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Д.В. Сокольский атындағы «Жанармай,
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ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
АО «Институт топлива, катализа и
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NAS RK is pleased to announce that News of NAS RK. Series of chemistry and technologies scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of chemistry and technologies in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of chemical sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабарлары. Химия және технология сериясы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Химия және технология сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді химиялық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия химии и технологий» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по химическим наукам для нашего сообщества.

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PUBLIC ENVIRONMENTAL MONITORING OF THE STATE OF SNOWPACK IN NORILSK

Abstract. It is considered that Norilsk ranks second in terms of atmospheric contamination. Industrial enterprises annually emit large amounts of sulphur dioxide, phenols, and heavy metal particles. The city is located within the Far North and is distinguished by the harsh climate of the subarctic type. The snow cover can lie from 244 to 277 days. Snow is a good sorbent; therefore, the snow cover accumulates solid and gaseous pollutants that enter it from the atmosphere with precipitation or are absorbed from it. The purpose of this study was to analyse the snow cover in the Norilsk industrial region and assess the state of atmospheric air in the winter. To achieve this goal, it is necessary to solve the following tasks: conduct a literature review on a given topic; take samples of snow in various industrial districts of Norilsk; study the dependence of the qualitative characteristics of snow on the sampling site; draw conclusions on the quality of snowpack in different areas of the industrial districts of Norilsk. In the course of the study, the following methods were used: organoleptic, visual, methods for determining water transparency, titrimetric analysis, etc. Heavy metal ions and sulphate ions were not detected in the thawed snow, so no industrial gas pollution was noted in the residential area. Most of the particulate contamination was caused by slagging of roads to improve vehicle traction.

Key words: precipitation, industrial area, melt water, chemical characteristics.

Introduction. Norilsk is located in the north of the Krasnoyarsk Krai and is the administrative centre of the district. The region is a zone of permafrost rocks, the thickness of which is 40-80 m. It is one of the coldest cities in the world. It is much colder than Murmansk, despite the fact that both cities are located almost at the same latitude. Norilsk is located 300 km north of the Arctic Circle, 2400 km from the North Pole, and 1500 km to the capital of the Krasnoyarsk Krai. It is considered that Norilsk ranks second in pollution of air, into which enterprises annually emit large amounts of sulphur dioxide, phenols, and heavy metal particles. The cold and long winter with January temperatures of -40°C is exacerbated by very strong winds. The period of severe cold lasts about 280 days, from mid-September to early May, of which 130 days are accompanied by blizzards. The summer period begins at the end of June and lasts until the end of August. On average, the frost-free period lasts 84 days, and sometimes its duration is reduced to 53 days. The relative humidity is 76%. The snow cover can lie from 244 to 277 days.

Snow is a good sorbing agent, therefore, it imbibes solid and gaseous pollutants from the atmosphere. It is possible to judge about air pollution from enterprises and transport emissions by the state of the snow cover. Hypothesis: the snow cover accumulates pollutants found in dust – gas emissions from industrial enterprises and vehicle exhaust gases. Therefore, the purpose of this study is to analyse the snow cover in the Norilsk industrial region and assess the state of atmospheric air in the winter. To achieve this goal, it is necessary to solve the following tasks: conduct a literature review on a given topic; take samples of snow in various industrial districts of Norilsk (IDN); study the dependence of the qualitative characteristics of snow on the sampling site; draw conclusions on the quality of snow cover in different areas of the IDN.

Materials and methods. Organoleptic method, organoleptics – a method for determining quality indicators based on the analysis of sensory perception: sight, smell, hearing, touch, taste. The advantages

include the availability and speed of determining the quality indicators, as well as no need for expensive equipment for measurements. The disadvantages of organoleptic methods include the subjectivity of the assessment, the relative expression of its results in dimensionless quantities (colour – green, red, etc.; taste – sweet pronounced, mild, tasteless, etc.), incomparability and insufficient reproducibility of the results.

Visual method – a method based on the perception of the appearance and/or colour of an object with the help of sight. Appearance is a complex indicator that includes colour, odour, turbidity and is determined visually. With the help of sight, a person receives the most information (70-80%). The intensity of the liquid odour is assessed using a 5-point system, presented in table 1. The smell of water should not exceed 2 points.

Table 1 – Odour intensity assessment

Odour intensity	The nature of the smell manifestation	Odour intensity, points
No	The odour is not felt	0
Very weak	The odour is not felt by the consumer, but is detected during laboratory analysis	1
Weak	The odour is noticed by the consumer if he pays attention	2
Noticeable	The odour is easily noticed and leads to disapproval of the water	3
Distinct	The odour attracts attention and discourages from drinking	4
Very strong	The odour is so strong that it makes water unfit for consumption	5

Transparency is a water quality indicator that allows to simply and quickly control the content of suspended solids and colloidal impurities in it. Turbidity of water can be caused by the presence of clay, inorganic compounds, as well as organic impurities or cake organisms, for example, bacteria, phyto- or zooplankton. Turbidity of drinking water is normalised mainly due to the fact that turbid water protects microorganisms during ultraviolet disinfection and facilitates the growth of bacteria, as well as for aesthetic reasons [1-3]. The classification of water by transparency is given in table 2.

Table 2 – Water transparency assessment

Transparency assessment	Snellen transparency, cm	Suspended solids content, mg/dm^3
Transparent	More than 30	Less than 3÷4
Low turbidity	25÷30	Less than 5÷6
Medium turbidity	20÷25	6÷10
Turbid	10÷20	10÷30
Very turbid	Less than 10	More than 30

Titrimetric analysis is a method for determining the amount of a substance by accurately measuring the volume of substances reacting with each other. The main task of titrimetric analysis is not only to use a solution of precise molarity (fixanal), but also to correctly determine the equivalence point [4,5]. The different total level of calcium Ca and magnesium Mg salts dissolved in water characterises the so-called total water hardness. Magnesium and potassium bicarbonates form carbonate (temporary) hardness, which is completely eliminated with prolonged boiling of water, but turns into an insoluble precipitate with the release of carbon dioxide [6-9].

By the value of the total hardness, water is distinguished: up to 4 mg-eq/L water is soft; from 4 to 8 mg-eq/L – medium hardness, from 8 to 12 mg-eq/L – hard; over 12 mg-eq/L – particularly hard. The water hardness of surface sources fluctuates significantly throughout the year; it is maximal at the end of winter, and minimal during flood periods. In groundwater, the hardness is usually higher (up to 8-10, less often up to 15-20 dH) and less changes during the year [10-13].

Salinity (total mineralisation) is a quantitative indicator of the content of substances dissolved in water. It is also called the total salt content, since the substances dissolved in water are in the form of salts. The most common inorganic salts (bicarbonates, chlorides and sulphates of calcium, magnesium, potassium, and sodium) and a small amount of organic matter soluble in water.

Conductivity is used to estimate the total solids dissolved in water. Conductometry is based on the numerical indicator of this physical quantity. Considering specifically water, which is a solution of a mixture of strong and weak electrolytes: the mineral part of water is made up of sodium, potassium, calcium, chlorine, sulphate (SO_4^{2-}), bicarbonate ions, it can be concluded that these ions determine the electrical conductivity of water.

Gravimetric analysis is a method of quantitative chemical analysis based on the accurate measurement of the substance mass. It is used to determine the chemical composition of various objects (rocks and minerals), the quality of raw materials and finished products, the content of crystallisation water in salts, the ash content of the fuel, and so on. The advantages of gravimetric analysis include high accuracy (usually the error is 0.1-0.2%) and the absence of the need for preliminary calibration of measuring instruments. On the other hand, its implementation is often more laborious and takes more time in comparison with other methods [14-16]. The gravimetric method for determining the mass concentration of suspended solids is based on filtering a water sample through a filter with a pore diameter of 0.45 μm and weighing the resulting sediment after drying it to constant mass [17,18].

The colour of water is determined photometrically – by comparing samples of the test liquid with solutions that imitate the colour of natural water. The following equipment, materials, reagents are used for testing: colour density meter with a blue light filter; sample cells with a thickness of the light-absorbing layer of 5-10 cm; volumetric flasks in accordance with GOST 1770, with a capacity of 1000 cm^3; measuring pipettes according to GOST 29227, with a capacity of 1, 5, 10 cm with divisions of 0.1 cm; Nessler tubes with a capacity of 100 cm; potassium dichromate according to GOST 4220; cobalt sulphate according to GOST 4462; sulphuric acid according to GOST 4204, with a density of 1.84 g/cm; distilled water in accordance with GOST 6709; membrane filters No. 4 [6,10]. All reagents used in the analysis must be of the analytical-reagent grade.

In a Nessler tube, 100 cm of the test water, filtered through a membrane filter, is measured and compared with the colourimetric scale, viewing from above on a white background. If the test water sample has a colour of more than 70°, the sample should be diluted with distilled water in a certain ratio until the colour of the test water is comparable to the colour of the scale. The result is multiplied by the number corresponding to the dilution [19-21].

When determining the chromaticity using a photocolorimeter, sample cells with a thickness of the light-absorbing layer of 5-10 cm are used. The control liquid is distilled water, from which suspended substances are removed by filtration through membrane filters No. 4. The optical density of the filtrate of the test water sample is measured in the blue part of the spectrum with a light filter at = 413 nm. The colour is determined by a grading schedule and is expressed in degrees of colour. Organoleptic methods determine the nature and intensity of the odour [22,23].

The nature of the water odour is determined at 20°C by the smell. In a flask with a ground plug with a capacity of 250-350 cm^3, 100 cm^3 of test water at a temperature of 20°C is measured. The flask is closed with a plug, the contents of the flask are stirred several times with rotary movements, after which the flask is opened and the nature and intensity of the smell is determined.

Determination of odour at 60°C: 100 cm^3 of test water is poured into a flask. The neck of the flask is closed with a watch glass and heated in a water bath to 50-60°C. The contents of the flask are mixed several times with rotary movements. Moving the glass to the side, the nature and intensity of the odour is determined. The intensity of the water odour is determined at 20 and 60°C and is assessed using a five-point system. For example: at 20°C first tap (Volga river) – no odour – 0 points, at 60°C first tap (Volga river) – earthy odour – 1 point; second tap (filtered reservoir) – chlorine odour – 1 point; 2 tap (filtered reservoir) – chlorine reservoir – 2 points.

The Snellen transparency of the waste water, according to the method [1], is determined with the Snellen cylinder. The test water is thoroughly mixed (shaken) and poured into a cylinder, under which a text printed in Snellen's font on white paper is placed at a distance of 4 cm from the bottom of the cylinder. The excess water is drained off with a tap or a tube while stirring continuously with a glass rod

until the text is readable. The height of the liquid column is read off the scale applied to the cylinder with an accuracy of 0.5 cm.

The scientific sanitary assessment of water is one of the most difficult problems of sanitary examination. Snellen font for measuring water transparency [24,25]. The result is expressed in centimetres as the arithmetic mean of the two definitions. The "cross transparency" is determined using a white plate with two crossed black lines 1 mm in thickness. This method is used to control the operation of treatment facilities. In thermal power engineering, the most often used is "font transparency (by Snellen)", equal to the height of the water column, through which the standard typographic font with a letter height of 3.5 mm is still readable [26,27]. The total stiffness is calculated using the formula (Eq. 1):

$$dH = \frac{V \times C \times 1000}{W} mmol - \frac{eq}{dm^3}, \quad (1)$$

where V – volume of 0.1 N Trilon B solution used for titration; C – concentration of Trilon B solution; W – aliquot part of the sample.

The electrometric method for determining salinity is based on measuring the relative electrical conductivity of water using a special device – a conductometer, which makes it possible to accelerate and increase the accuracy of its determination in comparison with other methods [28]. The operating principle of conductometer is based on the direct dependence of the electrical conductivity of water (current strength in a constant electric field created by the electrodes of the device) on the number of compounds dissolved in water. A wide range of relevant equipment now allows to measure the conductivity of almost any water, from ultraclean (very low conductivity) to saturated with chemical compounds (high conductivity) [29-31].

Drip method. The reaction can be carried out dropwise on filter paper. To do this, a drop of nickel (II) salt solution is applied to a sheet of filter paper, then a drop of an alcohol solution of dimethylglyoxime. The paper is held over a bottle with a concentrated ammonia solution (in ammonia vapor) until a pink-red spot appears [32,33].

Results and discussion**.** Subject of the study: snow sampled from different streets of Norilsk – 50 Let Oktyabrya, Talnakhskaya, Kirova, Komsomolskaya, Kotulskogo Passway, Metalurgov Square. Study of the impact on the ecological state of snow cover: industrial emissions – samples were taken near apartment buildings in the city of Norilsk; transport – samples were taken near the road (on the dividing strip) and on the streets.

The work was carried out in the spring (March-April). The average daily temperature in the city of Norilsk in March ranged from -15 to 0 (figure 1).

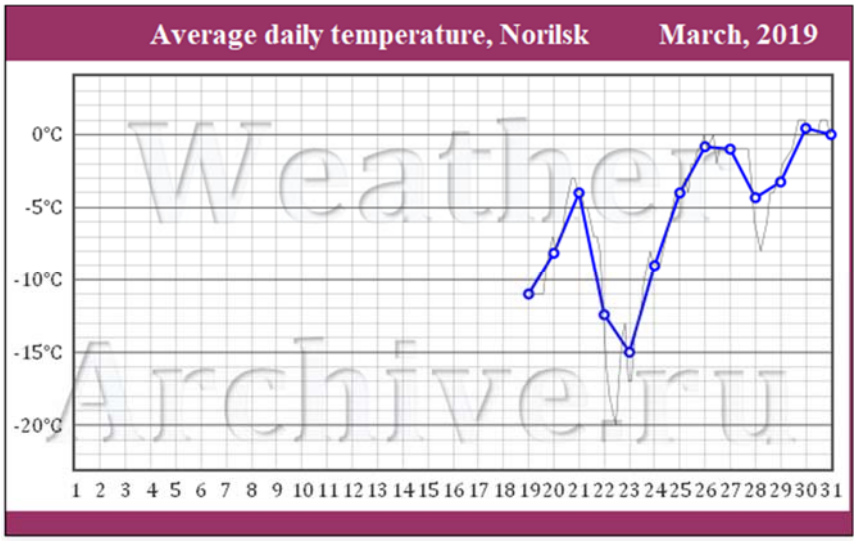

Figure 1 – Average daily temperature in Norilsk in March

The pH of the melt water has a value close to neutral and ranges from 7.1 to 8.6, with the exception of melt water from the snow sampled from the roadways of 50 Let Oktyabrya, Kirova streets and Kotulskogo Passway (table 3). Since the main salts that determine the salt content are calcium and magnesium bicarbonates, at a hardness of less than 0.1 mMol/L, the pH value from 8 to 9 is explained by the hydrolysis of these salts.

Table 3 – Qualitative indicators of the state of the snow cover

Sr. No.	Sampling location	Free alkalinity, mol/L	Salinity, mg/L	pH	Hardness, mMol/L	Solids, mg/dm^3
	Distilled water	<0.1	23.5	7.7	<0.1	0
5	50 Let Oktyabrya					
5.1	Street	<0.1	78.0	8.6	<0.1	3.8
5.2	Roadside	0.12	90.0	9.0	0.12	496
6	Talnakhskaya (Beginning)					
6.1	Street (NTEK, 11)	<0.1	66.8	8.3	<0.1	2.4
6.2	Roadside (Talnakhskaya, 10)	<0.1	54.5	8.6	<0.1	490
7	Kirova					
7.1	Lyceum No. 4 (Pushkina, 8)	<0.1	75.9	7.1	<0.1	3.1
7.2	Kirova, 5	<0.1	79.6	9.0	<0.1	154
8	Komsomolskaya					
8.1	Street	<0.1	56.2	8.3	<0.1	4.0
8.2	Roadside	<0.1	75.4	8.1	<0.1	400
9	Kotulskogo Passway					
9.1	Kotulskogo, 15 (street)	<0.1	67.1	8.1	<0.1	0.03
9.2	Kotulskogo, 5-13 (crossing, road)	<0.1	112	9.2	<0.1	160
10	Metalurgov Square					
10.1	Street	0.12	90.7	6.0	0.12	0.4
10.2	Roadside	0.3	102.0	7.2	0.3	128

The total salinity of melt water, depending on the place of sampling, is shown in figure 2: 1 – Distilled water; 2 – 50 Let Oktyabrya (street); 3 – 50 Let Oktyabrya (roadside); 4 – Talnakhskaya (street, near NTEK); 5 – Talnakhskaya, 10 (near Arbat shop); 6 – Kirova (Lyceum No. 40); 7 – Kirova, 5; 8 – Komsomolskaya (street); 9 – Komsomolskaya (roadside); 10 – Kotulskogo 15 (street); 11 – Kotulskogo, 5 (roadside); 12 – Metalurgov Square (street), 13 – Metalurgov Square (roadside).

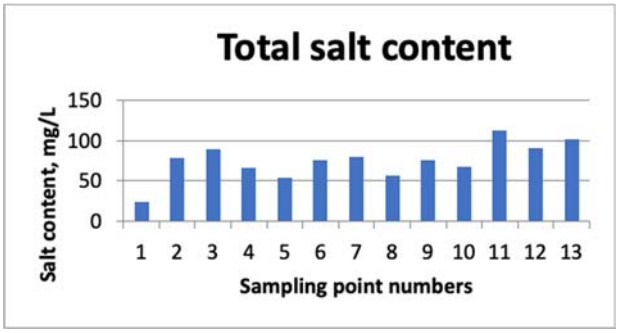

Figure 2 – Dependence of the total salt content on the sampling site

From table 4 it can be seen that the pollution of the snow cover with heavy metal ions was not observed.

Table 4 – Content of non-ferrous metal ions and sulphate ion

Sr. No.	Sampling location	Pb^{+2}	Fe^{+2}	Ni^{+2}	∑ non-ferrous metals	SO_4^{-2}
	Distilled water	<0.1	<0.1	<0.1	<0.1	<0.1
5	50 Let Oktyabrya					
5.1	Street	<0.1	<0.1	<0.1	<0.1	<0.1
5.2	Roadside	<0.1	<0.1	<0.1	<0.1	<0.1
6	Talnakhskaya (Beginning)					
6.1	Street (NTEK, 11)	<0.1	<0.1	<0.1	<0.1	<0.1
6.2	Roadside (Talnakhskaya, 10)	<0.1	<0.1	<0.1	<0.1	<0.1
7	Kirova					
7.1	Lyceum No. 4 (Pushkina, 8)	<0.1	<0.1	<0.1	<0.1	<0.1
7.2	Kirova, 5	<0.1	<0.1	<0.1	<0.1	<0.1
8	Komsomolskaya					
8.1	Street	<0.1	<0.1	<0.1	<0.1	<0.1
8.2	Roadside	<0.1	<0.1	<0.1	<0.1	<0.1
9	Kotulskogo Passway					
9.1	Kotulskogo, 15 (street)	<0.1	<0.1	<0.1	<0.1	<0.1
9.2	Road at Kotulskogo, 5-13 (crossing)	<0.1	<0.1	<0.1	<0.1	<0.1
10	Metalurgov Square					
10.1	Street	<0.1	<0.1	<0.1	<0.1	<0.1
10.2	Roadside	<0.1	<0.1	<0.1	<0.1	<0.1

Thus, the main contaminant of snow cover is solid slag particles, which are sprinkled on roads and sidewalks to improve vehicle traction and prevent pedestrian injury. Cars, when driving, throw off slag particles to the side of the road and thereby pollute the snow cover, the pollution of snow with solid particles depends on the number of vehicles passing along this section of the road.

Conclusions.

1. The pH of the melt water of the snow cover is close to neutral and is equal to 6.0-9.0.
2. Salinity is caused by the presence of ions (Ca+2, Mg+2, HCO3-).
3. Ions of heavy metals and sulphate ions were not detected in the melt snow, thus, no pollution with industrial gases in the residential area was noted.
4. The main contamination with solid particles is due to the slagging of roads to improve the vehicle traction on the road surface.

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НОРИЛЬСКІДЕГІ ҚАР ЖАМЫЛҒЫСЫ КҮЙІНІҢ ҚОҒАМДЫҚ ЭКОЛОГИЯЛЫҚ МОНИТОРИНГІ

Аннотация. Атмосфераның ластану деңгейі бойынша Норильск екінші орында тұрады деп есептеледі. Өндірістік кәсіпорындар жыл сайын күкірт диоксиді, фенол мен ауыр металл бөлшектерін ірі көлемде ауаға шығаруда. Қала Қиыр Солтүстік жақта орналасқан және субарктикалық типті қатаң климатымен ерекшеленеді. Қар жамылғысы 244-тен 277 күнге дейін жатуы мүмкін. Қар – жақсы сорбент. Сондықтанда қар

жамылғысы оған атмосферадан жауын-шашын түрінде түсетін қатты және газтәрізді ластағыштарды жинайды немесе өзіне сіңіріп алады.

Зерттеудің мақсаты – Норильск өнеркәсіптік ауданының қар жамылғысына талдау жасау және қысқы кезеңдегі атмосфералық ауаның күйіне баға беру. Аталмыш мақсатқа қол жеткізу үшін келесідей міндеттерді шешу қажет: берілген тақырып бойынша әдебиеттерді саралау; Норильскінің түрлі өнеркәсіптік аудандарынан (көше және жолжағадан) қар сынамасын алу; қардың сапалық сипаттамасының сынама алынған орынға тәуелділігін анықтау; түрлі IDN аумақтарындағы қар жамылғысының сапасына қатысты қорытынды жасау.

Зерттеу барысында келесідей әдістер қолданылды: органолептикалық, көзбен шолу, судың тазалығын анықтайтын тәсілдер, титриметрлік талдау және т.б. әдістер. Судың түсі фотометриялық әдіспен, яғни зерттелетін сұйықтық сынамаларын табиғи судың келтіріндісі болып саналатын ерітінділермен салыстыру арқылы анықталды. Ең алдымен стандартты ерітінді дайындалды; кейін ерітінді күкірт қышқылымен сұйытылды; колориметрикалық шкала жасалды.

Ауыр металл иондары мен қар суындағы сульфат-иондары байқалмады, сондықтанда тұрғын ауданының өнеркәсіптік газданғандығы белгіленбеді. Қатты бөлшектермен ластанудың ауқымды бөлігі көлік құралдарының тартымын жақсарту мақсатында жүргізілген жолдарды қождау іс-шараларына тиесілі деген қорытынды жасалды.

Түйін сөздер: жауын-шашын, өнеркәсіптік аймақ, қар суы, химиялық сипаттама.

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ОБЩЕСТВЕННЫЙ ЭКОЛОГИЧЕСКИЙ МОНИТОРИНГ СОСТОЯНИЯ СНЕЖНОГО ПОКРОВА В НОРИЛЬСКЕ

Аннотация. Считается, что Норильск занимает второе место по уровню загрязнения атмосферы. Промышленные предприятия ежегодно выбрасывают большие количества диоксида серы, фенолов и частиц тяжелых металлов. Город расположен в пределах Крайнего Севера и отличается суровым климатом субарктического типа. Снежный покров может лежать от 244 до 277 дней. Снег – хороший сорбент; следовательно, снежный покров накапливает твердые и газообразные загрязнители, которые попадают в него из атмосферы с осадками или абсорбируются из нее.

Целью исследования был анализ снежного покрова в Норильском промышленном районе и оценка состояния атмосферного воздуха зимой. Для достижения этой цели необходимо решить следующие задачи: провести обзор литературы по заданной теме; брать пробы снега в различных промышленных районах Норильска (с улиц и у обочин); изучить зависимость качественных характеристик снега от места отбора проб; сделать выводы о качестве снежного покрова в различных областях IDN.

В ходе исследования использовались следующие методы: органолептический, визуальный, методы определения прозрачности воды, титриметрический анализ и др. Цвет воды определяется фотометрически – путем сравнения образцов исследуемой жидкости с растворами, имитирующими цвет природной воды. Сначала был приготовлен стандартный раствор; затем – разбавленный раствор серной кислоты; изготовлена колориметрическая шкала.

Ионы тяжелых металлов и сульфат-ионы в талом снеге не обнаружены, поэтому в жилом районе промышленной загазованности не отмечено. Сделан вывод, что большая часть загрязнения твердыми частицами была вызвана зашлаковыванием дорог для улучшения тяги транспортных средств.

Ключевые слова: осадки, промышленная зона, талая вода, химические характеристики.

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