 50 % retention efficiency at an aerodynamic diameter of 2.5 mm according to EN 12341 [7].

«$PM_{2,5}$» denotes particulate matter passing through a size-selective air sampler specified in the comparative method for the sampling and measurement of $PM_{2,5}$ with a 50% retention efficiency at an aerodynamic diameter of 2.5 mm according to EN 12341 [7].

In a calm air environment, large dust particles (10–100 μm) settle quickly. Particles up to 0.1 μm practically do not settle and are in a state of constant Brownian motion and are able to spontaneously connect with each other.

Suspension in the air of solid particles with a size of 0.1–100 μm, depending on its composition and concentration, has various types of adverse effects on the human body [8]. As shown by domestic and foreign studies, dust particles with a diameter of 10–100 μm are retained in the upper respiratory tract, dust with a size of 5 μm and below can penetrate the deep respiratory tract, causing pathological changes in the respiratory system and allergic reactions.

The degree of harmful effects of dust depends on its physicochemical properties (dispersity, chemical composition, solubility, shape and structure of particles, electrical charge and radioactivity).

Fine dust of the fraction is considered the most dangerous for human health. $PM_{2,5}$. The consequence of its influence is pulmonary and cardiovascular pathologies. Among the most common chemical components $PM_{2,5}$ Among them are sulfates, nitrates, ammonia, other inorganic ions (sodium, potassium, calcium, magnesium, chlorine ions), as well as organic and elemental carbon, bound water, various metals, and polycyclic aromatic hydrocarbons, including benzo(a)pyrene [8, 17]. In the composition $PM_{2,5}$ biocomponents, including allergens and microorganisms, are also found [8]. Elevated concentrations $PM_{2,5}$ lead to pulmonary dysfunctions, chronic inhibition of lung development, long-term pulmonary insufficiency, lung cancer, cause asthma and allergic reactions, and exacerbate cardiovascular diseases. In general, on a global scale, due to the impact $PM_{2,5}$ account for approximately 3% of deaths from cardiovascular and respiratory diseases and 5% of deaths from lung cancer [8].

By nature, dust is divided into organic, inorganic and mixed. Organic dust can be natural (e.g., coal) and artificial (e.g., toxic chemicals). Inorganic dust can be mineral (e.g., sand) and metallic (e.g., lead). Most often, mixed dust is present in the atmospheric air. From enterprises with harmful production, in the event of malfunction or inefficient operation of gas emission cleaning units, dust of a specific nature may enter the air. In Ukraine, gas cleaning units are particularly poorly operated (up to 15% of those surveyed) at enterprises of the energy, machine-building, metalworking, light, textile, processing industries and the agro-industrial complex.

Sources of atmospheric dust pollution are divided into natural (volcanic eruptions, dust storms, forest and steppe fires, etc.) and anthropogenic (fuel combustion in industrial and household installations, production activities of enterprises of ferrous and non-ferrous metallurgy, coal and chemical industries, building materials, cement, enrichment factories of the mining and metallurgical complex, elevators, waste incinerators, etc.). The air is polluted with rubber dust from car and aircraft tires. In Ukraine, the main atmospheric dust pollutants are enterprises of the fuel and energy complex - 56%.

The main criterion for atmospheric air quality is maximum permissible concentrations (MPC, mg/m^3) pollutants in the atmospheric air. For hygienic assessment of the level of dustiness of the atmospheric air, the following MPC standards are used: ***maximum single maximum permissible concentrations*** (MPCm.r***) and average daily maximum permissible concentrations*** (MPCs.d) ***of dust content.***

In the case of an established chemical composition of dust, its content in the air should not exceed the values of MPCm.r, MPCs.d of pollutants regulated in the regulatory document “Hygienic regulations. Maximum permissible concentrations of chemical and biological substances in the atmospheric air of populated areas”, approved by the order of the Ministry of Health of Ukraine dated January 14, 2020 No. 52. The maximum permissible concentrations of dust in accordance with this regulatory document are given in Appendix B..

In cases of determination ***undifferentiated dust composition*** (aerosol) it is allowed to take the value of its maximum single-time MAC – ***0,5 mg/m^3***, average daily – ***0,15 mg/m^3***, 3rd hazard class; these values do not apply to aerosols of organic and inorganic compounds (metals, their salts, plastics, biological, medicinal products, etc.), for which appropriate MPCs are established.

Thus, *the dust factor is assessed by comparing the obtained values of single and average daily dust concentrations with the maximum permissible concentrations (MPC,mg/m^3)*, established by the regulatory document "Hygienic regulations. Maximum permissible concentrations of chemical and biological substances in the atmospheric air of populated areas", approved by the order of the Ministry of Health of Ukraine dated 14.01.2020 No. 52 [9].

In order to ensure the collection, processing, storage and analysis of information on the quality of atmospheric air, assessment and forecasting of its changes and the degree of danger, development of scientifically based recommendations for making management decisions in the field of atmospheric air protection, in the field of environmental protection, as well as informing the population about the quality of atmospheric air, the impact of its pollution on the health and vital activity of the population, state monitoring in the field of atmospheric air protection is carried out. Atmospheric air monitoring is an integral part of the state system of environmental monitoring. The procedure for conducting state monitoring in the field of atmospheric air protection was approved by the resolution of the Cabinet of Ministers of Ukraine dated August 14, 2019 No. 827 [10].

Atmospheric air monitoring is carried out based on air quality indicators and precipitation.

The Ministry of Environmental Protection and Natural Resources of Ukraine (MEP) is responsible for the overall organization and coordination of air monitoring activities. The Ministry of Health of Ukraine (MOH) establishes monitoring points and monitors pollutant levels; determines the possible impacts of air pollution on the health and livelihoods of the population.

The mandatory air quality monitoring program includes seven pollutants: dust, nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide, formaldehyde (H_2CO), lead and benzo(a)pyrene. Some stations monitor additional pollutants.

Air monitoring for dust content in Ukraine is carried out in 53 cities of Ukraine at 162 stationary, two route observation posts and two transboundary transfer stations. Observations of the total mass concentration of atmospheric dust are mandatory. Studies on air pollution by fine dust fractions, including $PM_{2,5}$, are at the initial stage in Ukraine. According to the Procedure for State Monitoring in Ukraine, particulate matter has been included in List A of the list of pollutants for which assessment and assessment of atmospheric air quality is carried out (TP_{10}) and in 24 hours solid particles ($TP_{2,5}$). The average value should be determined TP_{10} in 24 hours, average value TP_{10} per year, average value TP $_{2,5}$ per year. The standards for these indicators are presented in Table 1.

Table 1 – Standards for the content of solid particles in atmospheric air (TP_{10}/$TP_{2,5}$) by [10].

Evaluation threshold	**Average value TP_{10} in 24 hours**	**Average value TP_{10} per year**	**Average value $TP_{2,5}$ per year**
Upper	70 percent of the limit value (35 µg/ m^3) shall not be exceeded more than 35 times in any calendar year)	70 percent of the limit value (28 mg/m^3)	70 percent of the limit value (17 mg/m^3)
Lower	50 percent of the limit value (25 µg/ m^3shall not be exceeded more than 35 times in any calendar year)	50 percent of the limit value (20 mg/m^3)	50 percent of the limit value (12 mg/m^3)

The assessment of air pollution levels and their risks to public health in almost all countries is carried out using the Air Quality Index (AQI). AQI is a numerical value of the air pollution level, which is used to inform the public about the level of air pollution. AQI was developed by the United States Environmental Protection Agency (EPA), which was used to report on air quality. This index is divided into six categories that indicate an increase in the level of health [11–14].

The AQI air quality index is divided into levels, each level has its own description and characteristics, color code and standardized information message about the impact on public health. When the air quality index exceeds 100, the population receives a warning about possible health effects. The AQI value and its level assessment are given in Table 2.

Table 2 – Assessment of ambient air quality for human health by AQI

Air Quality Index	**Health hazard levels**	**Colors**
Від 0 to 50	Good	Green
51 to 100	Moderate	Yellow
101 to 150	Harmful to sensitive groups	Orange
151 to 200	Harmful	Red
201 to 300	Very harmful	Violet
301 to 500	Dangerous	Burgundy

Air quality is characterized by the AQI level as follows:

– 100 to 150 (yellow) – air quality is acceptable; however, there may be moderate health impacts for some people who are extremely sensitive to air pollution. Active children and adults, as well as people with respiratory conditions such as asthma, should limit prolonged outdoor exposure;

– 151–200 (orange) – air quality is unhealthy for sensitive populations who may experience health impacts. The population is unlikely to be affected. Active children and adults, as well as people with respiratory conditions such as asthma, should limit prolonged outdoor exposure;

– 201–250 (red) – everyone may begin to experience health impacts; and members of sensitive groups may experience more serious health effects, and people with respiratory conditions such as asthma should avoid prolonged outdoor activity; everyone else, especially children, should limit prolonged outdoor activity;

– 251–300 (purple) – very unhealthy air quality, health emergency warning required. The entire population is likely to be affected. Active children and adults, as well as people with respiratory conditions such as asthma, should avoid any outdoor activity; everyone else, especially children, should limit outdoor activity.

– 301 and above (burgundy) – hazardous air quality. Mandatory health warning – everyone may experience serious health effects. Everyone should avoid any outdoor activity. Wearing a respirator is recommended to prevent fine particles from entering the lungs.

The air quality index is calculated over a certain average period (usually 8, 24 and 48 hours). Data is obtained from gas analyzers of the air quality monitoring system. This takes into account the concentration and time of distribution of pollutants in the atmosphere. The health effect of a specific amount of pollution. The air quality index takes into account the concentrations of substances such as ozone (O3), sulfur dioxide (SO2), nitrogen dioxide (NO2) and fine particulate matter particles PM_{10} and $PM_{2,5}$ [12–14].

The AQI is used in many countries, but has its own national characteristics. The air quality index used in the UK is the Daily Air Quality Index, proposed by the Committee on the Health Effects of Air Pollutants [13] This index consists of ten items, which are grouped into 4 groups: low, moderate, high and very high. Each group has recommendations for the general population and risk groups. In Singapore, the Pollutant Standards Index (PSI) is used to describe air quality. In Europe, the Common Air Quality Index (CAQI) is used to describe air quality.

There is no automatic atmospheric monitoring station in the state environmental monitoring system of Ukraine. Instead, a public air quality monitoring system is being actively implemented in Ukraine - about 400 automatic Eco-City and SaveDnipro stations are constantly operating, which measure the concentration of fine dust online and constantly measure all major pollutants, including ozone, ammonia, and background radiation.

Real-time air quality, which is studied at more than 10 thousand stations around the world, can be tracked in real time on an interactive map [15]. The air quality monitoring map can also be installed on a mobile phone. Fig. 1–2 shows an example of an atmospheric air quality monitoring map and atmospheric air quality indices of different countries.

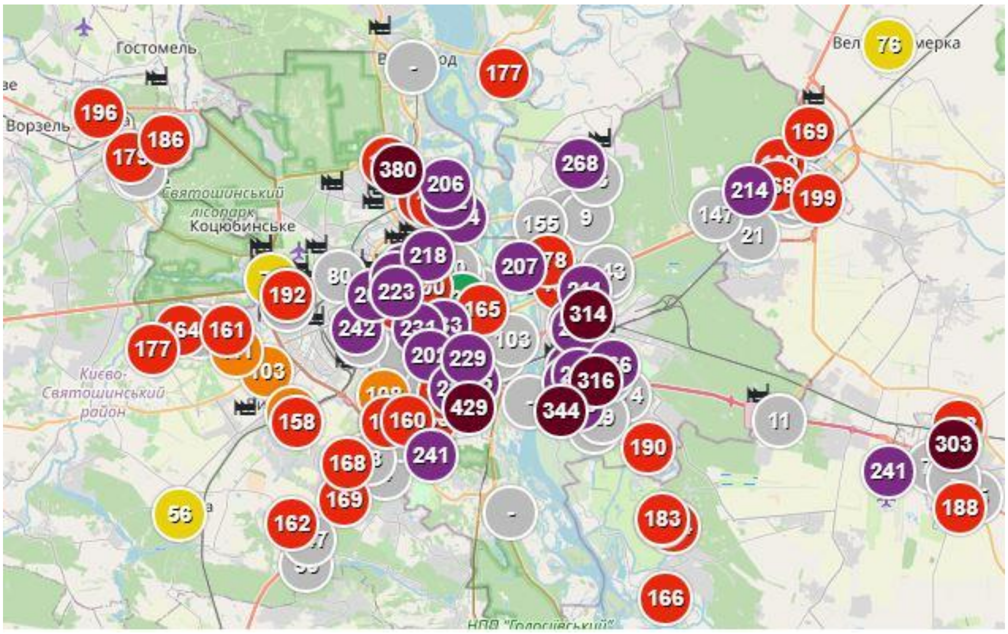

Figure 1 – State of atmospheric air in Kyiv [16]

#	Country	Population	US AQI
1	Bangladesh	166'368'149	165
2	Pakistan	200'813'818	156
3	Mongolia	3'121'772	154
4	Afghanistan	36'373'176	153
5	India	1'354'051'854	152
6	Indonesia	266'794'980	141
7	Bahrain	1'566'993	129
8	Nepal	29'624'035	123
9	Uzbekistan	32'364'996	115
10	Iraq	39'127'900	111
60	**Ukraine**	44'009'214	60

Figure 2 – Air quality indices of different countries [11]

У країнах Європи і США в основу моніторингу за вмістом пилу і відповідного нормування якості повітря покладено визначення рівнів дрібнодисперсних фракцій, які становлять найбільшу небезпеку для здоров’я людини. Нормативні вимоги до вмісту завислих речовин у повітрі представлено в табл. 3.

Table 3 Maximum permissible dust concentrations of fractions PM_{10} and $PM_{2,5}$ in atmospheric air [8]

Pollutant	**Averaging time**	**Maximum permissible (threshold) concentration, μg/m^3**		
		EU	**WHO**	**Ukraine**
Total suspended solids (TSP)	20 minutes	–	–	500
	24 hours	–	–	150
Suspended matter size	24 hours	50	50	–

<10 microns (PM_{10})	year	40	20	–
Suspended matter size <2.5 microns ($PM_{2,5}$)	24 hours	–	25	–
	year	20	10	–

In Ukraine, hygienic standardization affected only the total content of suspended solids in the air (TSP). The MPC of dust is standardized in the Hygienic Regulations [9]. This includes the entire set of suspended particles up to 500 microns in size without dividing them into fractions, which does not allow assessing the quality of air polluted with fine dust. This was emphasized [8]. At the same time, suspended substances are differentiated only by chemical composition (asbestos-containing dust, cotton, grain, kainite-cement, etc.). In cases of determination of dust not differentiated by composition, it is generally allowed to take the value of its MPC as the maximum single – 0,5 mg/m^3, average daily – 0,15 mg/m^3.

At the same time, in the USA and EU countries there is a fractional rationing of fine dust. Special attention is paid to the fraction $PM_{2,5}$. The hygiene standards revised by WHO in 2005 include the following values:

for $PM_{2,5}$: average annual concentration (ГДКс.р) 10 mg/m^3, середньодобова (ГДКс.д) 25 м mg/m^3 (its excess should not last more than 3 days per year);

•for PM_{10}: средньорічна концентрація (ГДКс.р) 20 mg/m^3, середньодобова (ГДКс.д) 50 mg/m^3 [17].

The assessment of PM2.5 pollution levels according to the international scale of risk to public health based on the Air Quality Index (AQI) proposed by the European Environment Agency (EEA) is given in Table. 4 [8].

Table 4 – Scale of air pollution level by fine dust fraction $PM_{2,5}$

Suspended particles < 2.5 µm ($PM_{2.5}$), µg/m^3	Air pollution level / Risk to public health
1-10	Good
10-20	Fair
20-25	Moderate
25-50	Poor
50-75	Very poor
75-800	Extremely poor

Data on the mass concentration of PM2.5 in the air of different countries of the world can be obtained from the open online monitoring platform “Air Pollution” (Fig. 3).

In May 2008, Directive 2008/50/EC “On ambient air quality and cleaner air for Europe” was adopted [18]. The purpose of the Directive is to define framework requirements for the monitoring and assessment of ambient air quality. It presents the values of limit concentrations of pollutants, as well as fine dust (PM_{10}, $PM_{2,5}$) and those that should be achieved in the future. The main limit values for the protection of public health are as follows: for PM_{10} average annual – 40 mg/m^3, 24-hour limit value – 50 mg/m^3, cannot be exceeded more than 35 times during a calendar year; for $PM_{2,5}$ target value and limit value for stage 1 – annual average –25 mg/m^3; для $PM_{2,5}$ threshold value for stage 2 — annual average – 20 mg/m^3 [19].

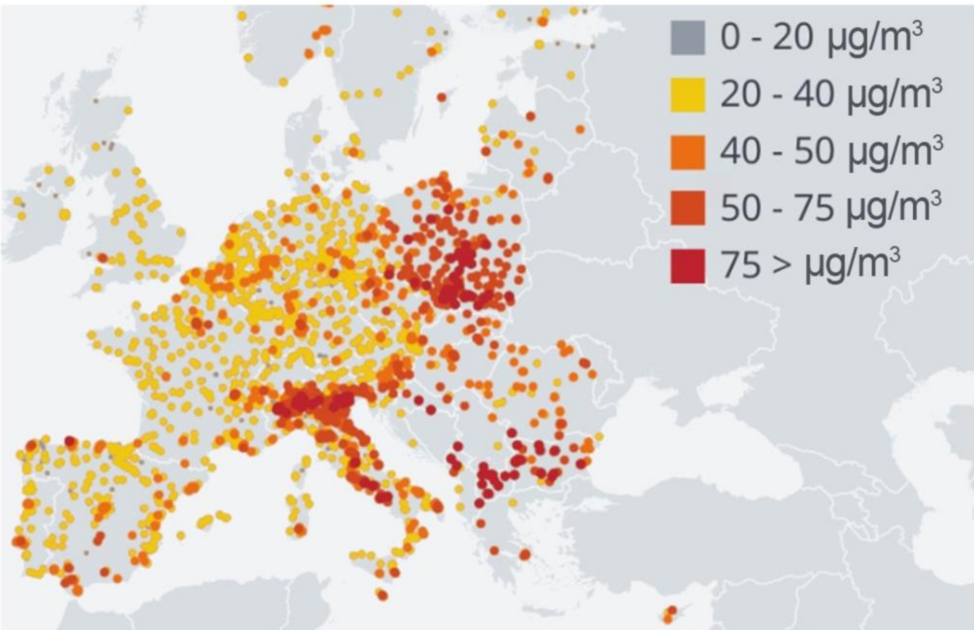

Figure 3 – European air pollution by fine particles
(according to the European Environment Agency, 2018) [11]

To establish the fact of atmospheric air pollution, it is necessary to determine the dust concentrations in the surface layer of the atmosphere (at a height of 1.5 to 2.5 m from the earth's surface). Based on the obtained values of dust concentrations, a conclusion is made about the level of pollution and the degree of its danger to human health.

Observation of the level of atmospheric air pollution is carried out at posts. A post is a place on the ground where a pavilion or a car is located, which are equipped with appropriate devices. There are three categories of posts: stationary, route and mobile (under the flare) (Fig. 4–5). A stationary post is designed to ensure continuous registration of the content of pollutants or regular sampling of air for subsequent analysis. A route post is designed for regular sampling of air when it is impossible (impracticable) to install a stationary post. Mobile (a post designed for sampling under a smoke flare in order to establish the impact of a pollution source on the environment (Fig. 4).

Figure 4 – Mobile environmental monitoring laboratory

To ensure optimal conditions for stationary observations, domestic industry produces standard observation pavilions or complete laboratories of the "POST" type. The mobile post is represented by the "Atmosphere II" laboratory.

Figure 5 – Air quality monitoring stations [20–22]

The POST laboratory is a warmed pavilion, which houses sets of instruments and equipment for air sampling and meteorological measurements.

The POST-1, POST-2 and POST-2a laboratories are produced, the latter being distinguished by higher sampling performance and degree of automation.

At stationary stations, monitoring of atmospheric air pollution and meteorological parameters is carried out all year round, in all seasons, regardless of weather conditions. As a rule, three monitoring programs are established for monitoring stations: full, incomplete and reduced. According to the full program, observations are carried out daily (weekends - Sundays, Saturdays - alternately) at 1, 7, 13 and 19 hours. Observations according to the first program involve measuring the content in the air of both basic, secondary and specific pollutants. Under the partial program, observations are conducted daily (Sundays and Saturdays alternate), but only at 7 a.m., 1 p.m., and 7 p.m. [23].

The measuring complex "POST-1" provides the following operations: simultaneous sampling of up to 6 air samples for various gas impurities; sampling of air for dust and soot; measurement of basic meteorological values.

"POST-2" provides automatic measurement and recording on a chart tape of concentrations of carbon monoxide and sulfur dioxide; automatic sampling of 33 air samples for determining 5 gaseous impurities, soot and dust; manual sampling of 5 air samples for determining the content of gaseous impurities, soot and dust; automatic measurement of meteorological parameters.

For sampling of air for dust and soot, two sampling blocks are used, each of which includes a filter holder for a dust filter and a cartridge for a soot filter. The blocks are inserted into the laboratory hatch, which is selected depending on the wind direction. To draw air through the soot cartridges, an EA-1 electric aspirator is used, and through the filter holders, an EA-2 electric aspirator is used.

The mobile laboratory "Atmosphere II" is designed for mobile monitoring of the state of atmospheric air in cities and industrial facilities, as well as for monitoring the spread of harmful substances from industrial sources.

The measuring complex of the laboratory "Atmosphere II" is mounted in the body of a UAZ-type van and provides the following operations: simultaneous sampling of up to four to six air samples for the necessary gas impurities; sampling of air for dust and soot; instrumental analysis of the content of four ingredients in atmospheric air: sulfur dioxide, hydrogen sulfide, ozone and chlorine; measurement of basic meteorological indicators.

2. DUST DETERMINATION METHODS, MEASURING DEVICES AND EQUIPMENT

2.1. Methods for measuring air dust content

Hygienic assessment of dustiness of the air environment includes quantitative and qualitative characteristics of dust.

Quantitatively, dustiness can be assessed by the mass of dust present in the air, or by the number of dust particles per unit volume of air. Qualitative characteristics of dust are given on the basis of studying its chemical properties, dispersion (ratio of particles of different sizes), and shape of dust particles.

Hygienic assessment of dustiness of atmospheric air is based on determining the mass concentration of dust (mg/m^3), its chemical and dispersed composition, concentration characteristics of fractions PM_{10}, and $PM_{2,5}$.

Methods for measuring air dust are divided into two groups:

•• methods based on ***on preliminary particle deposition*** and sediment research (weight or gravimetric method), radioisotope, optical; method based on dust capture with water; method that records pressure changes on the filter, etc.);

•• methods ***without prior particle deposition*** (acoustic, optical, electrical, etc.).

• The advantages of the methods of the first group include the possibility of quantitative measurement of the mass concentration of dust. The main disadvantages are the cyclical nature of the measurements, laboriousness, low sensitivity and the duration of obtaining the result.

The main advantages of the methods of the second group are the possibility of direct measurements of the concentration of dust in the air without using a sampling device, continuity of measurements, high sensitivity, practical inertialessness, the possibility of full automation of the measurement process. The disadvantages of the methods of this group include the possibility of the influence of changes in the dispersed composition and other properties of dust on the measurement result.

Let us consider the methods most often used to determine the levels of dust content in atmospheric air.

Gravimetric (weight) method. Today it is the main method of analyzing atmospheric air for the mass concentration of dust in the air without division into fractions. This method is standard in many countries. Thus, the ASTM D4096 – 17 Standard Test Method for Determination of Total Suspended Particulate Matter in the Atmosphere (High–Volume Sampler Method) is widely used. Standard test method for determining the total amount of suspended solid particles in the atmosphere (high-volume sampler method). Mandatory for use in Ukraine is DSTU EN 12341:2018 (EN 12341:2014, IDT) Atmospheric air. Standard gravimetric method for measuring the mass concentration of aerosol particles PM_{10} or $PM_{2,5}$.

In sanitary and hygienic practice, the gravimetric method is used to determine single and average daily concentrations of suspended dust particles in the air of settlements and sanitary protection zones of industrial enterprises in the range 0,04–10 (mg/m$^{3)}$. The essence of this method is to determine the mass of suspended dust particles retained by a special filter when a certain volume of air passes through it. This method allows you to measure the mass concentration of dust without the influence of its chemical and dispersion composition on the results of the research. But it is very time-consuming, does not allow you to organize continuous monitoring.

The deposition of dust particles can be carried out in various ways, but most often a sample of dusty air is drawn through the filter using an aspirator.

To determine the mass concentration of dust by the weight method, the following is used:

EA-2 electric aspirator (error □ 6%) or EA-2S or EA-2SM electric aspirator (error 5%) for measuring dust concentrations in the ranges of single and average daily concentrations of 0.007 - 50 mg/dm3 and EA-3 electric aspirator - in the range of concentrations of particles suspended in atmospheric air 0,4–150 mg/dm^3;

•• filters made of compacted pressed fabric FPP-15 with a working surface diameter of 69.4 mm and filters AFA-VP-20 with a degree of aerosol particle retention of at least 95% for measuring dust concentrations in the ranges of single and average daily concentrations 0,007–50 mg/dm^3 and FPP-15-1.5 and AFA-KHP(VP)-160 in the range of concentrations of particles suspended in atmospheric air 0,4–150 mg/dm^3;

- scales VLA-200;
- mass measures;
- anemorumbograph M-63MR;
- aneroid barometer M-67.
- desiccator;

- glass cups with a diameter of 5 and 10 cm;
- •tweezers with plastic tips.

After the dust is retained on the filter when a certain volume of dusty air is passed through it, it is dried in a desiccator to a constant mass and weighed on an analytical balance. Knowing the mass of the filter before and after sampling, it is possible to determine the dust content in a unit volume of air by the formulaрези ВЛА-200;

• mass measures;

• anemorumbograph M-63MR;

• aneroid barometer M-67.

• desiccator;

• glass cups with a diameter of 5 and 10 cm;

• tweezers with plastic tips.

After the dust is retained on the filter when a certain volume of dusty air is passed through it, it is dried in a desiccator to a constant mass and weighed on an analytical balance. Knowing the mass of the filter before and after sampling, it is possible to determine the dust content per unit volume of air by the formula

$$C = (P_1 – P) / V_0, \qquad (2.1)$$

where C – вагова концентрація пилу, mg/m^3;

P_1 – маса фільтра після відбору проби, мг;

P – маса фільтра до відбору проби, мг;

V_0 – об’єм повітря, що пропускається через фільтр, приведений до нормальних умов, тобто до такого об’єму, який він займав би при температурі 0 °С і тиску 760 мм рт. ст., m^3

Об’єм повітря при нормальних умовах розраховують за формулою

$$V_о = V_t \cdot 27 \cdot Р_б / (273 + t) \cdot 760, \qquad (2.2)$$

where V_t – volume of air drawn in at temperature t and pressure *B*, m^3;

$P_б$ – barometric pressure at the sampling location, mm Hg;

t – air temperature at the sampling location, °C.

Radioisotope method. This method is based on the physical properties of ionizing radiation to be absorbed by dust particles. The mass of dust is determined by the degree of attenuation of ionizing radiation when it passes through a layer of concentrated dust.

Despite the fact that the measurement error by this method can reach 15% and it has less sensitivity than the weight method, it allows its use in automatic atmospheric air control systems.

Optical methods. This group includes:

– photometric method, which is based on measuring the optical density of a dusty stream by the degree of light scattering;

– absorption method, which is focused on the absorption of light during its passage through dusty air. It allows you to determine the concentration of suspended particles quite accurately without prior air sampling. The main disadvantage of this method is its low sensitivity to low concentrations of aerosol particles, as well as the inability to use it to measure too high concentrations.

Piezoelectric method. It is divided into two options:

– measurement of the frequency of oscillations of a piezoelectric crystal when dust is deposited on its surface (the mass concentration of dust is determined) – the piezo-balance method;

– counting of electrical pulses when dust particles collide with a piezoelectric crystal (the number of particles is counted).

The piezo-balance method was first implemented by the KANOMAX company in a respiratory aerosol analyzer for monitoring dust at a concentration of 0.01–10 mg/m^3. It is an improved weighing method. The principle of operation of devices implementing this method is that samples of aerosol particles, taken periodically, pass through an impactor, which separates respiratory (up to 10 μm) fractions from the total mass of particles and transfers them to an electrode – a piezoelectric element (quartz).

Electrical methods. They are divided into induction, contact-electric and capacitive. These methods are used in dust meters to measure aerosol concentrations directly in the air environment. However, the accuracy of measurements is affected by meteorological parameters and physicochemical properties of dust, changes in its dispersion over time.

Counting method. It allows you to determine the total number of dust particles per unit volume of air and the ratio of their sizes. The study can be performed using:

• microscopes - visual determination of the number and size of dust particles;

• photoelectric counters (AZ-5), which register the number and size of dust particles in the air stream due to the effect of light scattering. AZ-5 provides the ability to measure the dispersed composition of particles with a diameter of 0.4–10 microns, as well as their total number;

• various dust particle counters (for example, the KORNO GT-1000-JM(FC) dust meter).

For microscopic study, dust contained in a certain volume of air is first deposited on a glass slide. For this purpose, sedimentators can be used, which deposit dust particles on glass for subsequent counting under a microscope. The glass slide is first covered with any adhesive substance (glycerol, petroleum jelly, 2% solution of Canada balsam in xylene, or transparent adhesive tape). Then, under a microscope, the number of particles is counted, their size and shape are determined. But this method is very time-consuming and requires special qualifications of the researcher and therefore is not used for mass analysis of atmospheric air pollution.

Dust control can be ***periodic*** (short-term single measurement of dust concentration) or ***permanent***, carried out using automatic devices and systems or individual dust meters.

Sawmills are devices for determining the concentration and/or dispersion composition of solid aerosol particles suspended in atmospheric air. They can be used to estimate average daily values of air dust levels.

Depending on the purpose of the measurements, the maximum single and average daily dust concentrations are determined by the mass of particles (all particles in the air) or the number of particles per unit volume of air. For this purpose, instruments and devices are used, the action of which is based on optical, electrical, radioisotope and other methods. Automatic systems with remote information transmission have been developed.

Dust meters can be divided according to the method on which their operation is based (gravimetric; optical, radioisotope, electrometric, acoustic, combined, etc.), into stationary and portable, by the period of operation (periodic and continuous), by the field of application, etc.

Today, a large number of airborne particle meters are offered on the Ukrainian instrument market, which implement various methods and modes of environmental environmental control.

Dust meters that determine the mass concentration of dust include the Atmas dust meter (Fig. 6).

Figure 6 – Sawdust meter "Atmas" [24]

Sawdust meter "Atmas is intended for express and inspection measurements, continuous monitoring of the mass concentration of dust of various origins and chemical composition in atmospheric air. It can be used for sanitary and hygienic, technological control in field conditions. The principle of operation of the particle meter is based on the charging of dust particles in the corona discharge field, which is created by a high-voltage electrode and their subsequent deposition on the surface of the dust sensor, which uses a quartz piezoelectric element. During the deposition of dust particles on the surface of the sensor, its oscillation frequency changes, which is proportional to the mass of dust. This device implements a direct method - it directly measures the mass concentration. It does not require correction of the conversion factor for different dust compositions. It has a computer module that allows you to present the measurement results and store them in a convenient form, transfer data to a flash memory or to a personal computer (USB port). The touch-sensitive color liquid crystal display provides the display of measurement results on the screen in the form of tables and graphs

The mass concentration of dust in atmospheric air is determined by *CEL* 712 *Microdust Pro* meter. Producer: *Casella Measurement* (Great Britain) (Fig. 7). This is a portable device for recording aerosol particles in the air in real time at a concentration 0,001–250 g/m^3 in field conditions. Continuous gravimetric measurements are carried out using a special pump. To obtain data on the concentration of particles with a size $PM_{10}/PM_{2,5}$ special filters are used *PUF*. *CEL* 712 *Microdust Pro* Equipped with a color display with a graphical data presentation function.

The group of gravimetric devices includes the automatic system of the model *ExplorerPlus (Zambelli,* Italy) [26]. It is used in monitoring atmospheric air with a high content of suspended particles. It can operate continuously for 16 days by automatically replacing filters. It is equipped with a liquid crystal display and a control unit with a built-in thermal printer. The information obtained can be transmitted to *PC*. Improved system *ExplorerPlus* presented in fig. 7.

a) б)

Figure 7 – Devices for recording aerosol particles in the air: a) dust analyzer *CEL*-712 *Microdust Pro* [25]; б) automatic model system ExplorerPlus (Zambelli, Italy) [26]

Mass dust meters include most radioisotope automatic dust analyzers. The measurement of the concentration of solid particles occurs by the increase in the mass of the sediment on the filter, during which radiation of a certain wavelength is transmitted through the filter with dust and the subsequent determination of the degree of its absorption. Continuity of operation is achieved by using moving belt filters.

Radioisotope method of measuring dust concentration, which is based on the ability of dust particles to absorb radioactive radiation (usually β- radiation) implemented, for example, in radioisotope stationary dust meters for monitoring dust in the atmosphere «*MPSI*-100», *MP* –101*P*» («*Environment*», France), «*F*–701» («*VEREWA*», ФРН). Structurally, radioisotope dust meters consist of a sampling device, a radioactive radiation source and a radiation receiver. The operation of these devices consists in pumping a certain volume of air through a filter tape with the subsequent determination of the thickness of the dust deposit by the degree of attenuation of β-radiation during its passage through a layer of accumulated dust. The dust concentration is calculated from the results of measurements on the filter before and after sample application [27]. Dust analyzer *Thermo ScientificTM* 5014*i-Beta* performs measurements using beta particle absorption technology (Fig. 8).

a) б)

Figure 8 – Radioisotope dust analyzers: a) – dust analyzer *Thermo ScientificTM* 5014*i-Beta* [28]; б) – dust analyzer *Verewa* models F-701-20 [29]

It allows continuous measurements of airborne particles PM_{10} and $PM_{2,5}$. Works in concentration ranges: 0–100, 1000, 2000, 3000, 5000, 10000 mcg / m^3. The source of radiation is carbon (C_{14}), < 3.7 MBq (< 100 mKi). During measurements, simultaneous fixation of air mass and volume is used. Concentration data is recorded in the device's memory.

The principle of operation of the dust analyzer *Verewa* model F-701-20 radioisotope, based on the absorption of β - radiation by dust particles deposited on a filter tape. Source of β - radiation isotope C^{14}. The measurement of the absorption value is carried out by a built-in Geiger-Muller counter. Allows for measurements of the mass concentration of dust in the air (TSP), as well as, when equipped with impactors for the separation of fine dust fractions - particle concentrations PM_{10} and $PM_{2,5}$). Dust mass concentration measurement ranges (TSP, PM_{10}, $PM_{2,5}$) 0,02–1,0/0,02–10 mg / m^3 (Fig. 8).

More complex devices are optical dust meters, which operate on the principle of absorption or scattering of light that has passed through a layer of dusty air. In the case of absorption, a beam of light attenuated by dust particles hits a photodetector and is compared with the beam on another photodetector - a control one.

Sawmill 7bit Pollution Monitor designed for measurements of mass concentration of aerosol particles with separation into fractions $PM_{1.0}$, $PM_{2.5}$, PM_{10}. (Fig. 9).

The results are transmitted via an Internet communication channel *Wi-Fi* into an automatic monitoring system *www.air-pollution.ml*. The dust meter is designed for a data collection network within the framework of the public air pollution monitoring system. The measurement principle is optical (operates on the principle of scattered light). Particle measurement range $PM_{2,5}$ 0–500 mcg / m^3.

Air pollution monitor APM-2 – particulate monitor for continuous measurement $PM_{2.5}$ and PM_{10} in real time (Fig. 9).

It uses the nephelometric method as an equivalent to the gravimetric method. The measurement method is based on a highly sensitive scattered light sensor. The light is emitted by a stabilized laser diode. Measuring range of dust concentrations 0–1000 mcg/m^3). Designed for measuring dust fractions $PM_{1.0}$ (0,3–1 microns), factions $PM_{2,5}$ (1–2,5 microns), factions PM_{10} (2,5–10 microns). Data transfer via Wi-Fi network. Weight 320 g.

a) б)

Figure 9 – Sawmills: a)– 7*bit Pollution Monitor* [30]; b) – air pollution monitor *APM*-2 [31]

Air quality analyzer KORNO GT-1000-JM3 – multifunctional portable gas and dust concentration meter that can contain up to 5 gas sensors or 3 gas sensors plus 1 dust sensor. The device can investigate dust particles of size 0,3/0,5 microns, 1,0 microns, 2,5 microns, 10 microns using a laser sensor. The air quality analyzer simultaneously determines the temperature and humidity of the environment being examined (Fig. 10).

KORNO GT-1000-JM3 Equipped with a waterproof and dustproof housing design with IP66 protection class and a 3.5 inch IPS color LCD display for high-quality readings from any angle. Automatic and manual storage of up to 154,000 groups of data is available, and the user can also view the reading data on the display. The data can be exported to a computer for viewing and saving in graphic format or Excel format (Fig. 10).

Figure 10 – Air quality analyzers: a)– *KORNO GT*-1000-*JM*3 [32];
б) – *DT*-9880 [33]

Air quality analyzer *KORNO GT*-1000-*JM*3 used in production, in office premises, in places where people stay for a long time, etc.

Dust particle counter KORNO GT-1000-JM(FC) – Multifunctional handheld dust meter retains the advantages of the previous model. In addition, it is a dust particle counter. Automatic and manual storage of up to 123200 groups of data is available, and they can be exported to a computer for viewing and storage in graphic format or format *Excel*.

Air dust analyzer DT-9880 is designed to measure the amount of fine particulate matter in the air. It is an ecological mini laboratory that performs a wide range of measurements (Fig. 10). The device provides simultaneous analysis of up to six different particle size ranges. It has a 2.8 inch color *TFT LCD*- screen, built-in camera for taking photos *(JPEG)* and video (3*GP*).

Dust collector ($PM_{2,5}$) *Walcom SR-516A* – universal dust meter for determining the AQI (air pollution index) level by dust particle size 0,3 microns, 0,5 microns, 1,0 microns, 2,5 microns, 5,0 microns и 10 microns based on the principle of laser scattering (Fig. 11). It is used for sanitary and hygienic control of atmospheric air. It has automatic and manual measurement in real time.

Air quality detector ($PM_{2,5}$; PM_{10}, 0–50°C) BENETECH GM8803– portable analyzer of fine particulate matter concentration manufactured by the company *Benetech* (Fig. 11).

а) б)

Figure 11 – Sawmills ($PM_{2,5}$): a) – *Walcom SR*-516*A* [34]; b) – air quality detector *BENETECH GM*8803 [35]

The device has two channels for the analysis of solid fine particles: up to 10 microns and up to 2.5 microns. Operation of the device *GM8803* is based on scattered light laser photometry technology.

A combined semi-automatic dust meter has been developed based on optical and gravimetric methods ОМПН-10,0 (Fig. 12). The principle of its operation is to register scattered radiation with an optical sensor and parallel forced pumping of an air sample through an aerosol filter АФА-ВП-10 using an electric aspirator. The optical unit provides measurement of the concentration of suspended particles PM_{10} in continuous mode. If the regulatory concentration is exceeded, an alarm is triggered.

Figure 12 – Combined semi-automatic dust collector ОМПН-10,0 [36]

A large group of dust meters are contact-electric, the action of which is due to the property of dust particles to receive an electric charge when rubbed. The magnitude of this charge is proportional to the surface area of the dust particles.

The basis of the work of induction dust meters is the determination of the induction charge that occurs during the movement of charged dust particles through a chamber with an electrode. The magnitude of the charge is a measure of the mass concentration of dust.

2.2. Instruments and equipment used

The laboratory setup for determining air dustiness consists of a dust chamber, a dust dispenser, an allonge with a filter, and an aspirator (Fig. 13).

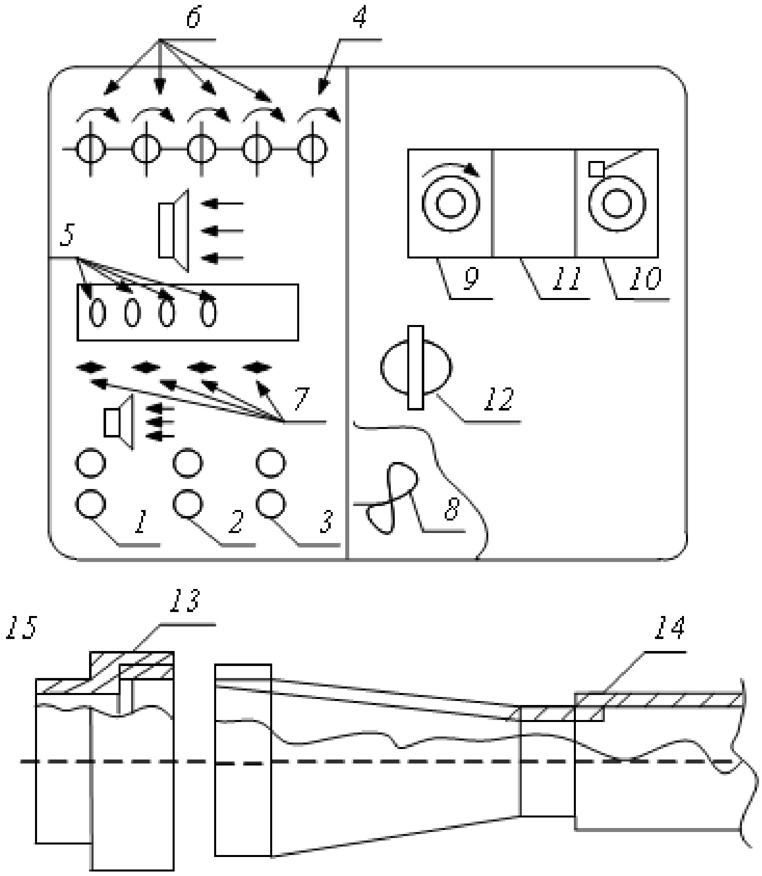

Figure 13 – Scheme of the installation for determining air dust content by the weighing method:

1 – toggle switch for switching on the installation; 2 – toggle switch for switching on the aspirator; 3 – toggle switch for switching on the fan; 4 – safety valve; 5 – rheometers; 6 – handles that regulate the air valves (sampling rate); 7 – fittings; 8 – fan; 9 – dispenser; 10 – plug for the hole for connecting the allonge; 11 – observation window; 12 – handle; 13 – allonge with a filter; 14 – rubber tube; 15 – filter

In the dust chamber, a dust-air mixture is artificially created, which simulates dusty air. For this, the dust is fed from the dispenser into the upper part of the chamber and evenly distributed throughout the volume by a fan located in the lower part of the chamber. The dispenser allows you to change the level of dust in the chamber within wide limits. There is a hole on the front panel of the chamber for installing an allonge with an AFA filter.

The *allonge* (filter holder) is designed to secure the filter during sampling and is a funnel, in the wide part of which the filter is secured using a ring that presses it (Fig. 14).

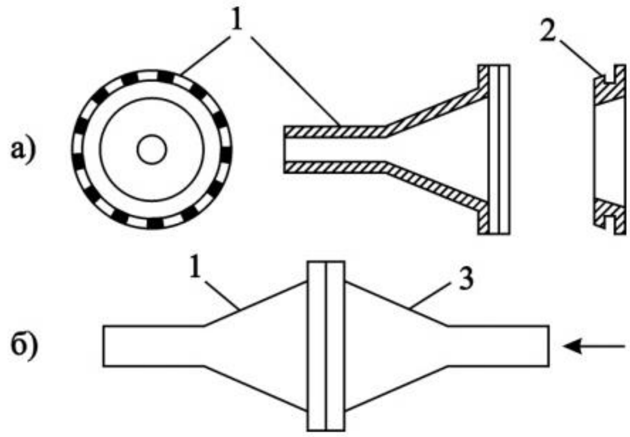

Figure 14 – Allonges for filters of open (a) and closed (b) types:
1 – body; 2 – cover; 3 – additional funnel

The allonge is connected by a hose to an aspirator designed to pass air through the filter. The aspirator is equipped with four rotameters that allow you to control the air flow through the filter in the range from 1 to 25 cm3/min. To adjust the air flow, valves are located on the front panel of the respiratory unit.

AFA filter – This is a layer of evenly arranged ultra-thin polymer fibers with pressed edges and protective rings with protrusions (Fig. 15).

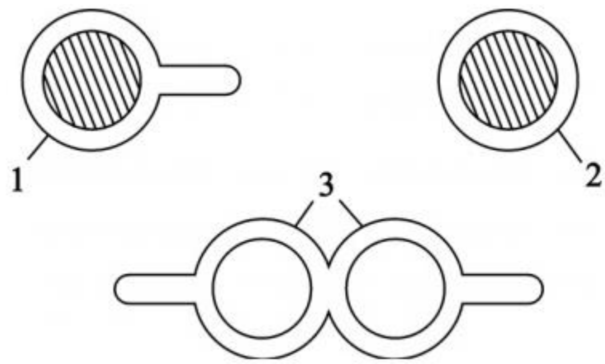

Figure 15 – AFA-B filter: 1– filter assembly; 2 – filtration element;
3 – protective rings

Weigh the filter on an analytical balance to the nearest 0.1 mg. In addition, a thermometer and a barometer are required.

3. WORK PROCEDURE

1. Get acquainted with general information about aerosol pollution of the atmosphere, sources and factors that determine the degree of its harmfulness, methods for assessing air dustiness, devices for measuring air dustiness (section 2.1).

2. Check the degree of your readiness to perform the work by answering control questions. (Discussion under the guidance of the teacher is possible).

3. Get acquainted with the structure of the laboratory installation (section 2.2).

4. Investigate air dustiness by weighing. Carry out the work in the following sequence.

1) Disconnect the aspirator from the dust chamber, for which remove the rubber tube from the fitting.

2) Turn on the aspirator with toggle switch 1 (see Fig. 13).

3) Turn on the rheometers with toggle switch 2 and set the required air flow rate (20 m/s) by turning the handle of the leftmost valve counterclockwise.

4) Weigh the filter on an analytical balance with an accuracy of 1 mg and place it in the allonge, securing it with a pressed ring.

5) Remove the plug 10 and insert the allonge with the filter into the dust chamber.

6) Connect the rubber tube coming from the allonge to the leftmost fitting of the aspirator.

7) Turn on the fan with toggle switch 3 and create an imitation of dusty air in the chamber.

8) Turn on the aspirator and pass the dusty air through the filter for 3-4 minutes. The air flow rate is measured on the rheometer scale.

9) Turn off the aspirator and the chamber fan, disconnect the allonge from the chamber, the rubber tube from the fitting, and plug the intake hole.

10) Use tweezers to remove the filter from the allonge, fold it with the sediment inward, and weigh it on an analytical balance.

11) Use appropriate instruments to take readings of the barometric pressure and temperature at the sampling site.

12) Determine the volume of air passed through the filter and bring it to normal conditions.

13) Calculate the mass concentration of dust, enter the results of measurements and calculations in Table 5.

14) Compare the result of the study with the maximum permissible concentration of the studied dust, which is given in Appendix B.

15) Record the results of the study (measurements and calculations) in the form of Table 5.

5) Prepare a report and draw conclusions on the work. In the conclusions indicate:

• the substance(s) of which the tested dust consisted (or make a reference to its undifferentiated composition if the chemical content of the dust is unknown);

• the determined dust concentration;

• the level of air pollution by dust (exceeding the MPC) based on the results of its study by the weight method.

Table 5 – Results of air dust study by weight method

Sampling location	Indoor air temperature, °C	Pressure, mm Hg	Filter mass after sampling, mg	Weight of retained dust, mg	The volume of air passed, brought to normal conditions, m^3	Dust concentration in the air, mg / m^3	MPC, mg/ m^3 (appendix B)
1	2	3	4	5	6	7	8

4. REPORT CONTENTS

1. Purpose of the work.
2. Scheme of the installation for determining air dust content.
3. Tables with measurement results.
4. Analysis of the results and conclusions.

Review questions

1. Indicate the main sources of dust entering the atmosphere.
2. What physicochemical properties of dust determine its harmful effect on the human body?
3. What methods are used to study air dustiness?
4. Name the types of maximum permissible concentrations of undifferentiated dust in the air.
5. Reveal the essence and positive qualities of the mass method of studying air dustiness.
6. Indicate the main criterion of atmospheric air quality.
7. How is the dust factor assessed?
8. For what purpose is atmospheric air monitoring carried out?

9.What is the Air Quality Index (AQI)? Describe the technical means of measuring suspended particles in atmospheric air.

APPENDICES

Appendix A

Table A.1 - Terms and their definitions

Term	Definition
1	**2**
1. Albedo	The characteristic of the Earth's reflectivity, which is the ratio of solar radiation reflected by the Earth (with its atmosphere) into outer space to solar radiation reaching the boundary of the atmosphere. There are two types: integral (energy **A** – for the entire radiation flux and spectral **A** – for individual sections of the radiation spectrum. The average **A** of the Earth is 35–45%, or 0.35–0.45).
2. Atmospheric air	A vital component of the natural environment, which is a natural mixture of gases located outside residential, industrial and other premises.
3. Upper assessment threshold	The level of a pollutant below which a combination of fixed measurements and modeling methods or indicative measurements is used to assess the quality of ambient air.
4. Limit value	The level of a pollutant is established with the aim of avoiding, preventing or reducing harmful effects on human health and/or the environment as a whole.
5.Maximum permissible concentration (MPC) of a pollutant in the atmospheric air of populated cities	The maximum concentration (mg/m3) at which, during a person’s lifetime, there is no direct or indirect adverse impact on the present and future generations, no reduction in a person’s working capacity, no deterioration in their well-being and sanitary and living conditions.
6.Atmospheric air pollution	A change in the composition and properties of atmospheric air as a result of the entry or formation of physical, biological and (or) chemical compounds in it that may adversely affect human health and the state of the environment.
7. Pollutant	A substance of chemical or biological origin that is present or enters the atmospheric air and can directly or indirectly have a negative impact on human health and the state of the environment.

Continuation of Table A.1

Term	Definition
8. Critical level	The level of a pollutant, if exceeded, may cause direct adverse effects on some objects of the natural environment (trees, other plants or natural ecosystems, but not on humans).
9. Air monitoring laboratory	An enterprise, institution, organization, their separate or structural unit that carries out laboratory studies of atmospheric air and/or atmospheric precipitation.
10. Lower assessment threshold	The level of a pollutant below which modeling or objective assessment methods are used to assess the quality of atmospheric air.
11. Assessment	Any method used to measure, calculate, predict or assess the level of pollutants.
12. Danger threshold	The level of a pollutant, the excess of which is associated with a risk to human health from short-term exposure. In the event of exceeding the danger threshold, air quality management authorities must take measures that can be implemented in a short time to reduce the risk or duration of such an excess in the territory of their management.
13. Air pollution monitoring point	A complex that includes a fixed area with installed measuring instruments and equipment that provides automatic registration of the level of pollutants and meteorological parameters or regular sampling of atmospheric air for their subsequent analysis.
14. Pollutant level	The concentration of a pollutant in atmospheric air or sediments at a specified time.

Appendix B

Hygiene regulations

Table B.1 – Maximum permissible concentrations of chemical and biological substances in the ambient air of populated areas (excerpt from [9])

№	Name of the substance	Maximum permissible concentration, mg/m³		Hazard class
		maximum one-time	daily average	
1	2	4	5	6
1.	Coal ash from thermal power plants (with a calcium oxide content of 35-40%, dispersion up to 3 microns not less than 97%)	0,05	0,02	2
2.	Shale ash	0,3	0,1	1
3.	Fuel ash from thermal power plants (in terms of vanadium	-	0,002	2
4.	Asbestos-containing dust (with a chrysotile asbestos content of up to 10% by asbestos)	-	0,06 fibers in 1 ml of air	1
5.	Cotton dust	0,2	0,05	3
6.	Grain dust	0,2	0,03	3
7.	Kainite dust	0,5	0,1	3
8.	Kalimagnesia dust (kalimag-40)	0,5	0,15	3

Continuation of Table B.1

1	2	4	5	6
9.	Inorganic dust containing silicon dioxide in %:	0,15	0,05	3
10.	– more than 70 (dinas, etc.)	0,3	0,1	3
11.	– 70–20 (fireclay, cement, etc.)	0,5	0,15	3
12.	– less than 20 (dolomite, etc.)	–	0,0001	1
13.	Cement dust (with a calcium oxide content of more than 60% and silicon dioxide of more than 20%)	–	0,02	3
14.	Soot	0,15	0,05	3

Notes: 1 – in cases of determination of undifferentiated dust (aerosol), it is allowed to take the values of its MPC: maximum single – 0.5 mg/m3, average daily – 0.15 mg/m3, 3rd hazard class; these values do not apply to aerosols of organic and inorganic compounds (metals, their salts, plastics, biological, medicinal products, etc.), for which the corresponding MPCs are established;
2 – the total dustiness created by emissions of enterprises and other objects containing solid aerosols of various chemical compounds, in the air environment of the surrounding residential buildings should not exceed the MPC established for undifferentiated dust (see paragraph 1 of the notes).

Sources of information

1. Law of Ukraine "On Protection of Atmospheric Air". – Introduced. October 16, 1992 as amended in 1995 and 2017.

2. Environment and Climate: Information and Analytical Review of Environmental and Climate Policy and EU Law". – Access mode: https://www.civic-synergy.org.ua/wp -content/uploads/2018/04/Dovkillya-i-klimat-informatsijno-analitychnyj-oglyad-ekologichnoyi-ta-klimatichnoyi-polityky-i-prava-YES-lyutyj-2019.pdf (access date 02/07/2020).

3. State of the Environment in Ukraine. Information and Analytical Review. – Access mode: https://refdb.ru/look/3488628-pall.html (access date 02/07/2020).

4. National report on the state of the environment in Ukraine in 2018. – Kyiv: Ministry of Environmental Protection and Natural Resources of Ukraine, 2018. – 483 p.

5. Air quality and health. Key facts. Information bulletin. World Health Organization. May 2, 2018. – Access mode: https://www.who.int/ru/news-room/fact-sheets/detail/ambient-(outdoor)-air-qualityand-health (access date 05.03.19).

6. Bashtannik M.P. State of atmospheric air pollution over the territory of Ukraine / M.P. Bashtannik, N.S. Zhemera, E.N. Kyptenko, T.V. Kozlenko // Scientific works of UkrNDGMI, 2014, vol. 236. – pp. 70–93.

7. Atmospheric air. Standard gravimetric method for measuring the mass concentration of aerosol particles PM10 or PM2.5. : DSTU EN 12341:2018 (EN 12341:2014, IDT). – [Valid from 01.01.2019]. – Access mode: https://www.google.com.ua/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiCs5PG68ruAhWeCRAIHd41A2MQFjAKegQIDh (access date 02.02.2020).

8. Bodak I. V. Spatial-temporal variation of atmospheric air pollution in Kharkiv with fine dust of the PM2.5 fraction. / I. V. Bodak, K. V. Dyadechko // Man and the Environment. Problems of Neoecology. Issue 33. 2020. – P. 91–101.

9. Hygienic regulations. Maximum permissible concentrations of chemical and biological substances in the atmospheric air of populated areas. Approved by order of the Ministry of Health of Ukraine dated 14.01.2020 No. 52.

10. Procedure for state monitoring in the field of atmospheric air protection. Approved by resolution of the Cabinet of Ministers of Ukraine dated August 14, 2019 No. 827.

11. Where in Europe is the highest level of air pollution. – Access mode: https://www.dw.com/ru/%D0%B3%D0%B4%D0%B5-%D0%B2-%D0%B5%D0%B2%D1%80%D0%BE%D0%BF%D0%B5-

(access date 01.02.2020).

12. Air pollution in the world: Air quality index. – Access mode: waqi.info › (access date 03.02.2020).

13. Air quality index. – Access mode:

https://www.google.com.ua/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjXr8HAxq_uAhVDposKHeHgD5kQFjACegQIBxAC&url=https%3A%2F%2Fuk.wikipedia.org%2Fwiki%2F%25D0%2586

(access date 03.02.2020).

14. More about the AQI index – Access mode: http://eco.aep.kiev.ua/novini/chto-takoe-aqi-i-pochemu-ego-znachenie-ochen-vazhno-dlya-ekologicheskogo-budushhego-strany (access date 03.02.2020).

15. Interactive pollution map. – Access mode:

https://www.google.com.ua/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwihg9SkzLzuAhWslosKHSqkDFUQFjAKegQIDRAC&url=https%3A%2F%2Fwww.saveecobot.com%2Fmaps&usg=AOvVaw0Z3u8JDAYlqttVz4bRibGc (access date 03.02.2020).

16. Bogolyubov V. What is the cause of the deterioration of air quality in Ukraine? – Access mode: https://www.google.com.ua/url?sa=i&url=http%3A%2F%2Fnubip.edu.ua%2Fnode%2F75283&psig=AOvVaw1DacR_cZ9BLIX4GIdy8gy2&ust=161184854899 (access date 12.09.20).

17. Impact of suspended particles on health Importance for policy development in countries of Eastern Europe, the Caucasus and Central Asia. – WHO, 2013. – 15 p. – Access mode: https://www.google.com.ua/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjG_fT3_L7uAhXIlosKHfWfDFoQFjAAegQIARA (access date 15.12.2019).

18. Directive 2008/50/EC of the European Parliament and of the Council of the European Union of 21 May 2008 on ambient air quality and cleaner air for Europe. – Access mode: https://zakon.rada.gov.ua/laws/show/994_950 (access date 05.03.19).

19. Koltsov M. Monitoring of ambient air quality: Ukrainian and international experience. [Analytical note] / M. Koltsov, L. Shevchenko. – Kyiv: NGO “Open Society Foundation”, 2018. – 13 p.

20. An air quality monitoring station in the NSW Hunter Valley. – Access mode: https://www.google.com.ua/url?sa=i&url=https%3A%2F%2Fwww.abc.net.au%2Fnews%2F2015-02-03%2Fair.jpg%2F6066126&psig=AO (access date 13.01.2020).

21. Air quality monitoring station. – Access mode: https://www.google.com.ua/url?sa=i&url=https%3A%2F%2Fwww.wikiwand.com%2Fen%2FEnvironmental_monitoring&psig=AOvVaw1BsJZvy4KPzj2U_fK (access date 13.01.2020).

22. Colorado Mobile Air Quality Monitoring. – Access mode: https://www.google.com.ua/url?sa=i&url=https%3A%2F%2Fadvm2.com%2Fenvironmental-consulting-projects%2Fcolorado-mobile-air-quality-monitoring- (access date 01.13.2020).

23. Manual for the control of atmospheric pollution: RD 52.04.186-89 – [Valid from 01.07.1991]. – M.: Goskomgidromet, 1991. – 695 p.

24. Figure – Pylemir "Atmas". – Access mode: https://donbas-spetspribor.com.ua/p516963908-pylemer-atmas.html (access date 03.02.2020).

25. CEL-712 Microdust Pro dust analyzer – Access mode: https://www.google.com.ua/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwi675_wmMvuAhWqtYsKHfjCAWsQFjAAegQIA (access date 03.02.2020).

26. ExplorerPlus model automatic system (Zambelli, Italy). – Access mode: https://www.google.com.ua/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiy2MCNmcvuAhXCmIsKHai0Bq (access date 03.02.2020).

27. Primyskyi V. P. State and prospects for the development of dust meters. Part II. Structural diagrams of the construction / V. P. Prymisky, D. G. Kornienko // Metrology and Instruments, 2016. – No. 3. – P. 17–24. – Access mode: http://nbuv.gov.ua/UJRN/mettpr_2016_3_7 (access date 04.01.2020).

28. Thermo ScientificTM 5014i-Beta dust analyzer. – Access mode: https://www.google.com.ua/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwi71veFmsvuAhXwBBAIHfnOB1EQFjACegQIBB (access date 04.01.2020).

29. Verewa dust analyzer model F-701-20. – Access mode: https://www.google.com.ua/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwicqNGomsvuAhVdAxAIHbYuDcUQFjABegQIAh (access date 04.01.2020).

30. About the Air Pollution project. – Access mode: https://www.google.com.ua/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwj9v- (access date 04.01.2020).

31. Air pollution monitor APM-2. Particulate matter monitor for continuous monitoring of PM2.5 and PM10 in real-time continuously. – Access mode: https://www.comde-derenda.com/en/

(access date 04.01.2020).

32. Air quality analyzer KORNO GT-1000-JM3. – Access mode: https://www.google.com.ua/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwipq9LAmsvuAhWrmIsKHVJ8A-(access date 04.01.2020).

33. Air dust analyzer DT-9880. – Access mode: https://www.google.com.ua/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwid9N7jmsvuAhXSpIsKHY51Cp0QFjABegQIAhA (access date 09.02.2020).

34. Dust meter (PM2.5) Walcom SR-516A. – Access mode: https://www.google.com.ua/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwizttr-msvuAhVPlosKHbhx (access date 09.02.2020).

35. Air quality detector (PM2.5; PM10; 0–50 °C) BENETECH GM8803. – Access mode: https://www.google.com.ua/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjM78OYm8vuAhVV2SoKHa_fAzkQFjAFegQICR9M12Y (access date 09.02.2020).

36. Combined semi-automatic dust meter OMPN-10.0. – Access mode: https://www.google.com.ua/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjbxdrPm8vuAhWnlosKHdJGAt0QFjABegQIBBA (access date 09.02.2020).

Content

Introduction………………………………………………………………………… 3

1. Air quality criteria and factors determining the degree of harmfulness of aerosol air pollution ……………………………………………………………. 5

2. Methods for determining dust content, measuring instruments and equipment…………………………………………………………….……. 21

2.1. Methods for measuring air dust content ………………….. 21

2.2. Instruments and equipment used ……………… 36

3 Procedure for performing work ……………………………..……..… 38

4. Contents of the report ……………………………………………………....... 40

Review questions…………………………………………………………… 40

Applications ………………………………………………………… 42

Applications A

Terms and their definitions ……..…………………………………..…. 42

Applications B

Hygiene regulations …………………..……………………….. 44

List of information sources ……………………………………….. 46

Educational edition

METHODICAL INSTRUCTIONS

for laboratory work

"Determination of dust content of atmospheric air"

in the discipline "Ecology"

for students of all specialties and all forms study

Compilers:

VASKOVETS Lyudmila Antonivna

YEVTUSHENKO Nataliia Serhiivna

TVERDOHLIEBOVA Natalia Evgenivna

Responsible for the release of the prof. *VAMBOL S. O.*

The work was recommended for publication by prof. *MEZENTSEVA I.O.*

In the author's edition

Plan 2026,

item._201____

____

Publishing Center of NTU "KhPI", 61002, Kharkiv, Kyrpychova St., 2

Certificate of State Registration of the State Educational Institu dated 21.08.2017