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Pollution impact on lakes quality of Russian Arctic region

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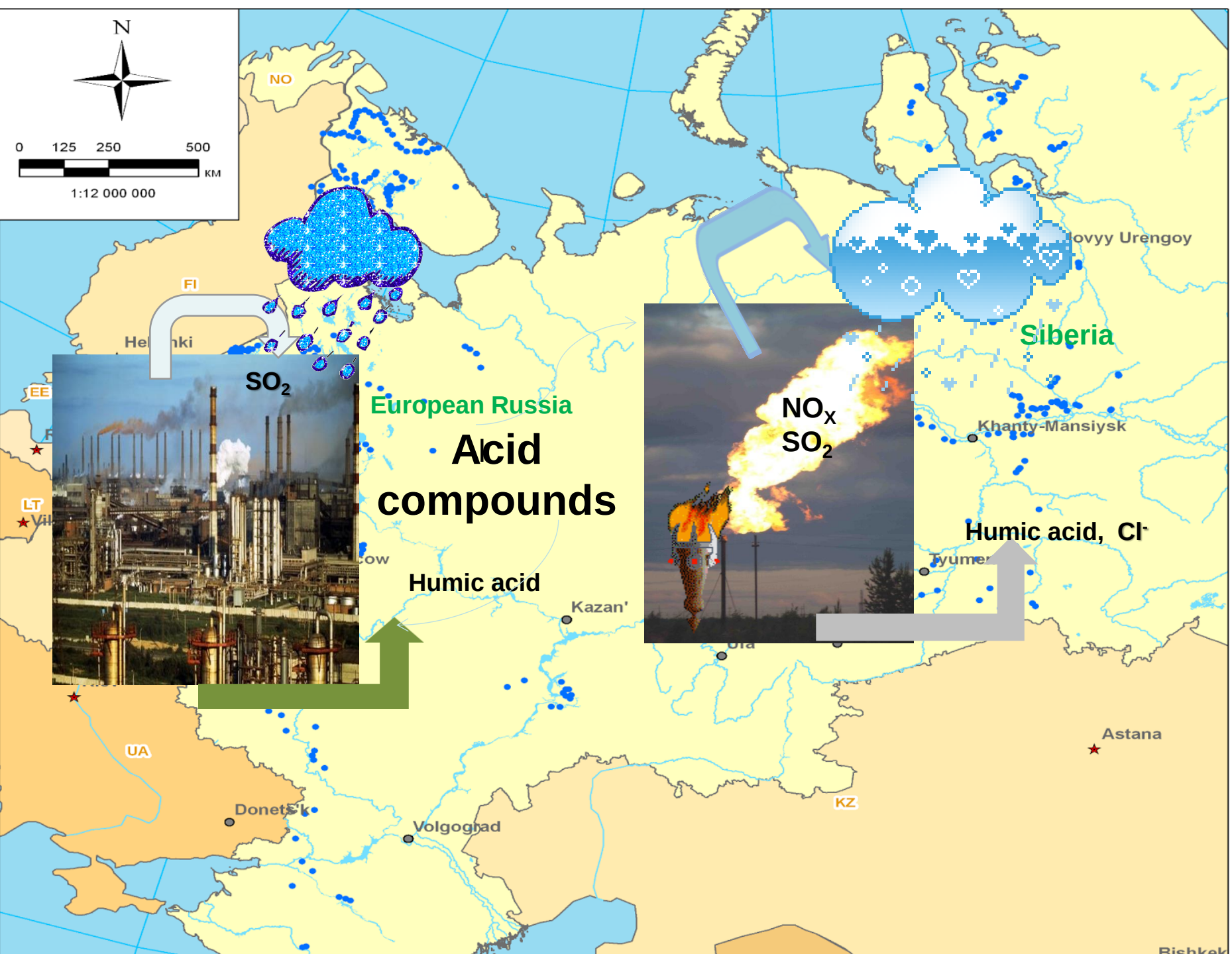
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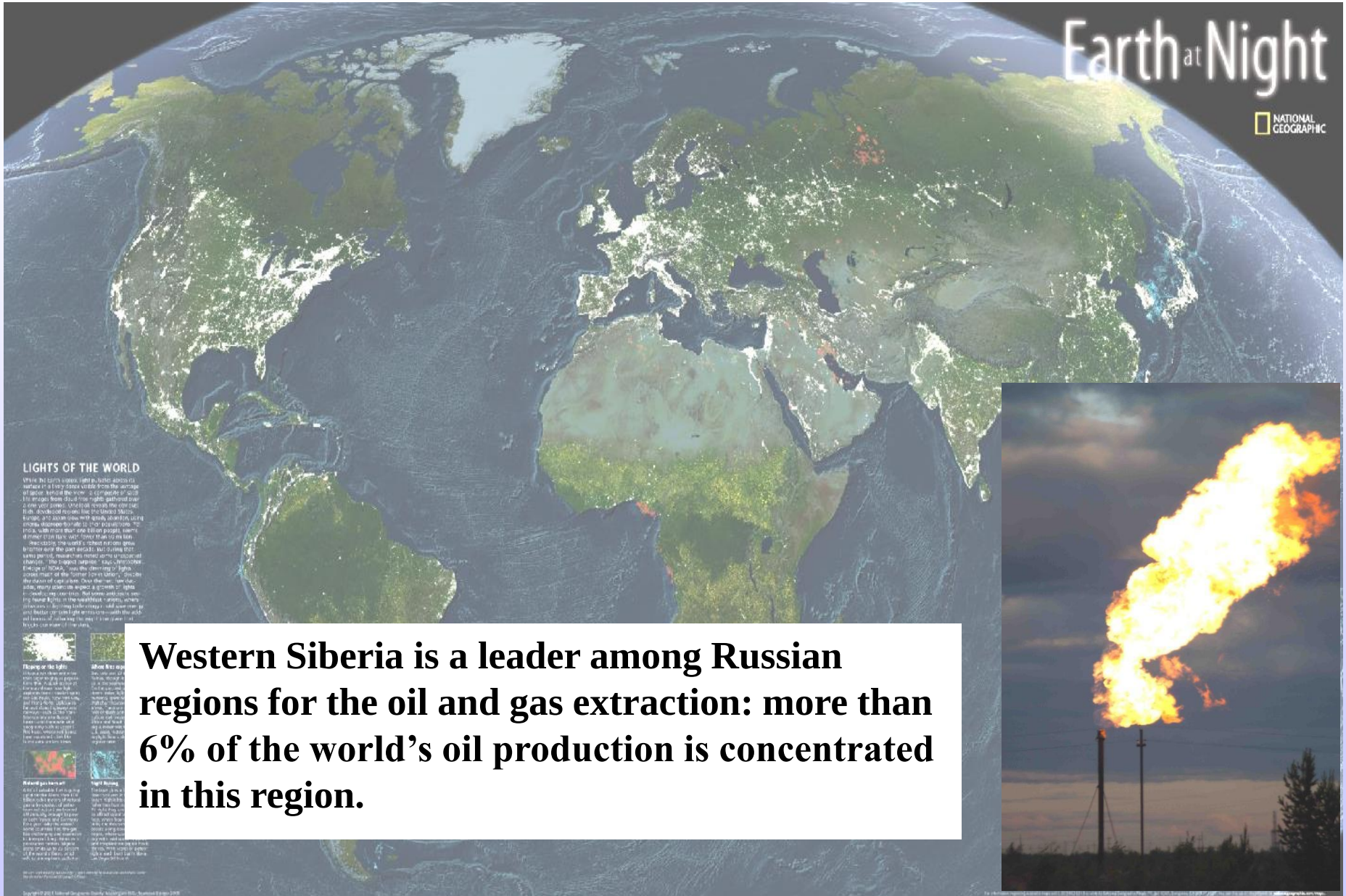
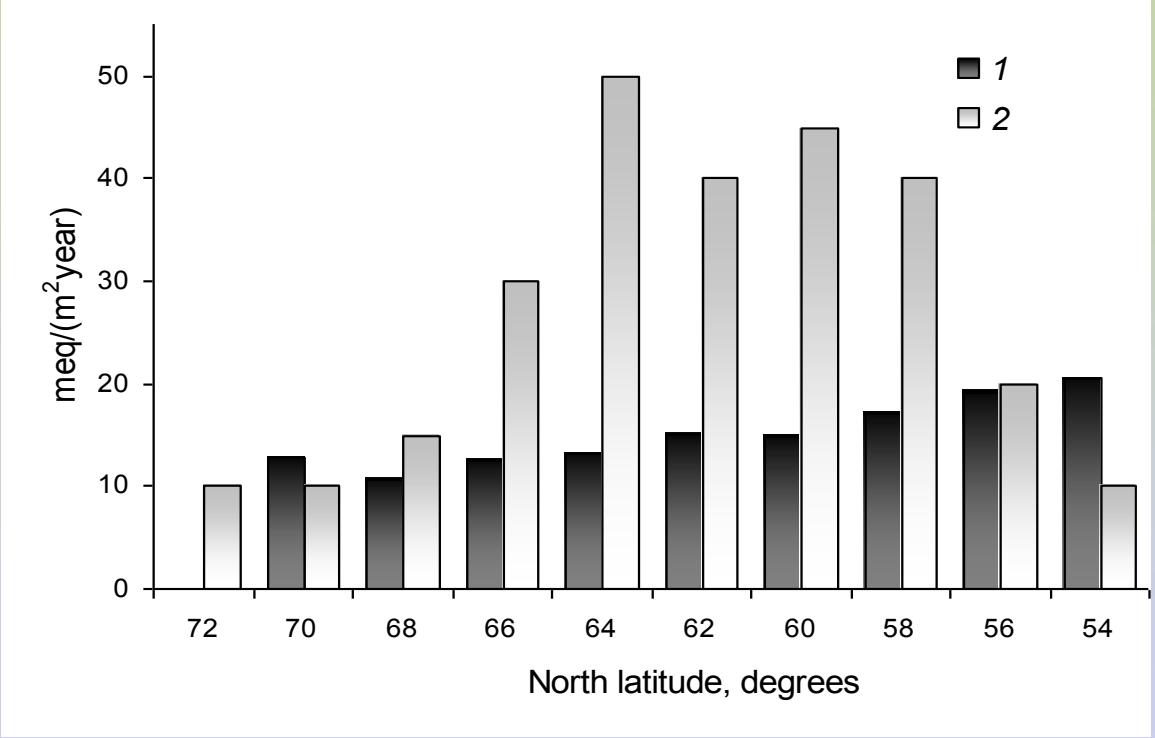
Bishkek
Novyy Urengoy
Siberia
European Russia
SO_2
NO_X
SO_2
Acid compounds
Humic acid
Humic acid, Cl^-

Gas flaring during of oil production in Western Siberia leads to air pollution by oxides of nitrogen, sulfur, chlorine.



Western Siberia is a leader among Russian regions for the oil and gas extraction: more than 6% of the world's oil production is concentrated in this region.

Deposition



Deposition of strong acids (meq/m^{2}year) by the latitudinal gradient **in European territory of Russia - 1** (EMEP, 2000) and **in Western Siberia - 2** (Semenov, 2002)

pH of precipitation

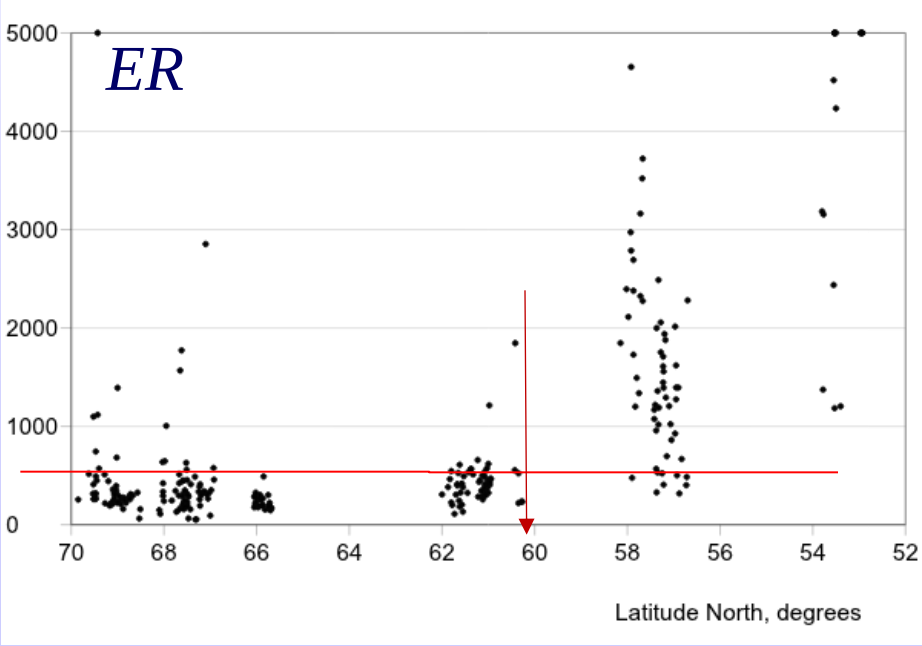
Region	pH of precipitation	
	Min	Max
North and North-West of ER	3.1 3.4	6.2 6.3
Center of ER	3.2	7.0
South of ER	3.1	7.1
Urals and the Urals region	4.0	7.2
Center of Western Siberia northern coast and north-eastern seas	3.6	7.0

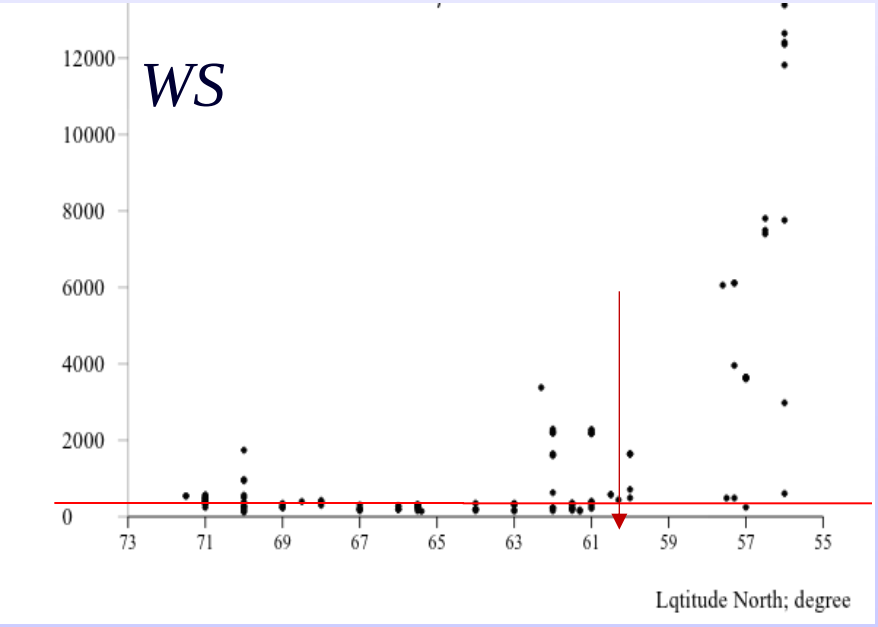
Buffer capacity

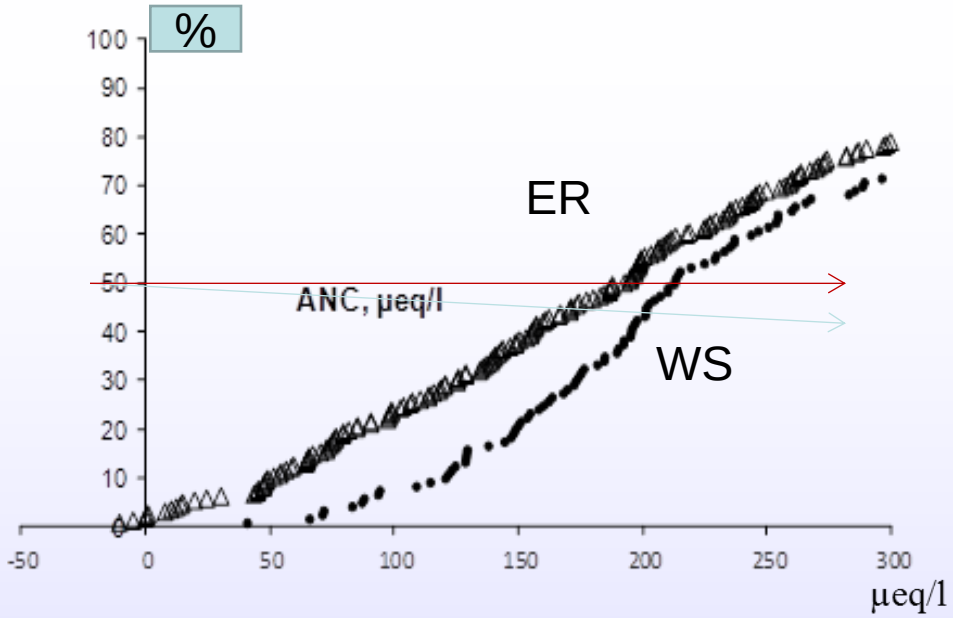
The main feature of both regions is **an increase of cations and alkalinity concentrations** in water towards the south: for ER - 55-60 °, for WS - 55-60 ° North latitude. The lakes of forest-steppe zones in ER and WS are highly resistant to acidification.

Buffer capacity of northern and middle taiga region of ER and WS connect with the features of geology.

Concentration of cations (Ca+Mg+K+Na), µeq/l, in smalls lakes



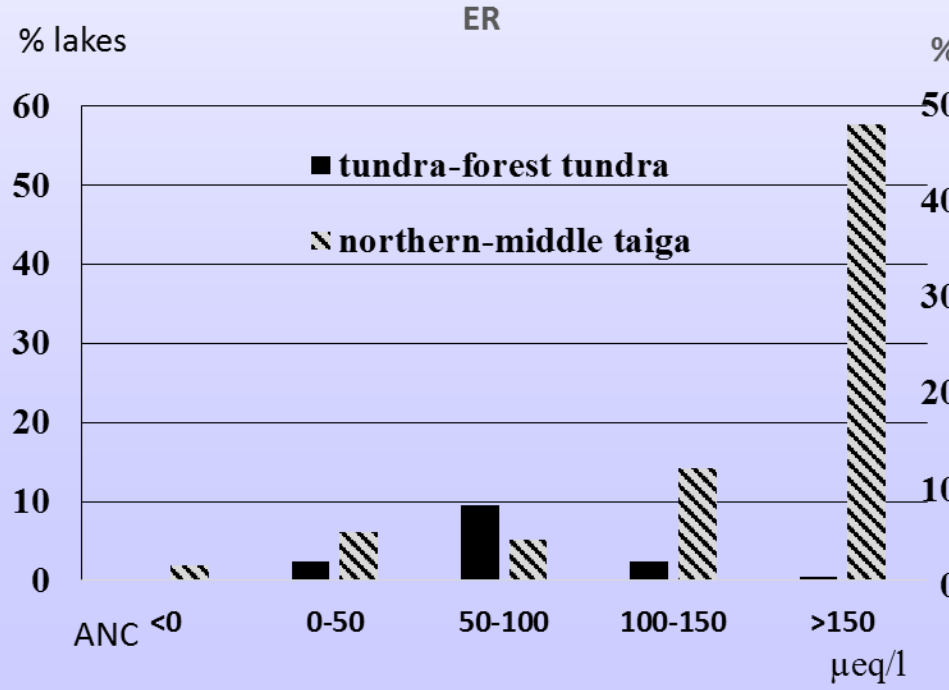


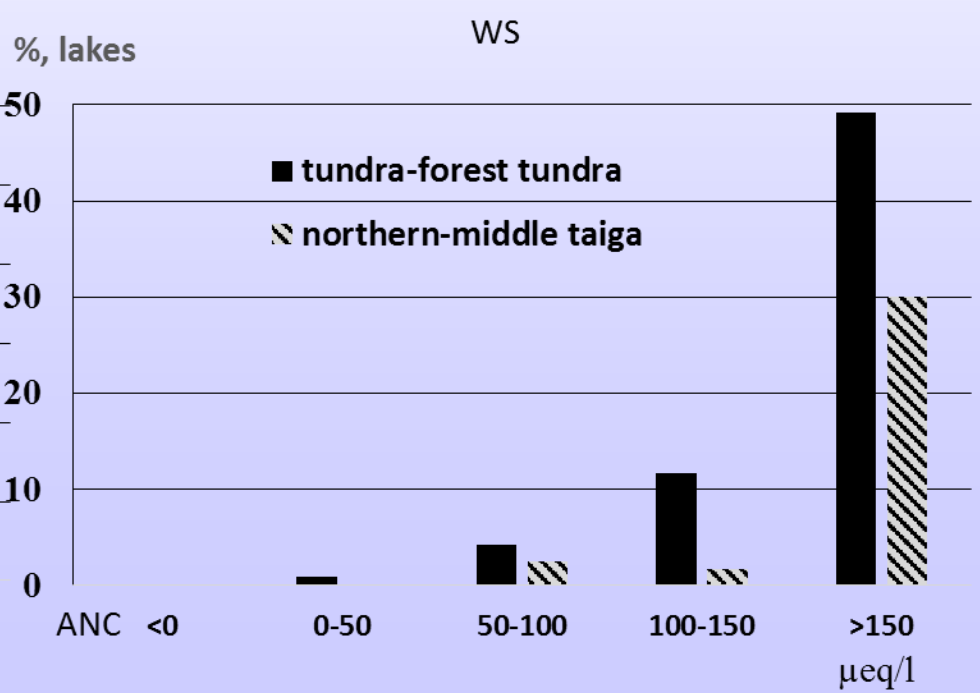


The acid neutralizing capacity of water (ANC, µeq/l) is used to estimate the anthropogenic acidification as a difference between cations and anions of strong acids (Henriksen et. al., 1992)

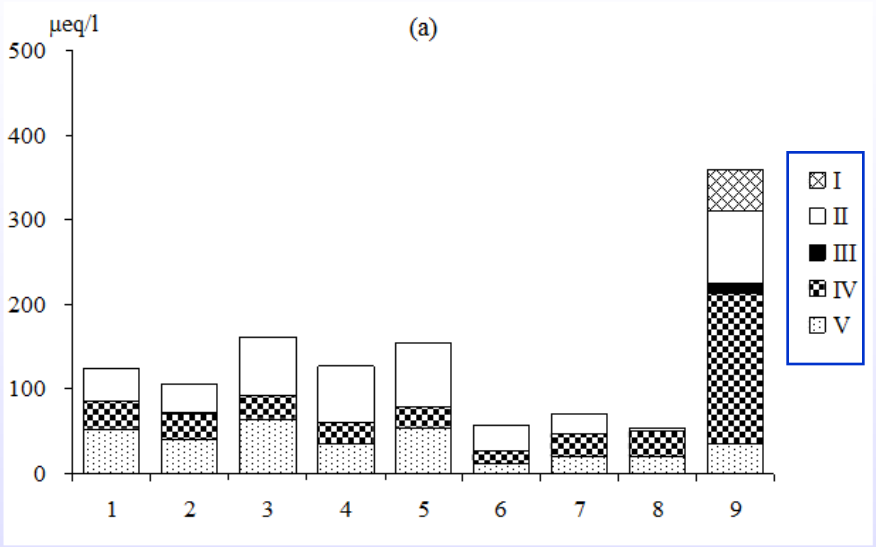
1. $ANC1=Ca^{2+}+Mg^{2+}+Na^{+}+K^{+}-SO_4^{2-}-NO_3^{-}$

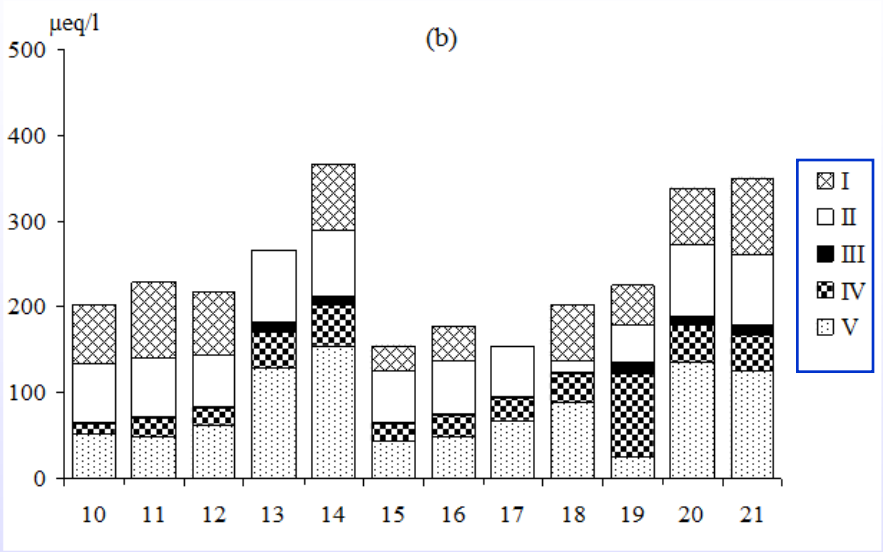
2. $ANC2=HCO_3^{-}+A^{n-}-H^{+}-Al^{3+}$





The anionic composition (I – Alk. II - A^{n-}. III – NO_3^-. IV – SO_4^{2-}. V – Cl^-) of the water lakes with **pH <5** on the ER (a) (1 - in the tundra, 2-8 - in the northern taiga, 9 - in the middle taiga) and WS (b) (10-12 in the tundra, 13-14 - in the northern taiga, 15-21 - in the middle taiga).





Water acidification due to anthropogenic sulfate is characterized of ER.
In the acidic lakes of WS the water contained: chlorides, nitrates and sulfates.
Chlorides (lakes 13. 14. 20. 21) are dominated in majority lakes, but in same lake sulfates are dominated (lake 19).
Concentration of nitrates in water WS are higher in compared to the waters of ER.

NO^-_3

i) Delivery with the marsh waters, wetland and marsh is widely developed in the WS

(Nорг = 49.7·DOC – 114. (r=0.87. n=120);

i) the gas flaring forms the nitrogen oxides;

Cl^-

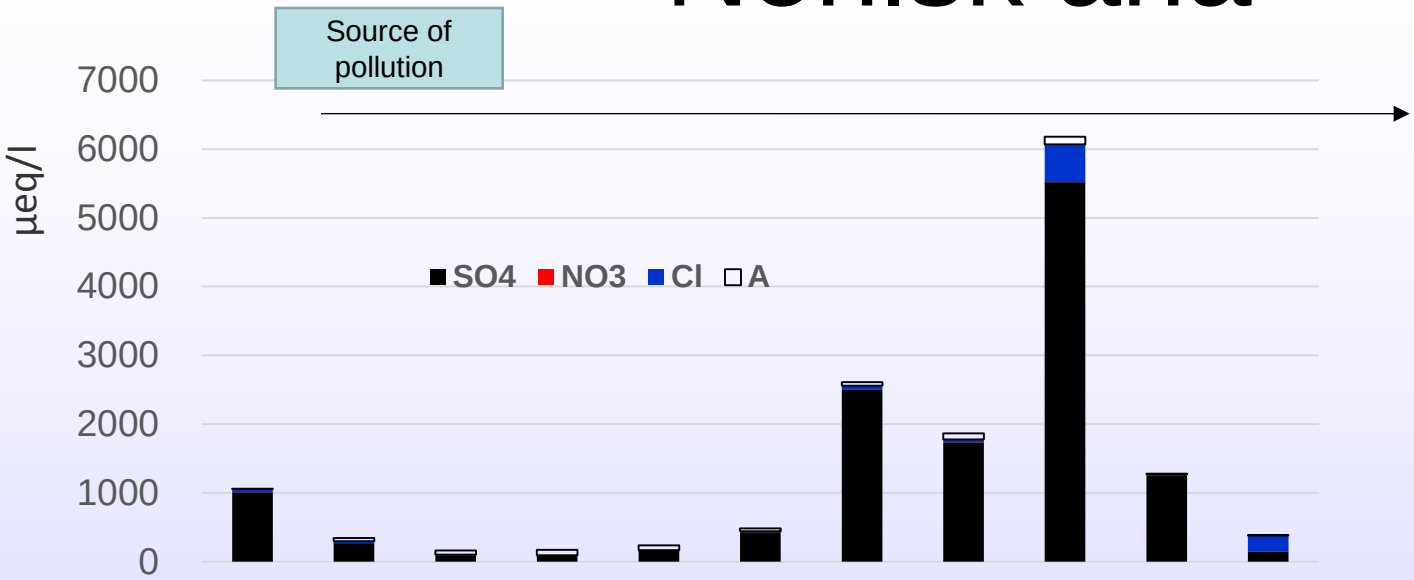
i) WS is located on the site of paleosee area and Quaternary rocks contain a amount of chloride (Arkhipov et al.. 1987).

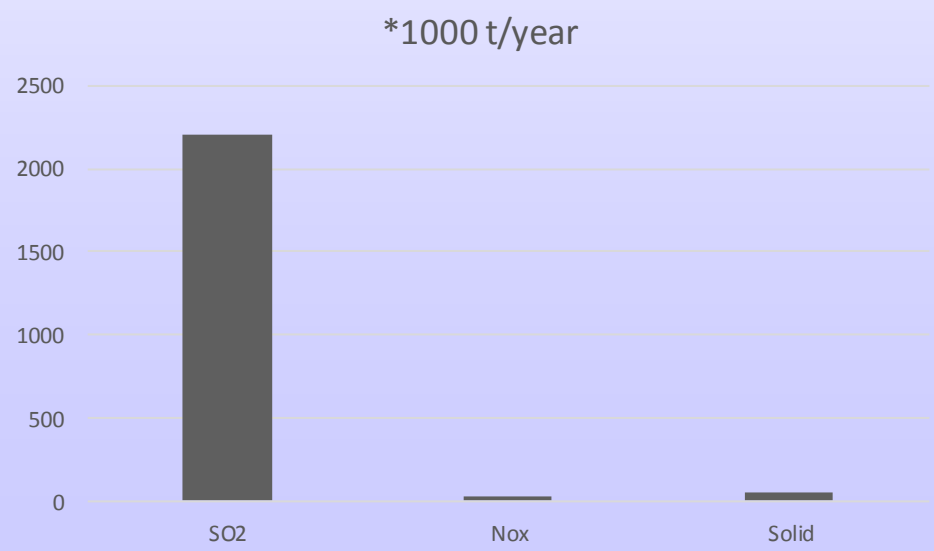
ii) The chlorides are present in the waters of WS as part of pollution of the oil and gas fields development (Kiriushin et al.. 2013).

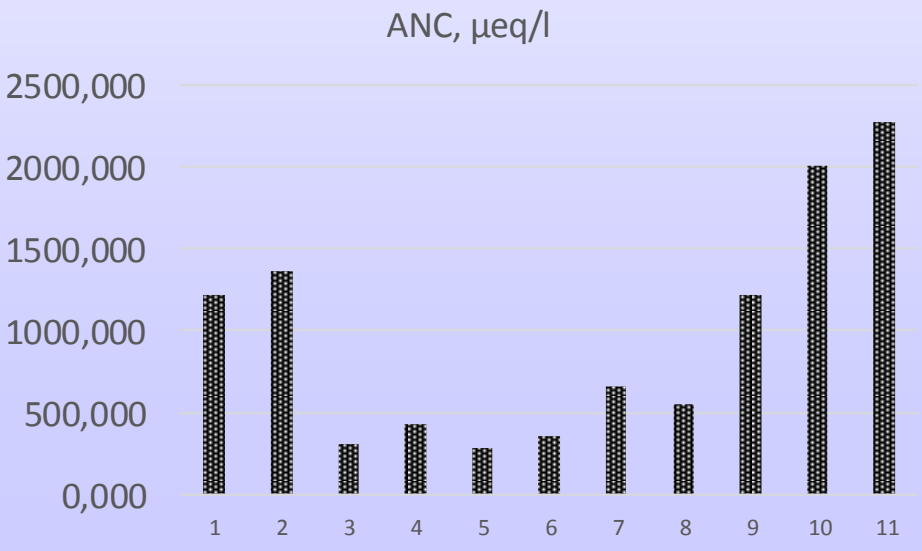
Organic compound (A^-)

Natural humus acids enters with the marsh waters.

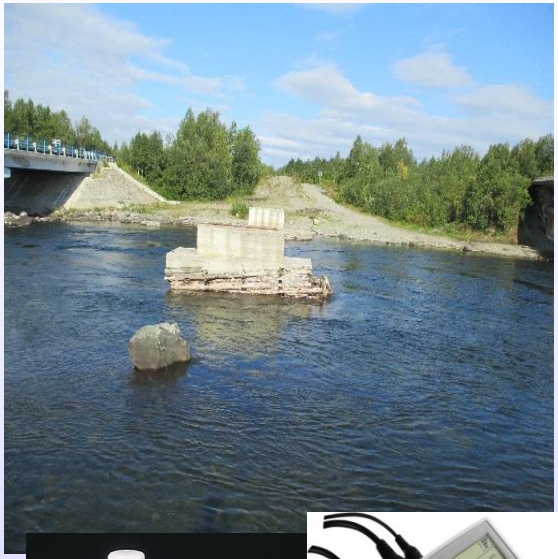
Norilsk aria







Forms specification



РОССИЙСКАЯ ФЕДЕРАЦИЯ

СВИДЕТЕЛЬСТВО

о государственной регистрации программы для ЭВМ

№ 2015617036

ACIDFORMMET

Правообладатель: *Федеральное государственное бюджетное учреждение науки Ордена Ленина и Ордена Октябрьской революции Институт геохимии и аналитической химии им. В.И. Вернадского Российской академии наук (ГЕОХИ РАН) (RU)*

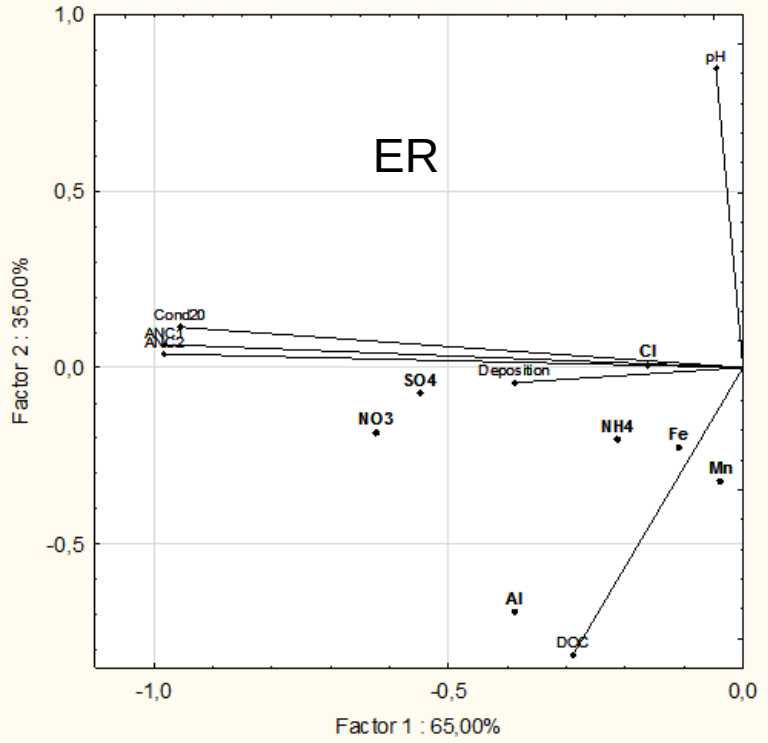
Авторы: *Дину Марина Ивановна (RU), Моисеенко Татьяна Ивановна (RU)*

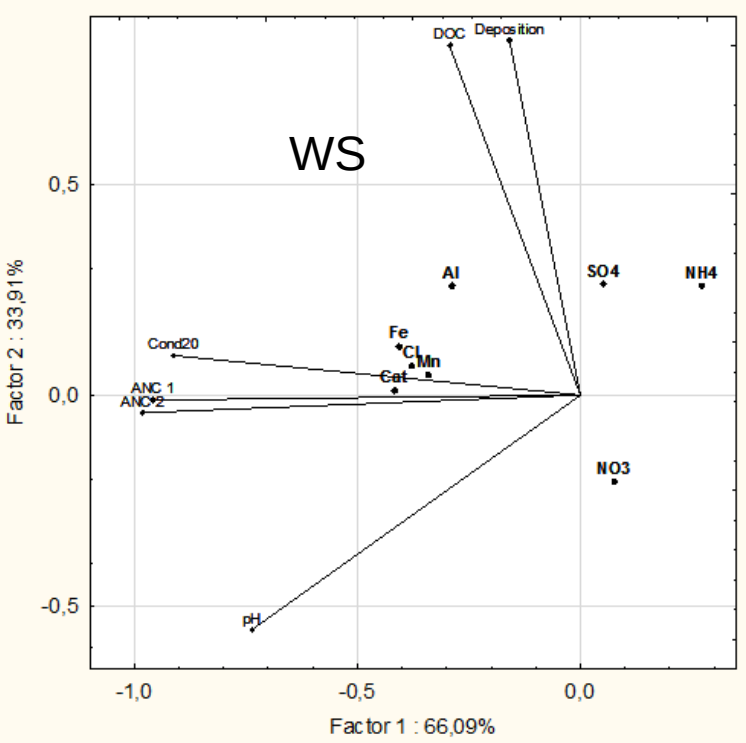
Заявка № 2015612317
Дата поступления 26 марта 2015 г.
Дата государственной регистрации в Реестре программ для ЭВМ *29 июня 2015 г.*

Врио руководителя Федеральной службы по интеллектуальной собственности

Л.Л. Кирий

In addition to conducting model experiments were performed calculations of the forms of metals (a technique Dinu Moiseenko. 2015) on the basis of data on the chemical composition of the water the lakes. Results showed high similarity - more than 80% for ions of iron, aluminum and heavy metals, the subgroup metals of chromium and tin, etc.



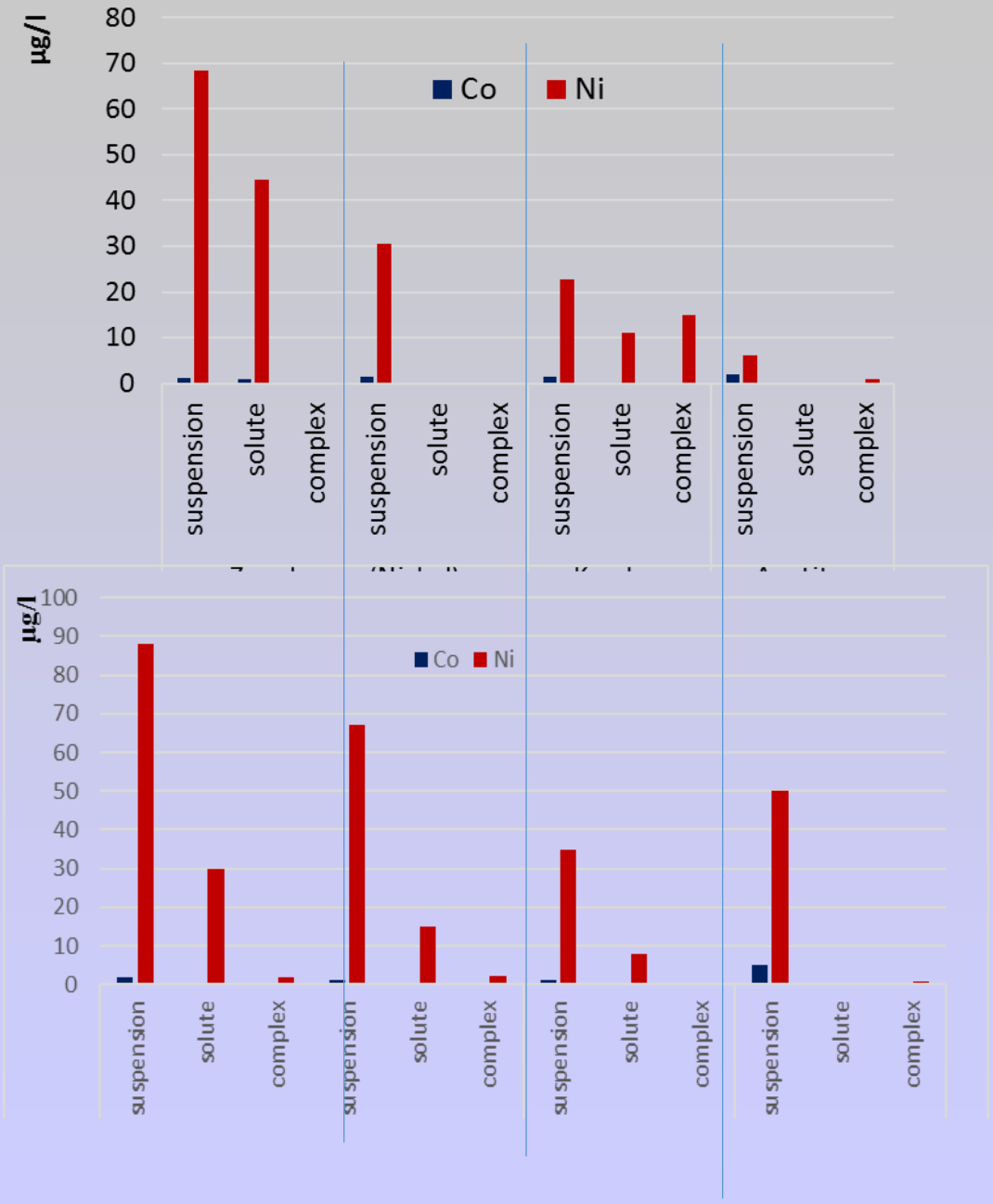


We have chosen same main explanatory variables and tested with used a PCA and RDA technique. According to the results of the calculation: **ANC 1 and ANC 2 are very close** that means the reliable of analyzes.

In ER: SO_4^{2-}, Cl^- and NO_3^- mostly have an affinity for Cond. In WS: SO_4^{2-} have an affinity for Deposition.

In WS water Cl^- have an affinity for Cond. But nitrate is inert to the selected axes. Despite the more higher sulfate concentrations in waters ER the technogenic sulfates also have a significant effect in the water lakes WS.

The greatest acid deposition in an areas with steady geological formations to acidification was found. This is reflected in synchronization of deposition increase and the water buffering to acidification towards the south.



Kola **Lakes** near source of pollution

The affinity of these elements to an organic substance as follows:

Fe>Al>Zn>Ni>Cu>Pb>La>Ce>Co

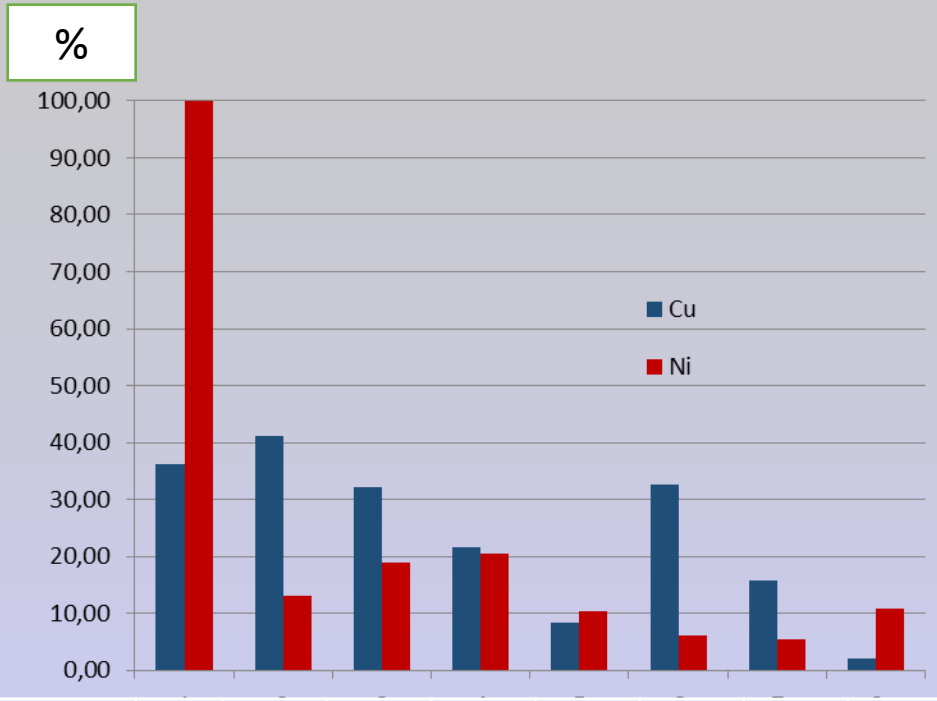
Norilsk Lakes near source of pollution

TOC (Mn) << 5 mg O/l

Degradation organic matter

ANC >>> 1000 µeq/l

Very significant reduction of complex forms of nickel and copper, as well as their total contents was found.



Parameters	1	2	3	4	5	6	7	8
pH	6.50	6.55	6.25	6.18	6.64	5.99	6.16	6.48
Cond20	56	24	22	29	27	38	27	30
Color	58	18	30	51	28	55	67	62
COD Mn	10.54	3.76	6.87	9.29	5.58	13.74	11.00	10.67
AlK	316	85	73	140	151	67	116	156

The distribution of metal affinity for organic substances should be
Lake1 - Lake 4
Ni>Cu>Fe>=Al>Y

Lake 4 – Lake 8

Fe>Al>Cu>Ni>Y

Critical Loads and its exiding

$$CL = ([BC_o^*] - [ANC_{limit}])\, Q - BC_d^*$$

$$BC_o^* = [BC^*]_t - F\,\Delta([SO_4^*] + [NO_3]) = [BC^*]_t - F\,(([SO_4^*]_t + [NO_3]_t) - ([SO_4^*]_o + [NO_3]_o))$$

$$F = \sin(\pi/2)\,[BC]_t / S$$

$$[SO_4]_0^* = 15 + 0.16[BC_t)$$ * (Henriksen et al., 1992)

European Russia

$BC_o = [BC]_t - F\,(([SO_4]_t - [SO_4]_o)$

Zones of tundra, forest-tundra and northern taiga (Kola Peninsula):
$[SO_4^*]_o = 15.3 + 0.02\,[BC^*]_t$. $r = 0.71$. $p < 0.001$;
Zone of the middle taiga (Karelia):
$[SO_4^*]_o = 15.4 + 0.11\,[BC^*]_t$. $r = 0.64$. $p < 0.001$;
Zone of mixed forests:
$[SO_4^*]_o = 15.2 + 0.05\,[BC^*]_t$. $r = 0.68$. $p < 0.001$.

S is 400 μeq / l for the tundra and taiga zones.
S is 1100 μeq / l for mixed ER forests.

$CL_{ex} = CL - SO_4^*{}_{dep} - NO_{3dep} + BC^*_{dep}$

Western Siberia

$BC_o = [BC]_t - F\,(([SO_4]_t - [SO_4]_o) + ([NO_3]_t - [NO_3]_o) + ([Cl]_t - [Cl_{Na}]))$

$[NO_3]_o = 0.118\,[A^{n-}]_t$.

(Cl_{Na} is compensated by Na)

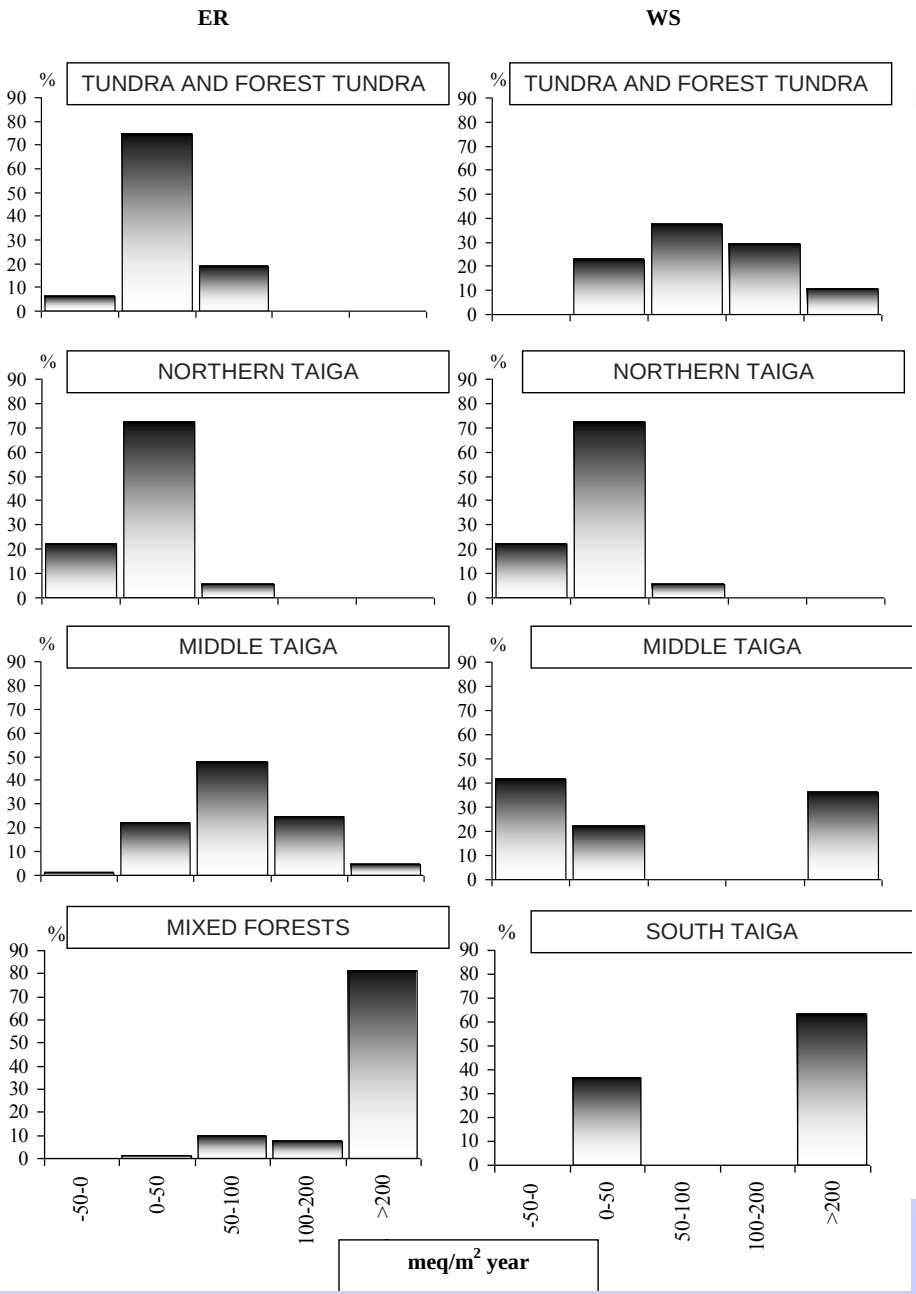
Zones of tundra, forest-tundra and northern taiga:
$[SO_4]_o = 2.67 + 0.021\,[BC]_t$. $r = 0.72$. $p < 0.001$;
Zone of the middle taiga:
$[SO_4]_o = 16.9 + 0.015\,[BC]_t$. $r = 0.76$. $p < 0.001$;
Zone of southern taiga:
$[SO_4]_o = 12.4 + 0.002\,[BC]_t$. $r = 0.69$. $p < 0.005$.

S is 500 μeq / l for the tundra and northern taiga zones.
S is 1250 μeq / l for the middle taiga
S is 3000 μeq / l for the southern taiga.

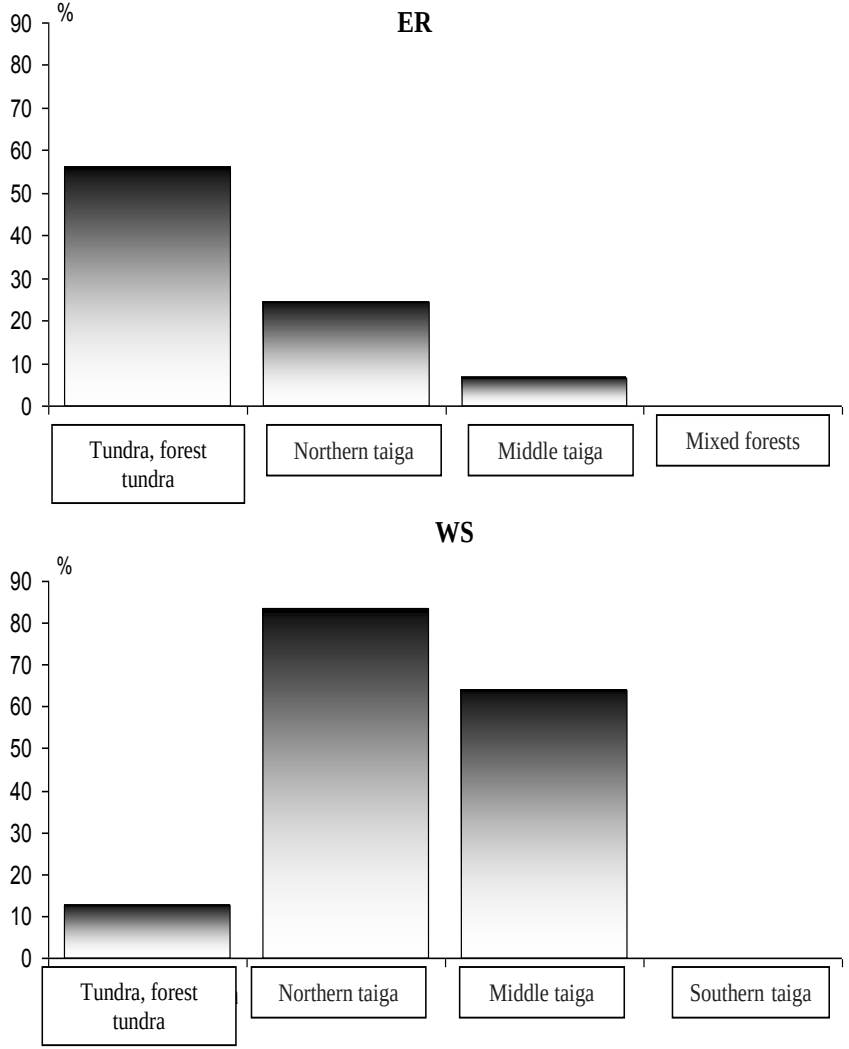
$CL_{ex} = CL - SO_{4dep} - NO_{3dep} - Cl_{dep} + BC_{dep}$.

Thus, the necessary date for estimating the flow of cations into water systems ensuring neutralization of technogenic acids have been determined. Taking into account the complete and correctly obtained hydro-chemical information. ANClimit was adopted as 50, μeq/l

CL

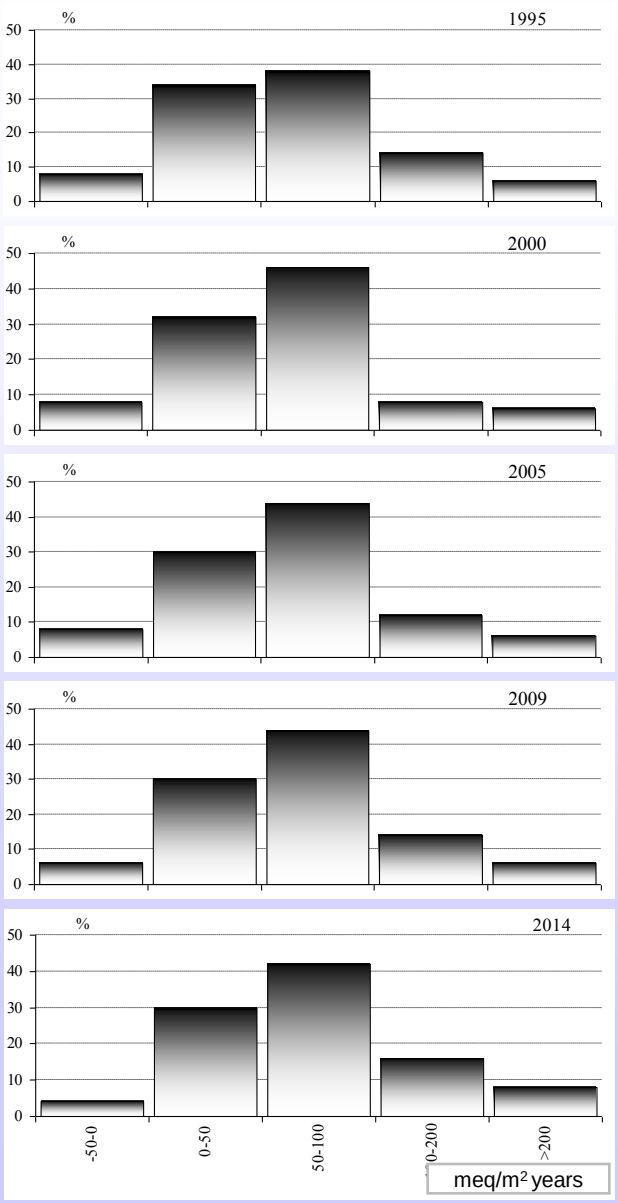

ER
WS
TUNDRA AND FOREST TUNDRA
NORTHERN TAIGA
MIDDLE TAIGA
MIXED FORESTS
SOUTH TAIGA
%
-50-0
0-50
50-100
100-200
>200
meq/m2 year

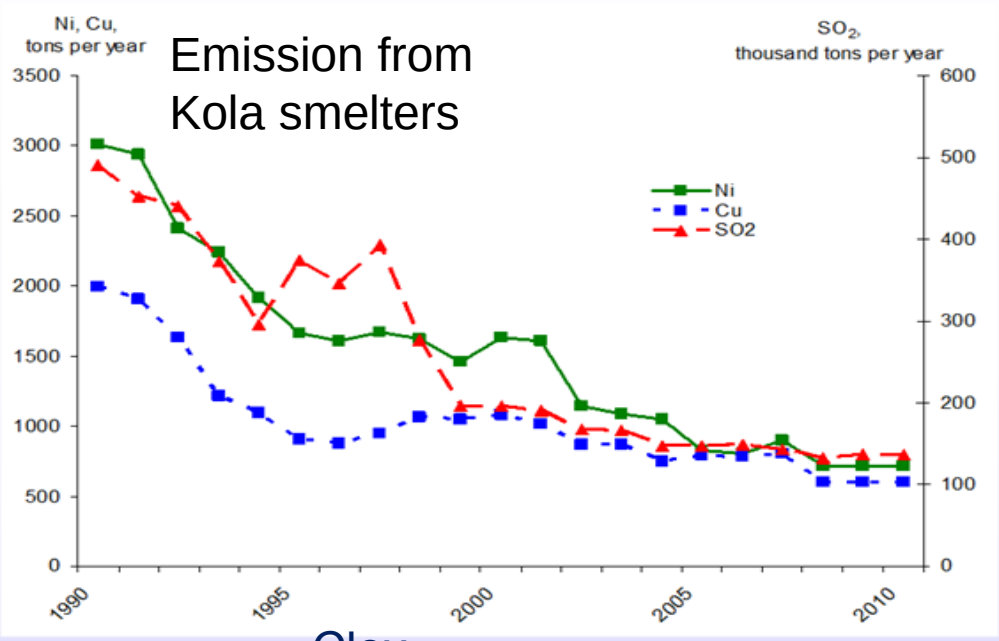
CLex


ER
WS
%
Tundra, forest tundra
Northern taiga
Middle taiga
Mixed forests
Southern taiga

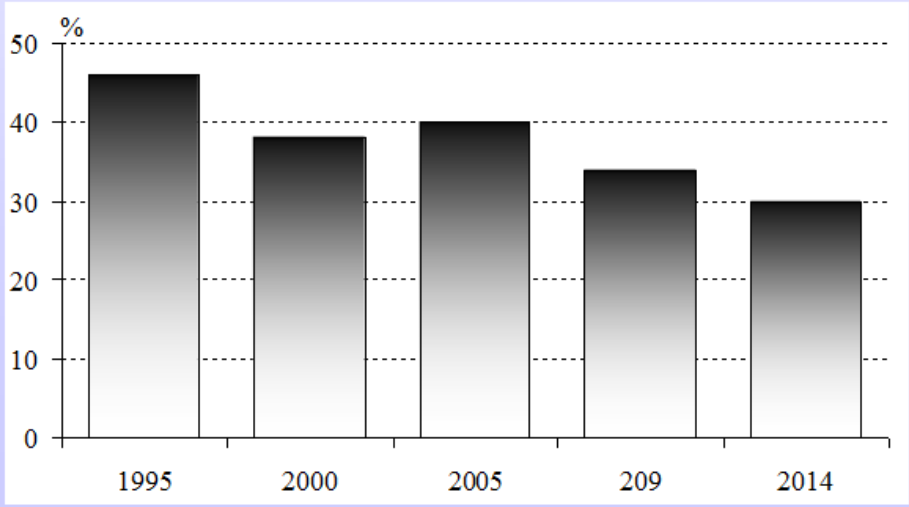
Long-term trends- recovery

CL





Clex



Conclusions

1. On the European territory of Russia, lakes with high buffer capacity are located in the taiga climatic zones, in Siberia - in the tundra regions. This is due to geochemical factors (geological rocks).

2. High anthropogenic influence (in the European territory of Russia - copper-nickel production in Western Siberia - oil refining complexes, in Eastern Siberia - Norilsk Nickel) determines the various chemical equilibria in natural waters.

For example, in the Norilsk region (from 0 to 500 km from the source), the absence of metal complexes with organic matter of water

3. The calculated critical loads and their exceedances for the European territory of Russia and Western Siberia showed the differences in the parameters for the climatic zones of the territories

THANK YOU

FOR YOUR ATTENTION !