Geochemical characteristic of springs of the East of the Moscow region

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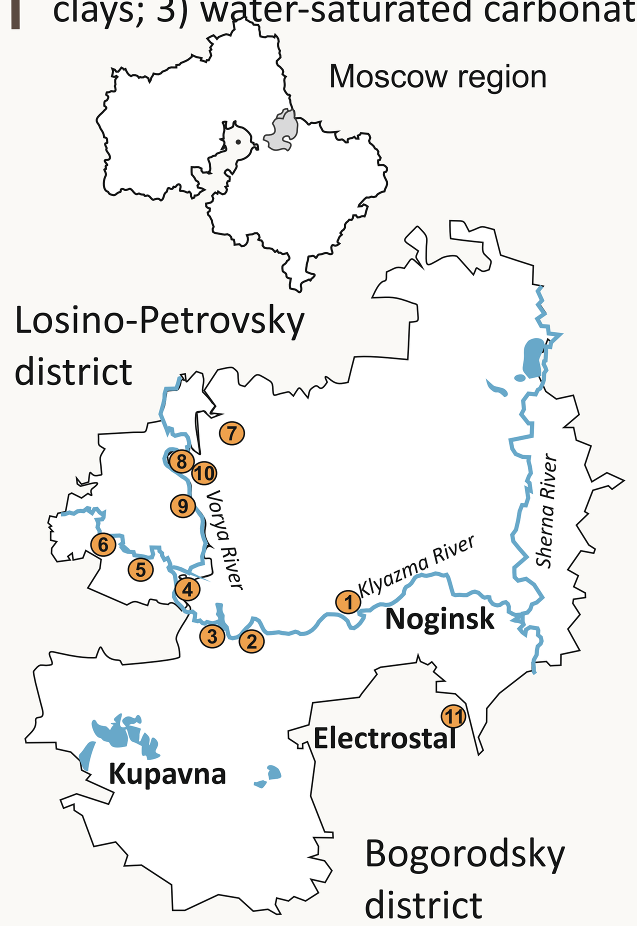
Abstract

The paper studies the anthropogenic impact on the water of springs for the Bogorodsky and Losino-Petrovsky urban districts (east of Moscow region). The samples of 12 springs have been analyzed for pH and electrical conductivity (EC), COD, main components (Na^+, K^+, Ca^{2+}, Mg^{2+}, NH_4^+, SO_4^{2-}, Cl^-, HCO_3^- and NO_3^-), trace elements (Co, Ni, Cu, Zn, Cd, Pb, Sr, Ba, Mn, Fe). It was shown that the springs are localized in Quaternary sediments, which are poorly protected from human impacts. Overall, the waters present high loads of SO_4^{2-} and Cl^- and nitrogen compounds. In terms of NO_3^- and Nh_4^+ ion content, COD values and iron concentration several samples did not correspond to standard for maximum permissible concentration (MPC) for drinking water.

Introduction

Active use of springs as drinking sources by residents of the study area makes it necessary to pay attention to quality of water. The springs of the east of Moscow region are mainly fed by atmospheric precipitation but the springs feeding area is influenced by the sewage systems in residential areas, sulfate, nitrogen and potassium fertilizers from agro-industrial enterprises, as well as road anti-icing agents at winter period. The analysis of the composition of spring waters and the comparison of the results obtained with sanitary standards makes it possible to identify pollution and take measures to protect the waters. The focus of our study is the characterization of the present hydrogeochemical situation of the spring water quality in the east of Moscow region.

The study area is within Meshcherskaya lowland (East European Plain), landscape is determined by the river Klyazma and its tributaries, in the valleys of which spring outlets are located. The climate of the study area is temperate continental, the average annual rainfall is about 520 mm, the average height of snow cover is 25-35 cm. The hydrogeology structure is presented by the sequence: 1) water-saturated sands, sandy loams and other Quaternary and Mesozoic sediments; 2) Upper Jurassic waterproof clays; 3) water-saturated carbonate rocks C_3g_{2-1}.

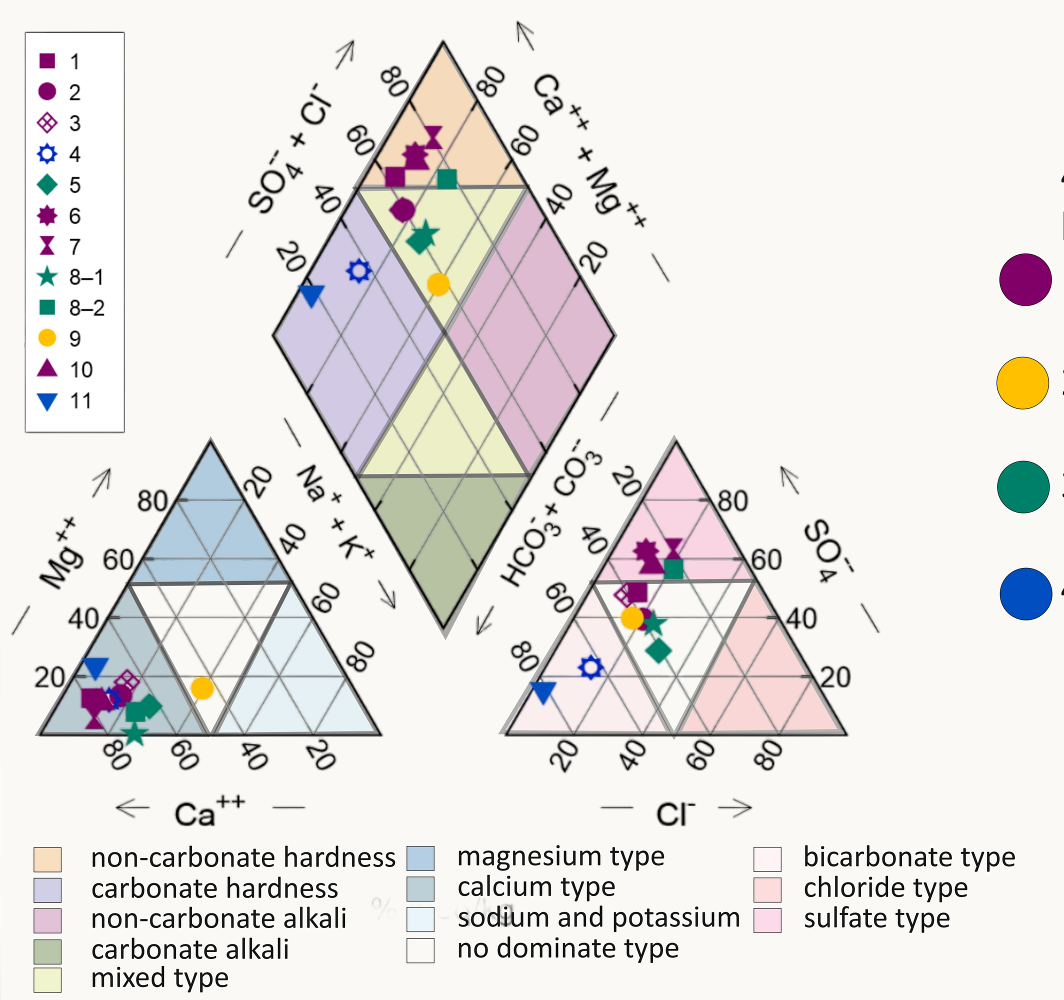


Materials And Methods

Water samples were taken in the autumn of 2022 and in the winter of 2023. pH and EC were measured at the sampling points (portable meter BLE-C600). The Ca^{2+}, Mg^{2+}, HCO_3^-, Cl^- were determined by titration techniques, NH_4^+, NO_3^- – by potentiometry (EXPERT-001, Econix-Expert, Russia), SO_4^{2-} – by XRD [1], the COD value – by photometry (Portlab 501), K^+, Na^+, trace elements – by ISP-MS (SUPEC 7000, Focused Photonics Inc). The composition of winter and autumn waters is similar for all springs

[1]. X-ray fluorescence analysis for sulfate ion in aqueous solutionsby the dried-drop technique using a portable spectrometer / T. N. Lubkova, O. A. Lipatnikova, O. R. Filatova, I. V. Balykova // Moscow University Geology Bulletin. 2022. Vol. 77, no. 3. P. 305–314. DOI 10.3103/S0145875222030085

Results. Major ions



4 groups of waters are selected by major ions (on the x axes):

1) **Ca-Cl-SO_4-HCO_3,** *(springs 1, 2, 3, 6, 7, 10);*
2) **mixed** (spring 9).
3) **Na-Ca-(SO_4)-HCO_3-Cl,** *(springs 5 and 8-1, 8-2);*
4) **(Mg)-Ca-HCO_3,** *(springs 4 and 11);*

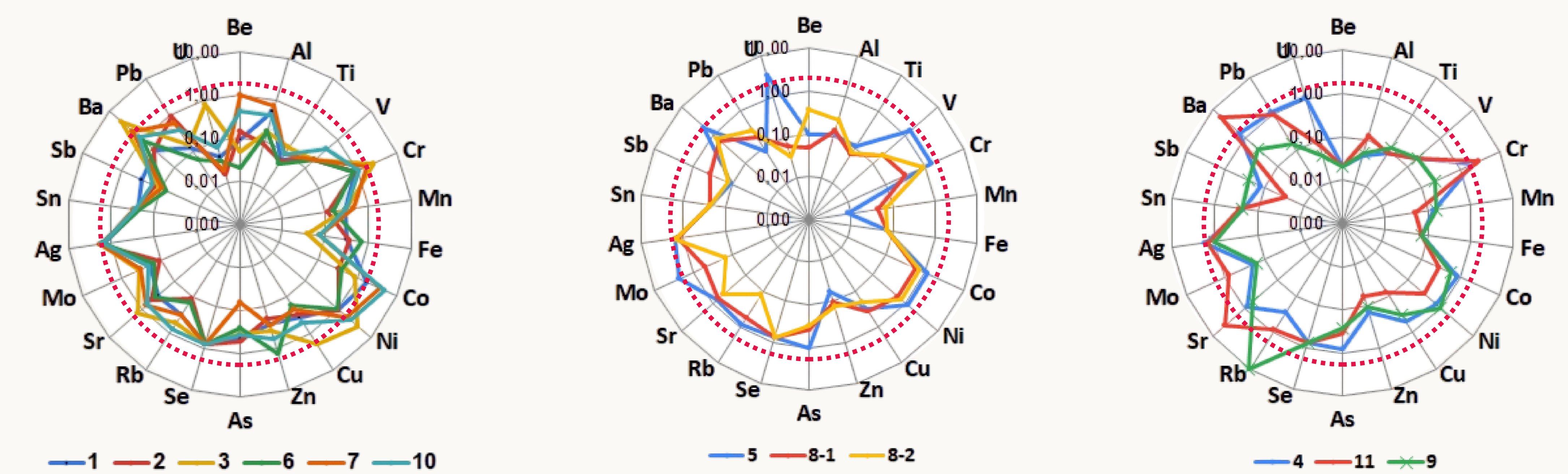
The table shows the results obtained, as well as WHO recommendations for drinking water. We have identified concentrations that do not meet the standard.

Spring №	1	2	3	4	5	6	7	8-1	8-2	9	10	11	WHO*
Ca, mg/L	13	16	52	77	60	14	15	22	18	29	27	75	-
Mg, mg/L	2	3	14	12	9	2	1	0	2	10	4	24	-
Na, mg/L	2	5	19	24	42	3	3	15	12	18	6	5	200
K, mg/L	1	3	8	7	10	1	2	2	1	34	3	5	-
NH4+, mg/L	1	1	2	2	2	0,5	0,5	0,4	1	6	1	1	2
HCO3, mg/L	23	31	112	220	110	22	13	44	23	78	35	308	30–400
SO4-, mg/L	15	15	65	39	38	25	21	22	29	36	36	28	250
Cl, mg/L	9	16	33	48	83	8	12	29	22	32	18	14	250
(NO3)-, mg/L	4	6	27	36	46	3	8	10	10	37	11	3	50
pH	6,5	6,5	6,1	6,0	5,8	6,5	6,5	6,4	6,4	5,9	6,4	6,5	6,5–8,5
COD	9	8	7	13	16	1	3	10	9	15	9	5	
TDS, mg/L	76	92	334	473	419	77	75	162	125	305	131	494	600
Heardness	15	19	66	90	70	16	17	22	20	39	32	99	100-300

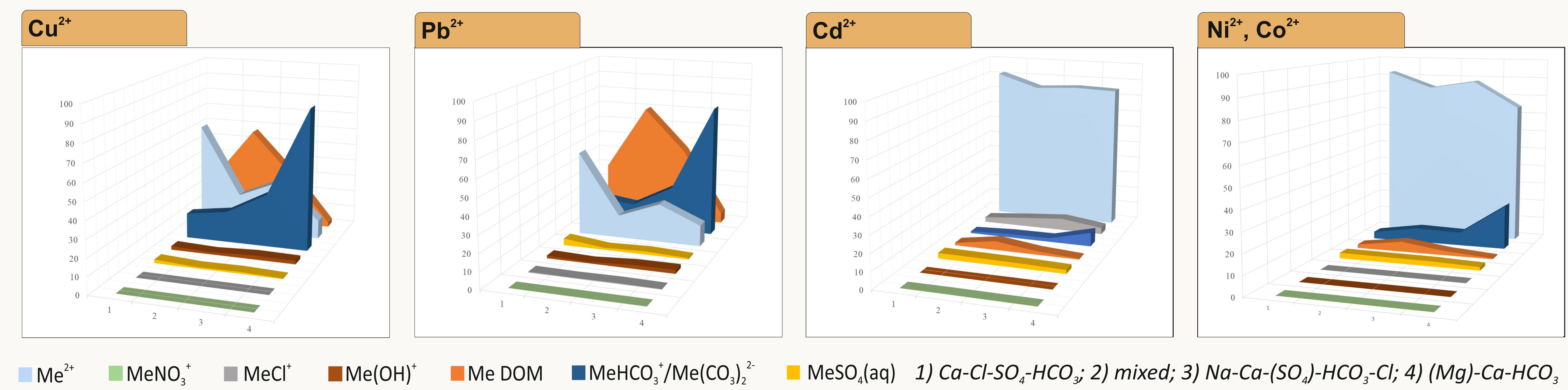
*World Health Organization. Guidelines for Drinking—Water Quality, 4th ed.; WHO: Geneva, Switzerland, 2017

Results. Trace elements

Concentrations of trace elements were companied to average content of trace elements in waters of hypergenesis zones, temperate climate regions [2]. Red circles in diagrams show double excess of trace elements average content. Deviation of Rb could be caused by its presence in potassium fertilizer. Cr, Co, Ni and Cu ions show a tendency to increase in springs that were arranged in the form of a well. The aquifer that feeds the spring 11 is located in pre-Quaternary deposits (presumably, Cretaceous). Therefore, Ba and Sr elevated concentrations could be provided by composition of rocks.



[2]. Hydrogeology. Hydrogeochemistry. Ed. by Shvartsev S.L. Novosibirsk: Science. 1982. 284 p.



Thermodynamic calculation of trace elements dissolved forms was carried out the Visual-MINTEQ. We have plotted them on a graf into four groups, separated by major ion, to show the differences in trace element forms depending on the predominance of major ions. It was found out from the analysis that the free form is predominates for most selected ions (example Ni, Co). Cu, Pb and Cd, shown in individual figures, have some remarkable features. The elevated concentration of organic matter (DOM=0.375COD) for the 2nd and 3rd groups resulted in the dominant role of organic complexes of Pb and Cu. Spring waters composition of the 4th group are determined only by bicarbonate ion. This leads to the dominance of bicarbonate form for Cu and Pb. Cd is also characterized by the presence of chloride forms (3–7%).

Conclusions

Finding suggest that the studied springs belong to modern and Quaternary deposits experiencing anthropogenic impact from the agricultural and transport industries that evidenced by the nitrogen compounds in the water and the significant role of Cl^- and SO_4^{2-}. However, the most of sanitary-chemical indicators of water (mineralization, pH, total hardness, Cl^-, SO_4^{2-}, Mg^{2+}, Na^+) are significantly below their regulatory limit for drinking water and the trace elements concentrations are mainly corresponds to average content of trace elements in waters of hypergenesis zones, temperate climate regions. Increased concentrations of the major pollutant-ions in the composition of water lead to transformation of the forms of transfer of separate trace elements in waters.