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«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
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«ХАЛЫҚ» ЖҚ

ХАБАРЛАРЫ

ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ
АКАДЕМИИ НАУК РЕСПУБЛИКИ
КАЗАХСТАН»
ЧФ «Халық»

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NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences 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 geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар 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. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» 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. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

ЧФ «ХАЛЫҚ»

В 2016 году для развития и улучшения качества жизни казахстанцев был создан частный Благотворительный фонд «Халык». За годы своей деятельности на реализацию благотворительных проектов в областях образования и науки, социальной защиты, культуры, здравоохранения и спорта, Фонд выделил более 45 миллиардов тенге.

Особое внимание Благотворительный фонд «Халык» уделяет образовательным программам, считая это направление одним из ключевых в своей деятельности. Оказывая поддержку отечественному образованию, Фонд вносит свой посильный вклад в развитие качественного образования в Казахстане. Тем самым способствуя росту числа людей, способных менять жизнь в стране к лучшему – профессионалов в различных сферах, потенциальных лидеров и «великих умов». Одной из значимых инициатив фонда «Халык» в образовательной сфере стал проект Ozgeris powered by Halyk Fund – первый в стране бизнес-инкубатор для учащихся 9-11 классов, который помогает развивать необходимые в современном мире предпринимательские навыки. Так, на содействие малому бизнесу школьников было выделено более 200 грантов. Для поддержки талантливых и мотивированных детей Фонд неоднократно выделял гранты на обучение в Международной школе «Мирас» и в Astana IT University, а также помог казахстанским школьникам принять участие в престижном конкурсе «USTEM Robotics» в США. Авторские работы в рамках проекта «Тәлімгер», которому Фонд оказал поддержку, легли в основу учебной программы, учебников и учебно-методических книг по предмету «Основы предпринимательства и бизнеса», преподаваемого в 10-11 классах казахстанских школ и колледжей.

Помимо помощи школьникам, учащимся колледжей и студентам Фонд считает важным внести свой вклад в повышение квалификации педагогов, совершенствование их знаний и навыков, поскольку именно они являются проводниками знаний будущих поколений казахстанцев. При поддержке Фонда «Халык» в южной столице был организован ежегодный городской конкурс педагогов «Almaty Digital Ustaz.

Важной инициативой стал реализуемый проект по обучению основам финансовой грамотности преподавателей из восьми областей Казахстана, что должно оказать существенное влияние на воспитание финансовой грамотности и предпринимательского мышления у нового поколения граждан страны.

Необходимую помощь Фонд «Халык» оказывает и тем, кто особенно остро в ней нуждается. В рамках социальной защиты населения активно проводится

работа по поддержке детей, оставшихся без родителей, детей и взрослых из социально уязвимых слоев населения, людей с ограниченными возможностями, а также обеспечению нуждающихся социальным жильем, строительству социально важных объектов, таких как детские сады, детские площадки и физкультурно-оздоровительные комплексы.

В копилку добрых дел Фонда «Халык» можно добавить оказание помощи детскому спорту, куда относится поддержка в развитии детского футбола и карате в нашей стране. Жизненно важную помощь Благотворительный фонд «Халык» оказал нашим соотечественникам во время недавней пандемии COVID-19. Тогда, в разгар тяжелой борьбы с коронавирусной инфекцией Фонд выделил свыше 11 миллиардов тенге на приобретение необходимого медицинского оборудования и дорогостоящих медицинских препаратов, автомобилей скорой медицинской помощи и средств защиты, адресную материальную помощь социально уязвимым слоям населения и денежные выплаты медицинским работникам.

В 2023 году наряду с другими проектами, нацеленными на повышение благосостояния казахстанских граждан Фонд решил уделить особое внимание науке, поскольку она является частью общественной культуры, а уровень ее развития определяет уровень развития государства.

Поддержка Фондом выпуска журналов Национальной Академии наук Республики Казахстан, которые входят в международные фонды Scopus и Wos и в которых публикуются статьи отечественных ученых, докторантов и магистрантов, а также научных сотрудников высших учебных заведений и научно-исследовательских институтов нашей страны является не менее значимым вкладом Фонда в развитие казахстанского общества.

С уважением,
Благотворительный Фонд «Халык»!

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HEAVY METALS IN THE SNOW COVER AND SOIL OF THE ILE RIVER DELTA

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Abstract. Near the ore deposits as well as in adjacent territories near enterprises and areas for storing raw materials and waste during the enrichment and processing of heavy metals, there are zones of accumulation of high concentrations of substances involved in the technological process of metallurgical production. To control the negative impact to the environment, to reduce negative consequences, it is required to monitor and carry out environmental protection measures aimed at preserving the acceptable properties of the habitat of various types of organisms in the soil, water and air. The harmful impact of human economic activity to the nature can be remote both in time and in space. This is due to a number of factors: the persistence of the processes of impact to the nature caused by the dynamics of biogeocenoses, the resistance and adaptation of the ecosystem to negative impacts, the effects of summation and migration of pollutants, etc. Studies of heavy metal contamination of snow cover and soil were carried out by taking soil and snow samples for atomic sorption spectrometry. When assessing the distribution of pollutant concentrations,the maps of contamination of Ile River delta territory by Copper (Cu), Zinc (Zn), Lead (Pb), Nickel (Ni), Cobalt (Co), Cadmium (Cd) were

created. This made it possible to clarify the mechanism of transport of pollutants and identify areas of accumulation of heavy metals in snow and soil. Based on the results of the analysis, were made the conclusions about participation of heavy metal deposits in the emissions of substances accumulated in the lithosphere. This is confirmed by the relative location of emission sources and pollutant accumulation zones. Transfer over land occurs over longer distances compared to air trajectories crossing the waters of the Lake Balkash. Research results can be taken into account for the development of environmental protection measures.

Keywords: contamination, copper, zinc, lead, nickel, cobalt, cadmium.

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ІЛЕ ӨЗЕНІНІҢ АТЫРАУЫНДАҒЫ ҚАР ЖАМЫЛҒЫСЫНДАҒЫ ЖӘНЕ ТОПЫРАҚТАҒЫ АУЫР МЕТАЛДАР

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Аннотация. Кен орындарының жанында, сондай-ақ кәсіпорындардың жанында және ауыр металдарды байыту және өңдеу кезінде шикізат пен қалдықтарды сақтауға арналған аумақтар маңындағы іргелес аумақтарда металлургиялық өндірістің технологиялық процесіне қатысатын заттардың жоғары концентрациясының жиналу аймақтары бар. Қоршаған ортаға теріс әсер етуді бақылау, жағымсыз салдарды азайту үшін топырақтағы, судағы және ауадағы әр түрлі организмдердің тіршілік ету ортасының қолайлы қасиеттерін сақтауға бағытталған қоршаған ортаны қорғау шараларын бақылау және жүргізу қажет. Адамның шаруашылық қызметінің табиғатқа зиянды әсері уақыт бойынша да, кеңістікте де алыс болуы мүмкін. Бұл бірқатар факторларға байланысты: биогеоценоздардың динамикасынан туындаған табиғатқа әсер ету процестерінің сақталуы, экожүйенің жағымсыз әсерлерге төзімділігі мен бейімделуі, ластаушы заттардың қосындысы мен миграциясының әсері және т.б. қар жамылғысы мен

топырақтың ауыр металдармен ластануы атомдық сорбциялық спектрометрия үшін топырақ пен қар үлгілерін алу арқылы жүргізілді. Ластаушы заттардың концентрациясының таралуын бағалау кезінде Іле өзенінің атырауы аумағының мыс (Cu), мырыш (Zn), қорғасын (Pb), никель (Ni), кобальт (Co), кадмий (Cd) бойынша ластану карталары жасалды. Бұл ластаушы заттардың тасымалдану механизмін нақтылауға және қар мен топырақта ауыр металдардың жиналу аймақтарын анықтауға мүмкіндік берді. Талдау нәтижелері бойынша литосферада жинақталған заттардың шығарындыларына ауыр металл кен орындарының қатысуы туралы қорытындылар жасалды. Бұл эмиссия көздерінің және ластаушы заттардың жиналу аймақтарының салыстырмалы орналасуымен расталады. Балқаш көлінің суын кесіп өтетін әуе траекторияларымен салыстырғанда құрлық арқылы өту ұзақ қашықтыққа жүреді. Қоршаған ортаны қорғау шараларын әзірлеу үшін зерттеу нәтижелерін есепке алуға болады.

Түйін сөздер: ластану, мыс, мырыш, қорғасын, никель, кобальт, кадмий.

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ТЯЖЕЛЫЕ МЕТАЛЛЫ В СНЕЖНОМ ПОКРОВЕ И ПОЧВЕ ДЕЛЬТЫ РЕКИ ИЛЕ

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Аннотация. Аннотация. Вблизи месторождений руд, а также на смежных территориях, расположенных рядом с предприятиями и зонами хранения сырья и отходов в процессе обогащения и переработки тяжелых металлов, существуют зоны накопления высоких концентраций веществ, участвующих в технологическом процессе металлургического производства. Для контроля негативного воздействия на окружающую среду, с целью уменьшения негативных последствий, необходимо осуществлять мониторинг и проводить мероприятия

по охране окружающей среды, направленные на сохранение приемлемых свойств среды обитания различных видов организмов в почве, воде и воздухе. Вредное воздействие экономической деятельности человека на природу может быть отдаленным как во времени, так и в пространстве. Это обусловлено рядом факторов: устойчивостью процессов воздействия на природу, вызванных динамикой биогеоценозов, сопротивлением и адаптацией экосистем к негативным воздействиям, эффектами суммирования и миграции загрязнителей и так далее. Исследования загрязнения снежного покрова и почвы тяжелыми металлами проводились путем взятия образцов почвы и снега для атомно-сорбционной спектрометрии. При оценке распределения концентрации загрязнителей были созданы карты загрязнения территории дельты реки Иле медью (Cu), цинком (Zn), свинцом (Pb), никелем (Ni), кобальтом (Co), кадмием (Cd). Это позволило уточнить механизм перемещения загрязнителей и выявить зоны накопления тяжелых металлов в снегу и почве. На основе результатов анализа были сделаны выводы о вкладе месторождений тяжелых металлов в выбросы веществ, накопленных в литосфере. Это подтверждается относительным расположением источников выбросов и зон накопления загрязнителей. Передвижение по суше происходит на большие расстояния по сравнению с воздушными траекториями, пересекающими воды озера Балхаш. Результаты исследований могут быть учтены при разработке мер по охране окружающей среды.

Ключевые слова: загрязнение, медь, цинк, свинец, никель, кобальт, кадмий.

Introduction. After studies of heavy metal contamination in the soil and snow cover of the Almaty agglomeration carried out in 2018-2020, over the next three years in the Laboratory of Hydrochemistry and Environmental Toxicology of the Institute of Geography and Water Security, sampling was carried out in the delta of Ile River and in the southern coast of the Lake Balkash, on territory of the State Natural Reserve “Ile-Balkash” (hereinafter referred to as the SNR “Ile-Balkash”). In this way, systematic coverage of environmental monitoring studies is realized in the entire area of Almaty region.

The high level of pollution in the study area is due to the presence of large enterprises located in adjacent regions. The transfer by air and deposition of heavy metal particles onto the surface of soil and snow cover is the main mechanism for the distribution of pollutants. In addition, certain concentrations of heavy metals are present in precipitation. Samples of which were also taken along with samples of soil, water and snow cover. During the sampling, the concentrations of substances such as Copper (Cu), Zinc (Zn), Lead (Pb), Nickel (Ni), Cobalt (Co), Cadmium (Cd) were determined. Along with the content of these pollutants, the concentration of polychlorinated biphenyls (PCBs) was also measured. A broad comprehensive study of quantitative and qualitative indicators of the characteristics of the chemical composition of atmospheric precipitation, snow cover and soil in the territory of Ile River delta and Ile-Balkash state natural reserve is being studied for the first time. However, studies of heavy metal pollution of the coast of Lake Balkhash have already been carried out by some scientists. Thus, since 2018, a

consistent study of the distribution of the level of heavy metal contamination of snow cover and soil has been carried out throughout the Almaty region.

The physiological activity of copper is associated mainly with its inclusion in the active centers of oxidation-redox enzymes. Excessive concentrations of copper have adverse effects the plant and animal organisms. By people this is accompanied by fever, irritation of the mucous membranes, dysfunction of the liver and kidneys; brain damage. Emissions of copper into the environment are caused by its mining and the activities of enterprises using this substance in their technological process (Illarionova Ye, et.al., 2016, Tapiero H, et.al., 2003; Northey S., et.al., 2013, Leiva González, J, et.al., 2022).

Zinc is one of the active microelements that influence the growth and normal development of organisms and also plays an extremely important role for human immune homeostasis. At the same time, many zinc compounds are toxic, primarily its sulfate and chloride. Excess zinc in the human body reduces immunity and causes disruption of the internal organs and reproductive system. (Illarionova Ye, et.al., 2016, Khlebnikova A, et.al., 2013, Wessels I, et.al., 2017; Prasad AS. et.al., 2008). Atmospheric zinc is generally associated with vehicular emissions and anthropogenic deposition of cadmium mainly occurs through coal burning, non-ferrous metal production and other industrial processes, as indicated by numerous previous studies, including (Guanghong Wu, et.al., 2016).

Cadmium is a toxic and cumulative element. Cadmium poisoning causes damage to the cardiovascular system, bone tissue, respiratory system and internal organs of a person (Cheng, K, et.al., 2014, Illarionova Ye, et.al., 2016). Metallurgy, electroplating, mining and processing of materials containing it, as well as the combustion of solid and liquid fuels are sources of this substance entering the atmosphere (Cheng, K, et.al., 2014, Ivut, 2021)

Cobalt is required for various forms of life. For example it is known as an essential component of vitamin B12. Cobalt is chemically similar to zinc, so the absorption and excretion processes characteristic of zinc are also characteristic of cobalt. Cobalt is a relatively low-toxic element. However, in high doses it reduces the ability of the thyroid gland to accumulate iodine, causing goiter disease (González-Montaña JR, et.al., 2020, Klaudia Jomova, et.al., 2022, Nikanorov, 2001).

Nickel is one of the rare elements; in natural conditions it is found mainly in the form of compounds with arsenic or sulfur. It has an impact to the nervous system, appearance of cancer, decreased immunity, and depression of the cardiovascular system (Singh R, et.al., 2011, Fazlutdinov, 2017, Robert A. Goyer, 1990).

Lead poisoning damages the hematopoietic and nervous systems, kidneys and bone tissue. [Illarionova Ye, et.al., 2016]. Main anthropogenic sources of lead emissions: fossil fuels, metal mining and processing; mining activities, waste burning and recycling, combustion of leaded gasoline (Singh R, et.al., 2011, Jaishankar M, et.al., 2014, United Nations Environment Programme 2010).

The content of heavy metals in soil and snow cover is determined by anthropogenic emissions and the possible natural presence of these substances in the lithosphere. The transfer of heavy metal particles in the atmosphere occurs under the influence of wind,

which picks up emissions from industrial enterprises. In addition, pollutants can be transported to the soil surface by streams of rain and melt water, as well as river flows. The migration of pollutants in the bowels of the earth under the influence of groundwater is also not excluded. Emissions of materials containing heavy metal impurities onto the soil surface are also one of the factors of environmental pollution. Analysis of the relative location of the source and zone of maximum concentration of emissions allows us to assess and forecast further conditions for the accumulation of pollutants in a certain area experiencing anthropogenic load.

Materials and main methods. This section should contain a description of the materials and work progress, as well as a detailed description of the methods used.

In 2021, 69 samples were taken to measure the content of heavy metals in precipitation, water, soil and snow cover. A year later, the number of samples was increased to 152. Samples were first taken at 52 points throughout the territory of the Ile-Balkash state natural reserve, later the number of sampling sites increased to 56. Initially, in 2021, only in 13 points of the considered territory was possible to collect snow samples (Table 1). The relatively small number of sampling points was due to intense snowmelt during the expedition period of work. The time between snow and soil sampling periods did not exceed 30 days in 2021. In 2022 in general, the entire period of sampling snow and soil was 2.5 months. The same time period was used in 2023.

The content of heavy metals in the samples was determined by the flame atomic absorption spectrometric method with preliminary processing of the samples using AA-7000 atomic absorption spectrophotometer from Shimadzu (Japan). Atomic absorption spectrometer with a hollow cathode lamp was used for the corresponding metals to correct the coefficient of non-specific absorption and with a nozzle burner operating on acetylene-air mixture [Felenberg, 1997]. A method of atomic absorption analysis based on the property of metal atoms to absorb in the basis condition light of certain wavelengths, which they emit in an excited condition. The resonance line required for absorption is most often obtained from a lamp with a hollow cathode made of the element being determined (Guidance Document 52.04.186-89, Sanitary Rules and Norms 07.28.10, Hygienic Standards 2.1.5.1315-03).

In addition to the content of heavy metals and polychlorinated biphenyls, the following were also determined in the samples: suspended substances, pH acidity, organic substances (by permanganate oxidation) and mineralization.

The content of heavy metals in snow cover and soil is provided in Tables 1 and 2, respectively. The tables provide extreme and average values of heavy metal concentrations for the specified number of sampling points. The number of sampling points is given in the second row of each table.

Table 1. Content of heavy metals in snow cover in the territory of "Ile-Balkash" State Natural Reserve.

Metal	2021			2022			2023			MPC	
	13 points			56 points			56 points				
	Min.	Avg	Max.	Min.	Avg	Max.	Min.	Avg	Max.	f.	h.
	μg/dm^3										
Copper Cu	1,0	6,4	11,4	0,1	7,1	17,4	1,0	7,4	16,6	1,0	1000
Zinc Zn	14,2	20,7	35,0	10,0	18,6	53,5	8,3	14,1	63,1	10,0	1000
Lead Pb	14,1	16,9	18,8	12,0	15,2	18,3	8,9	13,9	17,2	10,0	30
Cadmium Cd	0,2	3,5	13,3	0,0	3,3	12,2	0,0	6,0	19,1	5,0	1,0
Cobalt Co	17,4	57,2	85,3	17,4	71,5	109,6	20,6	58,2	90,2	10,0	100
Nickel Ni	17,2	40,5	62,1	19,1	40,6	79,0	7,9	49,4	93,9	10,0	100

Note. Min. – Minimum, Avg. – Average, Max. – Maximum values accordingly. MPC – Maximum Permissible Concentration. f – fishery. h. – household.

As can be seen from Table 1, over the past three years, the most acute situation has been with contamination of the snow cover with copper and cobalt. There is ten times excess of fishery permissible concentrations. In 2021 and 2022 zinc, nickel and cadmium were present in concentrations exceeding fishery permissible concentrations by 3-9.3 times. Lead emissions in snow cover did not exceed a two times value over the entire three-year study period. The maximum nickel concentrations in the last year of research at some sampling points exceeded the MPC by almost ten times.

Table 2. Content of heavy metals in the soil in the territory of the State Natural Reserve "Ile-Balkash".

Metal	2021			2022			2023			Gross MPC Value	Background value. Clarke
	52 points			56 points			56 points				
	Min.	Avg	Max.	Min.	Avg	Max.	Min.	Avg	Max.		
	mg/kg										
Copper Cu	6,1	12,9	26,0	1,7	7,5	15,8	1,1	3,5	17,2	3	47
Zinc Zn	7,8	16,1	75,1	2,6	9,9	107,5	1,3	3,9	17,6	23	83
Lead Pb	8,0	11,8	15,9	3,0	4,6	7,1	2,7	3,7	6,0	32	16
Cadmium Cd	0,9	3,8	6,5	0,02	0,62	1,41	0,2	0,9	2,0	2	0,13
Cobalt Co	6,7	13,7	20,6	0,3	14,4	22,5	2,4	6,7	13,6	5	18
Nickel Ni	11,3	15,7	22,2	0,4	4,1	11,6	3,2	6,4	10,1	4	58

Note. The same as for Table 1.

To determine the distribution of heavy metal contamination on the soil surface, samples were taken no later than two months after the snow cover melted. During the study, a correlation analysis was carried out between the concentrations of heavy metals in the snow cover and in the soil, completely for 2022 and 2023. The initial period of 2021 was partially involved in the analysis; the points for which there were concentrations of substances in the snow cover were taken. Each of the two compared concentration values characterized each certain sampling point, and thus assessed the continuity of the pollutant entering the soil after snowmelt. The assumption that soil

contamination corresponds to the distribution of heavy metal contamination in the snow cover and is a consequence of snowmelt is largely not supported by the correlation, which does not exceed 35% (corresponding to cadmium in 2022). For nickel in 2021, there was an inverse correlation between the spatial distribution of snow cover and soil contamination. And the value of this inverse correlation reached minus 39.6%. Thus, we can conclude that there is a significant migration of heavy metals in the lithosphere caused by meltwater. The predominance of sandstones in general causes significant migration of pollutants in the upper soil layers. The difference in the distribution of spots of maximum concentration of heavy metal pollution may also be due to different distances between the deposition zones of pollutant emissions and turbulent transport in the atmosphere.

Table 2 shows the extreme and average values of concentrations of heavy metals in the soil for the territory of the "Ile-Balkash" State Natural Reserve. During the entire period of research, copper and nickel several times and zinc, cadmium and cobalt periodically have concentrations exceeding the permissible gross values in soils. In 2021-22, the zinc content was 3-4 times higher than the maximum permissible concentration. Also, a difficult situation is typical for cobalt, when during the entire period of research the maximum concentration values were 3-4.5 times higher than the permissible values. Lead emissions for the entire three-year period did not represent critical values for the content in the soil.

Results. Based on the sample measurements, maps and diagrams of the distribution of heavy metal concentrations in the snow cover and in the soil were created for the territory of the "Ile-Balkash" State Natural Reserve. The distribution of areas with the maximum content of heavy metals leads to the need to search for sources of emissions in the considered area. Also, when studying emissions of pollutants, an important aspect is to determine the mechanism of particles transfer. In general, the transfer mechanism can be divided into three stages:

- raising particles to the transfer height.
- transfer of particles by air flow at the level of “convection”.
- deposition of pollutant particles in the deposition zone (zone of maximum concentration).

As a accompanying mechanism of soil surface contamination, it is necessary to take into account the transfer of pollutants by melt water. This will require a number of additional works and studies.

Sources of emissions of pollutants are deposits of heavy metals, places of their extraction and processing, as well as waste storage areas of metallurgical enterprises and industries using heavy metals. Therefore, the most important thing is to identify the pattern of movement from the source to the area of deposition of the pollutant. A particular difficulty in identifying the movement of pollutants is the presence of several sources of pollution located in different directions from the considered territory. In this case, the identification of areas with maximum pollutant concentrations may not be accurately determined. Also, the situation with the analysis of the distribution of pollutants is worsened by the need for additional research of the migration of heavy

metal particles connected with melt and groundwater. As can be seen from Figures 1-6, the zones of maximum concentration of different metals change position both within one year and in different years. Most likely, this is influenced by meteorological conditions that determine the height at which pollutants are transported.

Copper pollution primarily affects the southern coast of Lake Balkash, the western coast of Ile River delta and the central part of the Sary-Esik-Atyrau desert territory. On the southern shore of Lake Balkash copper particles accumulate when carried by the wind from the opencast mine and Shagala deposit; Zhamantuz, Sokyrkoy Kaskyrkazgan and Sayak-4 deposits, copper ore deposits located between the village of Gulshad and Mystobe deposit, also from the Karatas group of deposits and enterprises in the cities of Balkash and Kounrad. The western coast of the Ile River delta accumulates copper particles in the lithosphere, due to its proximity to the Rodnikovoye deposit. This deposit, as well as the Aktas deposit (26 km north-west from the village Sayak) is a source of emissions of all six heavy metals studied for the territory of Ile River delta and "Ile-Balkash" State Nature Reserve. Along with this, to copper pollution can contribute deposits such as Zhaisan, Shatyrkol and Taskuduk located to the southeast from the village of Khantau, near which there may be copper deposits in the soil. In the eastern part of the considered territory, copper accumulations in the soil and snow cover arise due to wind transfers from the Tekeli industrial hub (mining plant + tailings dump), Taldykorgan battery plant and Kokshiyel and Koksay deposits. Considering the configuration of the distribution of the copper concentration field in the soil and snow cover, we can assume the presence of copper deposits to the west from the settlement of Ushtobe.

Zones with high zinc content in the snow cover and soil of the southwestern part of considered territory arise due to the transfer of ore particles from Kuyazbai, Tolekol, Druzhnoye, Gagarinskoye, and Rodnikovoye deposits by air masses. They are located to the east from Khantau Range, between the settlements of Shokpar and Aksuyek. At a distance of 40.5 km to the west from the village Shyganak, the Buryltas lead-zinc deposit is located, which is also a source of emissions of zinc, lead and cadmium into the lithosphere of Ile River delta, as well as the Zhamantuz deposit and enterprises of the city of Balkash, industrial waste from enterprises in Taldykorgan region of the Zhetysu region, along with zinc emissions from the Kokshiyel deposit. Unidentified source of zinc emission is located northwest from the village of Akshiy of Ileysky district of Almaty region. Since there are no enterprises in the area of this settlement, it can be assumed that there is a natural source of zinc emissions, it is the accumulation of minerals containing this chemical element.

The lead content in the snow cover and in the soil across the territory of "Ile-Balkash" State Natural Reserve is determined by emissions from the Balkhash plants (copper smelting and processing of non-ferrous metals), from the Zhamantuz and Aktas deposits, located on the northern coast of Lake Balkhash. The southwestern part of the territory of "Ile-Balkash" Sate Nature Reserve accumulates emissions from the lead-zinc deposits Kuyazbay, Tolekol, Druzhnoye, Rodnikovoye, Buryltas and possibly from Gagarinskiy, located in the foothill zone at a bigger distance compared to other sources

of emissions. In the eastern part of the study area, lead accumulation in the snow cover and soil is observed to a lesser extent. This area may be subject to the accumulation of emissions from the Taldykorgan battery plant, Tekeli deposits and tailings dump. The territory t5o the north from the village Ushtobe may contain deposits of lead ores.

Nickel contamination of the snow cover occurred in 2021 on the northwestern side of the study area. It can be assumed that the source of pollution was industrial emissions from the Balkhash non-ferrous metals processing plant. Starting from the warm period of 2021 and in the next two years of research, the north-eastern part of the considered territory of "Ile-Balkash" State Nature reserve has been subjected to the incoming of heavy metals from the Aktas deposit. In the soil of the southern and southwestern parts of Ile River delta the high nickel content, which occurred in certain periods is due to emissions from the Rodnikovoye deposit. The absence of significant number of nickel deposits and volumes of emissions from enterprises on the territory adjacent to the territory of "Ile-Balkash" State Natural Reserve territory necessitates the search for potential locations of ores and minerals containing heavy metals. That is, undiscovered deposits and ore zones that create emissions of heavy metals should be studied for the existence and determination of the possibility of participation in the transfer of pollutants by air and in the migration of chemical elements in the soil. Among the potential areas for searching for nickel deposits, three areas can be distinguished: to the north from the village Ushtobe; western and northwestern areas adjacent to the village Gulshat; territory between the Kaskyrkazgan and Aktas deposits.

The rare presence of cobalt in rocks reduces the possibility of determination of the migration of contaminants of this substance. The southern and southwestern part of Ile River delta is exposed to pollution from the Rodnikovoye and Taskuduk deposits. Also possible source of cobalt emissions is the area to the north from the village Ushtobe, which is confirmed by the distribution of the concentration field of this element. South shore of the lake Balkash is subjected to pollution from Aktas, Sayak-4 deposits and enterprises of Balkash city.

The most difficult thing is to find and analyze the sources of cadmium incoming into the environment, since it is not an independent substance present in rocks at a particular deposit. As an accompanying element, cadmium is present in zinc-containing rocks and minerals. Southern and southwestern side of Ile River delta is a deposition area for cadmium transferred from the Rodnikovoye and Buryltas deposits. The northeastern and eastern parts of the territory of Ile-Balkash State Natural Reserve receive cadmium emissions from the Aktas deposit and Tekeli tailings dump. Possible zinc deposits to the northwest of Sary-Shagan village may contain cadmium in the form of different compounds.

As can be seen from Figures 1-6, at certain points in time, the southwestern part of Ile River delta has zones of deposition of different metals. It is possible that emissions from vehicles when driving along the Almaty-Astana highway contribute to the pollution of this area of the territory. Similar studies have been conducted in the United States [Reynolds R, et.al., 2020], but at much closer distances between high pollutant concentrations zones and heavily trafficked roads.

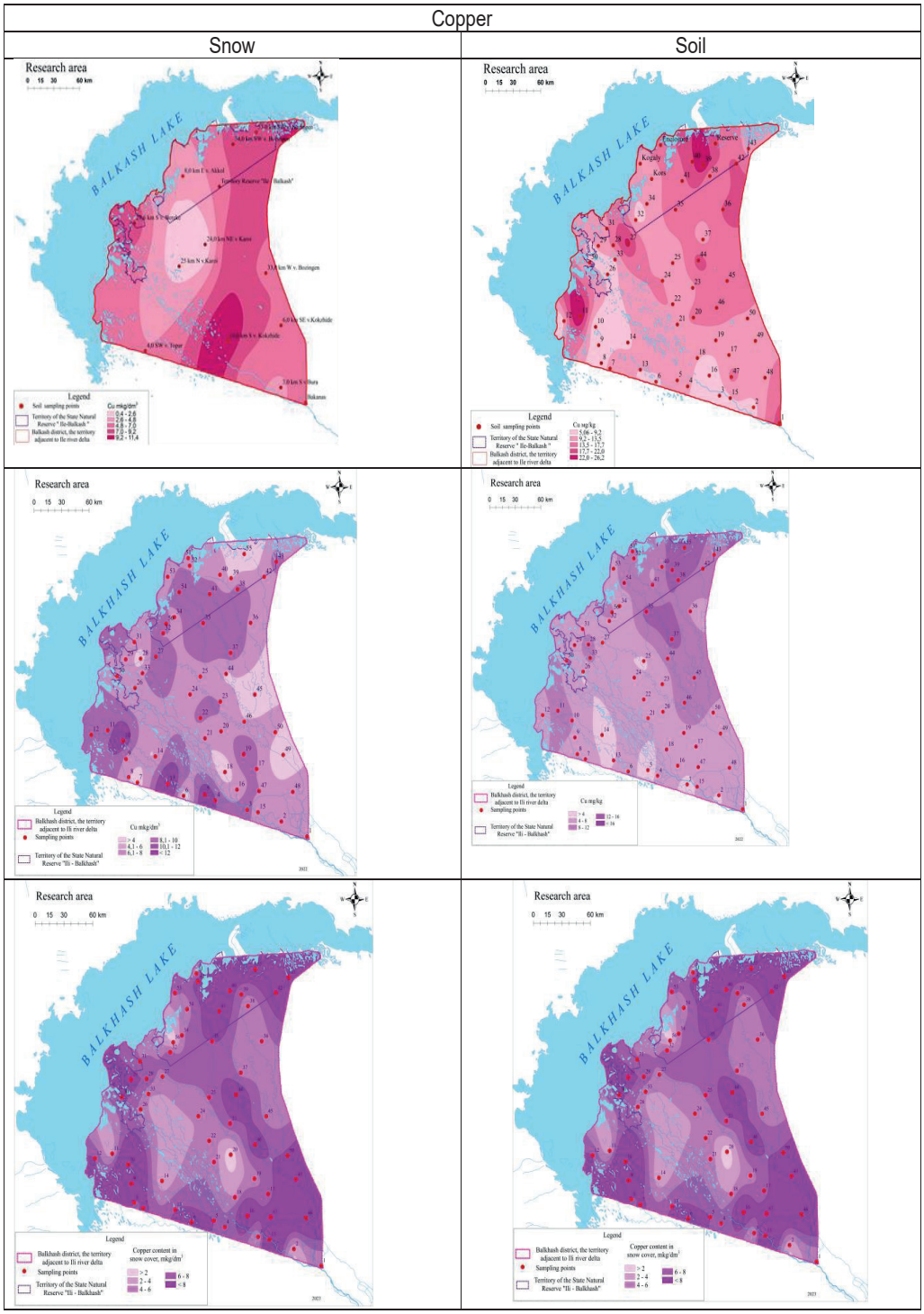

Figura. 1 Copper (Cu)

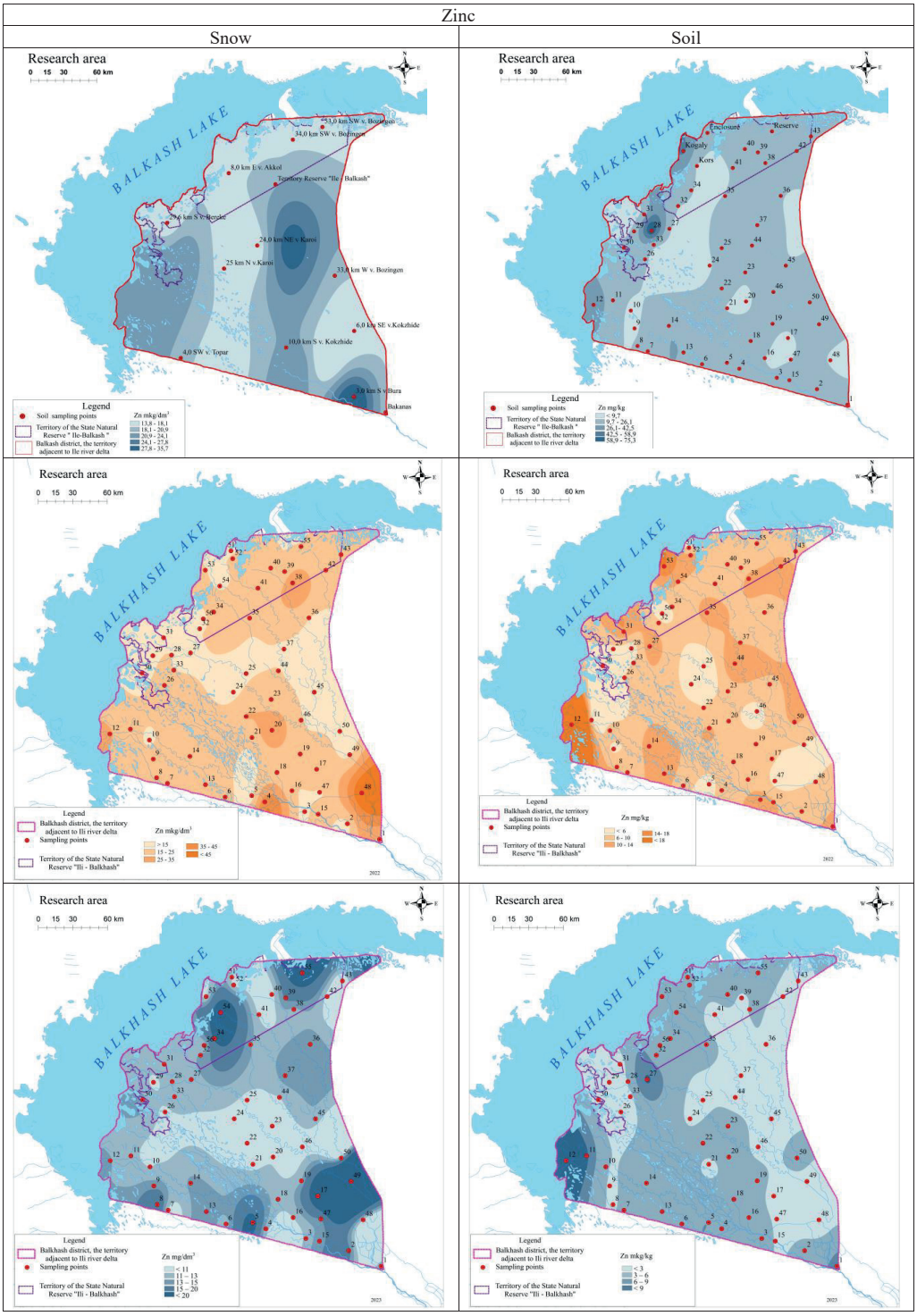

Figura. 2 Zinc (Zn)

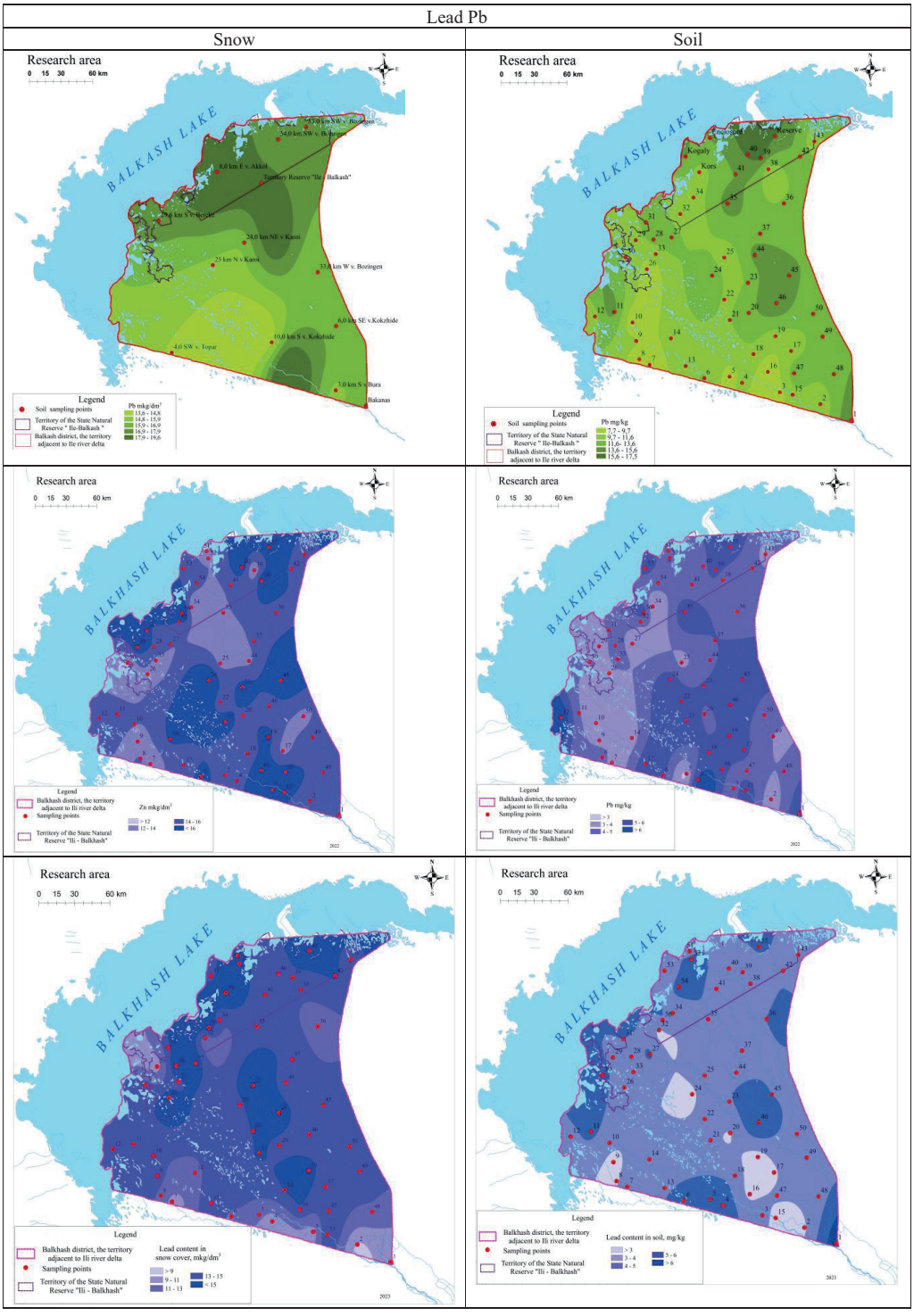

Figura. 3 Lead (Pb)

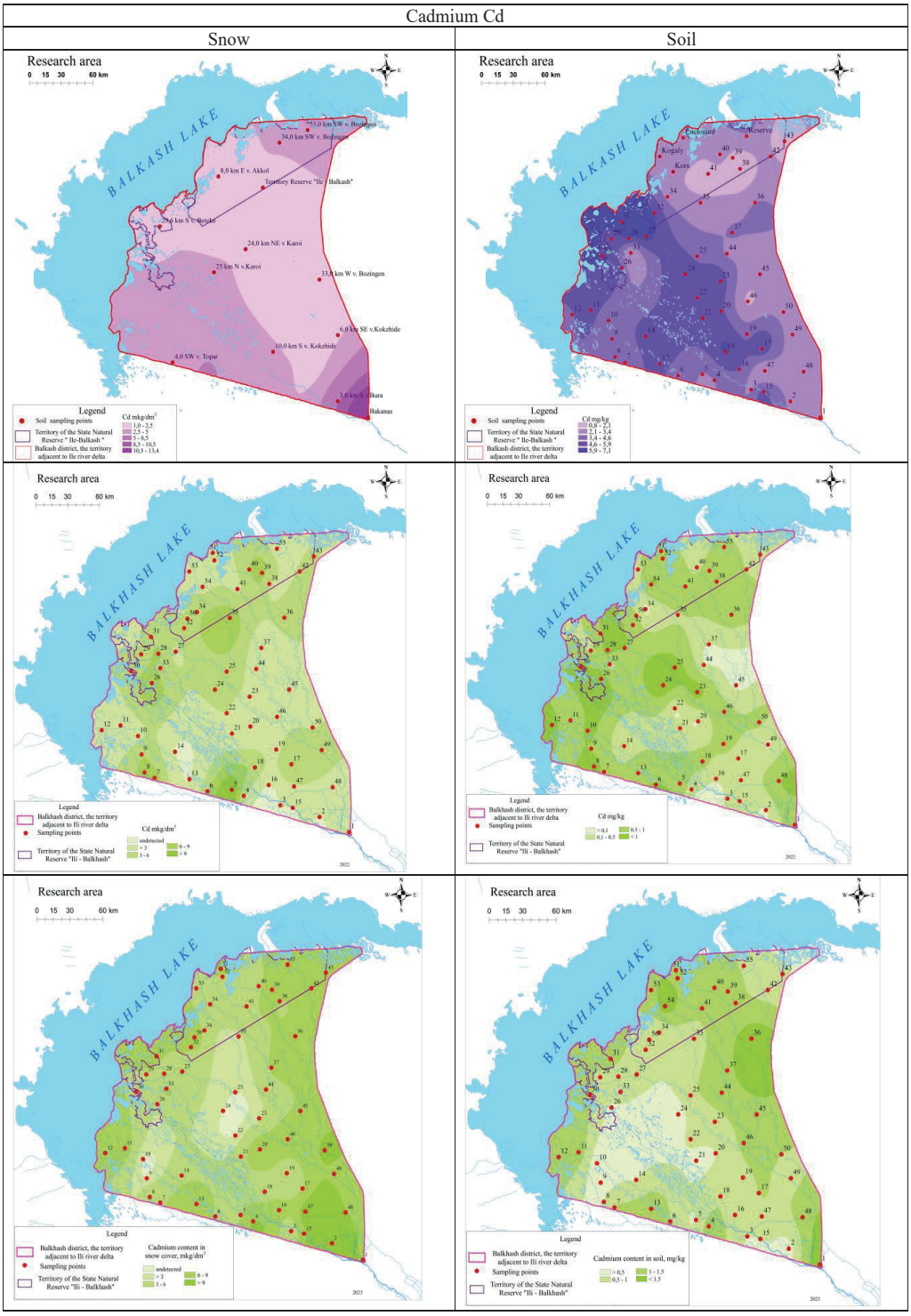

Figura. 4 Cadmium (Cd)

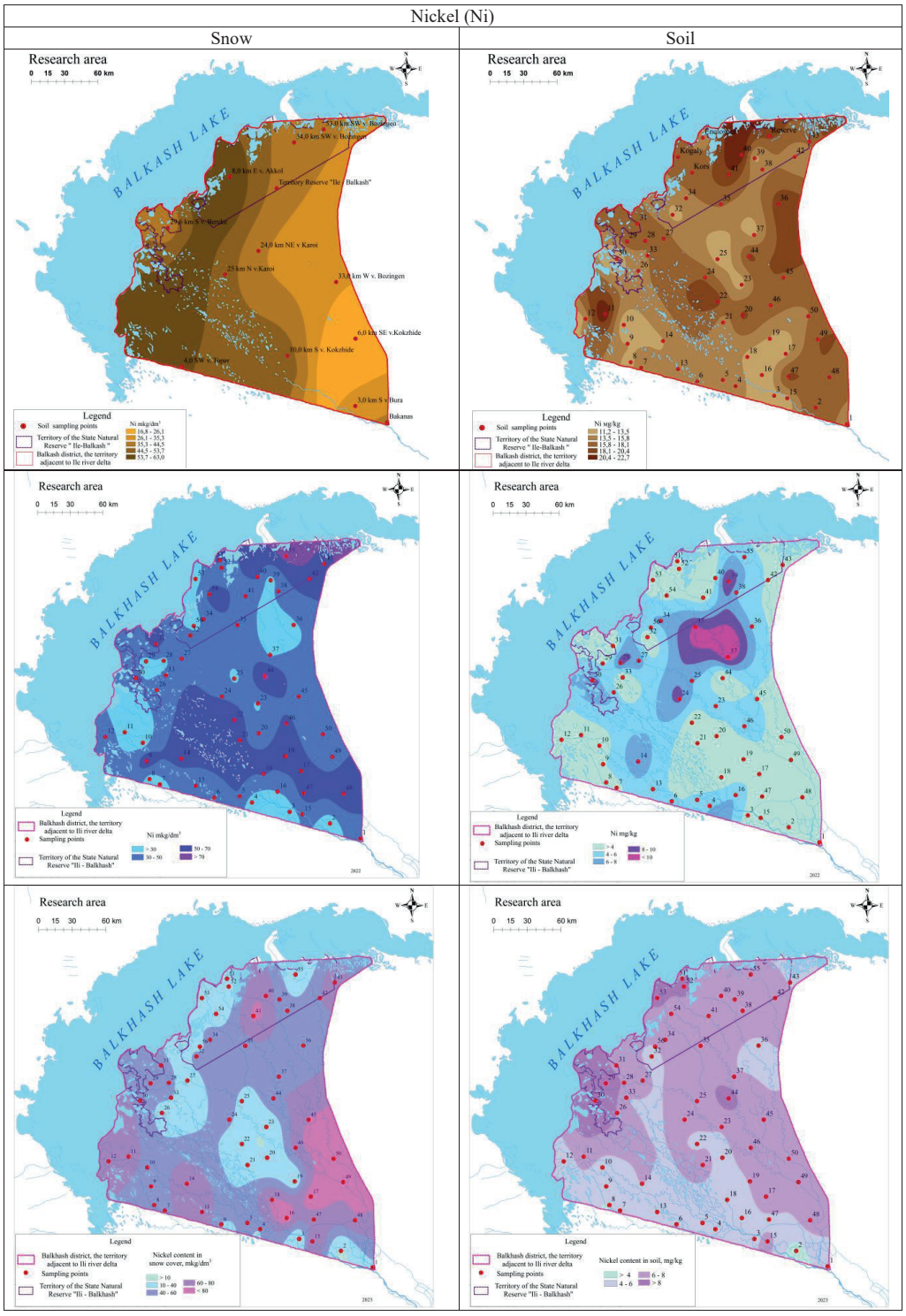

Figura. 5 Nickel (Ni)

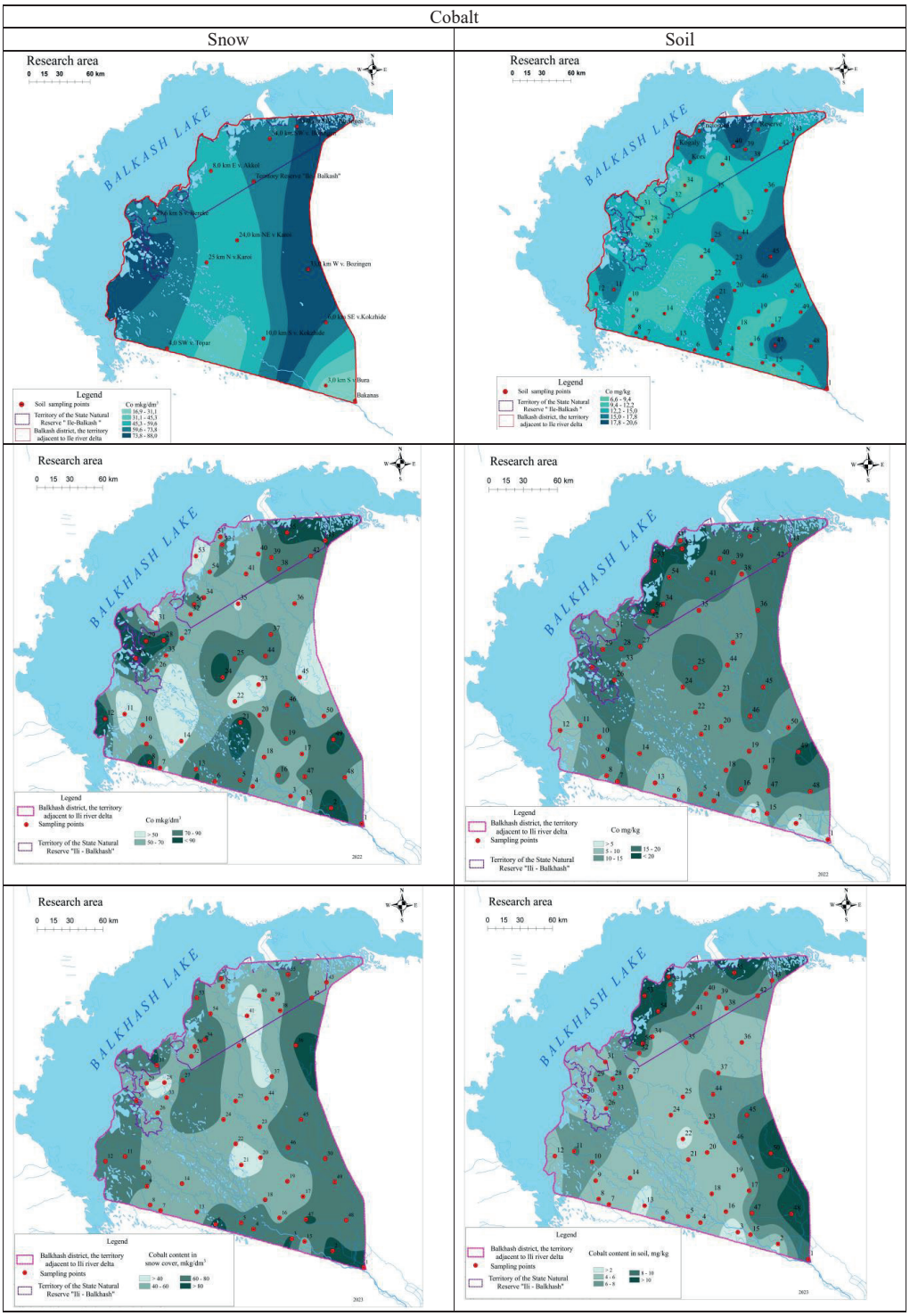

Figura. 6 Cobalt (Co)

Discussion. According to research of Tilekova and co-authors, in 2009-14, the territory under consideration was characterized by a mosaic content of chemical elements (Tilekova Zh, et.al., 2015, Ismukhanova L., et.al., 2022, Madibekov et.al., 2021, Amirgaliyev, et.al., 2019), this situation also occurs in the last three years of study. In the soils of the region, the maximum amount of cadmium is 26.4, copper is 8.6, lead is 11.8, chromium is 9.2, nickel is 5.4 times higher than the permissible concentration.

A decade later, copper by 17.4 and nickel by almost a dozen times exceeded the permissible concentration in some years of the entire research period and zinc, cadmium and cobalt in soils had concentrations exceeding the permissible gross values by 6.3, 3.8 and almost 11 times, respectively. Lead had the lowest concentrations among heavy metals, no more than 2 times.

A comparison of the results of the two works made it possible to partially assess changes in the level of soil contamination by heavy metals over the ten-year period. During the analysis, deposits and enterprises that are sources of emissions were mapped to assess the possibility of movement of heavy metal particles. For some sources, the wind direction was not always predominant, but part of the time there were wind directions towards the pollutant deposition zones. The movement of heavy metal emissions above the soil surface occurs over a longer distance, compared to the transport of pollutants by air flows crossing the waters of Lake Balkash. The temperature difference between land-water and the temperature distribution along the height above the water surface are restraining mechanisms for moving air masses carrying heavy metal particles. Thus, when pollutants are transported over the surface of water body, the deposition of the pollutant occurs at a closer distance from the source than the transfer of the same substances over the soil surface. It is possible that the transfer distance also depends on the particles size.

Conclusion. Over the past decade, the chemical element that has a leading position in terms of maximum concentrations of pollutants has changed. The assumption about the exclusive role of metal mining and processing enterprises as sources of emissions is disproved by the presence of deposits located sometimes in greater proximity to the study area, in comparison with factories to which were assigned the main part of the attributed heavy metal emissions. Despite the fact that some of the deposits are of closed type, the source of pollution is that portion of the mined ore that subsequently rises to the surface of the earth for subsequent transportation and processing.

Different heavy metals from the same emission source can be transported over different distances. This is confirmed by the mosaic distribution of the emission concentration zones themselves and by the distribution of zones with

different pollutant concentrations. A shift in zones of maximum concentration of heavy metals was revealed during the transition from snow cover to soil, which is caused by the different wind speeds and by the migration of pollutants with melt water. The nature of distribution and configuration of zones with different pollutant concentrations indicates the direction of the location of the emission source relative to the heavy metal deposition zones. The configuration of zones with maximum pollutant concentrations has an elongated shape along transporting wind directions [Madibekov A., et.al., (2018)], with lateral (and partially edge) distributions of zones of lower pollutant concentration.

Emissions are not always transported in the direction of winds with maximum frequency. The transfer of heavy metal particles above the soil surface over a longer distance, compared to the transfer of pollutants crossing the water surface of Lake Balkash, occurs due to more homogeneous conditions of the movement of air flows over the land. Circulating air flows in the coastal zone weaken the wind flows carrying heavy metal particles through water spaces.

Further research can be directed to the study of the mechanism of transport of heavy metal particles under different air movement conditions. Also, this study can serve as a basis for regulations on the implementation of environmental protection measures at mines and heavy metal deposits in areas adjacent to the territory of the "Ile-Balkash" State Natural Reserve.

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