Ecohydrogeological characteristics of spring waters in rural areas (northeast of Moscow region)

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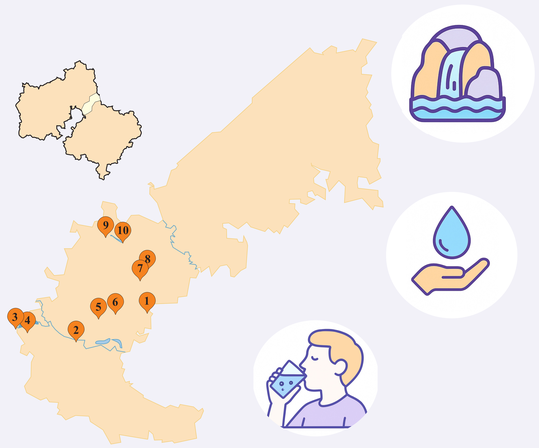
EGU25-11817

Introduction

Springs are widely used by people for various purposes, including cooking, watering agricultural land, and even in religious or cultural rituals. Their popularity is due to the perception of spring water as pure, natural and healthy. Springs often serve as a source of drinking water for the population, especially in rural areas where access to centralized water supply is limited. In agriculture, water from springs is used for watering plants, which is especially important in private farms and suburban areas. Due to urbanization, the problem of spring pollution is acute: agro-industrial, industrial and domestic wastewater leads to the ingress of various salts into the water, which degrade its drinking quality.

In recent decades, the Moscow Region has seen an increase in developed land due to the conversion of forested areas for other uses. The expansion of settlements and agricultural land has raised anthropogenic impact on water bodies. Although Shelkovsky District is less affected by urban development compared to other districts, groundwater is still impacted by industrial and domestic wastewater, altering its composition.

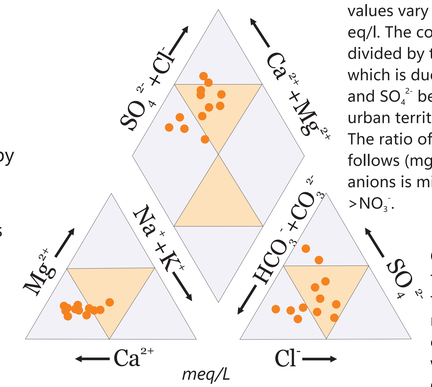
The geological structure of the territory includes Devonian, Upper Carboniferous, Upper Jurassic and Lower Cretaceous terrigenous-carbonate rocks, overlapped by thin Quaternary sandy deposits. Surface sediments are permeable to polluted runoff waters, which can increase the vulnerability of groundwater and reduce its quality.



Shelkovsky district

Methods and Materials

Water samples were taken in the autumn of 2023 and in the winter of 2024. 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[3], K^+, Na^+, trace elements – by ISP-MS (SUPEC 7000, Focused Photonics Inc). The composition of winter and autumn waters is similar for all springs.

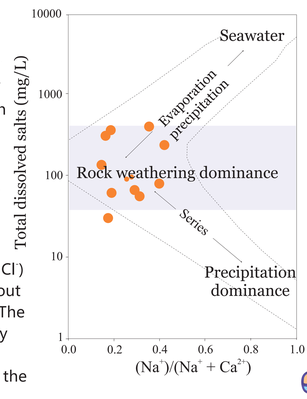


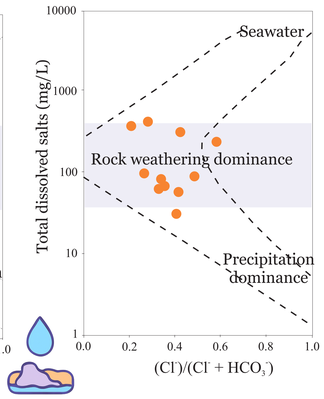
Results. Hydrochemical characteristics and water origin

The spring waters are slightly mineralized (M=0,1-0,5 g/l), pH values vary from 5,5 to 7,5. The total hardness is 0,63-5,7 mg-eq/l. The composition of the water is variable. Springs could be divided by the content of major anions: the dominance of HCO_3^- which is due to natural causes. In some cases the presence of Cl^- and SO_4^{2-} because of the use of fertilizers and deicing reagents in urban territories.

The ratio of cations in waters according to their content is as follows (mg/l): $Ca^{2+} > Na^+ > Mg^{2+} > K^+$; the composition of the anions is mixed, but for most samples it is true: $HCO_3^- > Cl^- > SO_4^{2-} > NO_3^-$.

Comparison of the ratios $Cl^-/(Cl^-+Na^+)$ and $Na^+/(Na^++Cl^-)$ to total dissolved salt was applied in order to figure out the mechanism of spring waters forming (Gibbs, [2]. The results showed that chemical composition is primarily controlled by rock weathering. The composition of waters with reduced mineralization is determined by the components of atmospheric precipitation.



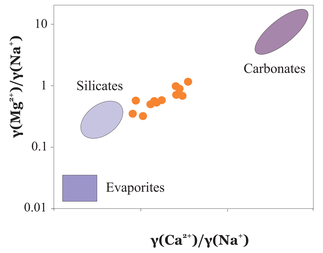


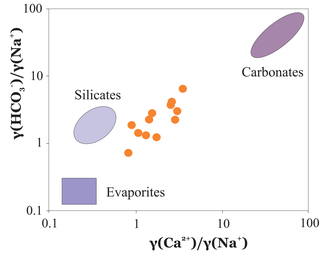
Discussion. Ecological state and anthropogenic impact

The first four springs are characterized by several indicators exceeding the WHO standards for drinking water. As you can see, the waters are exposed to man-made influences, which increase mineralization due to additional sources of calcium, potassium, ammonium, and nitrate.

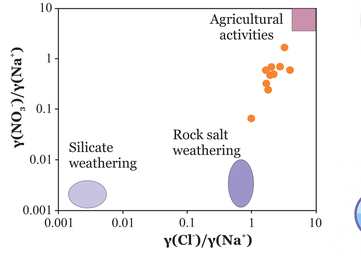
For the rest of the springs, there are no increased concentrations of major ions in the waters. However, it can be noted that the values of pH are below the standard range. This is due to the fact that at a temperature of 12-15 °C, the carbonate equilibrium shifts.

Spring №	Ca^{2+}	Mg^{2+}	Na^+	K^+	HCO_3^-	SO_4^{2-}	Cl^-	NH_4^+	NO_3^-	TDS	pH
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	-
1	44	12	32	9	61	35	85	**3,7**	**48**	329	**5,8**
2	**91**	17	50	5	189	136	75	0,7	9	**573**	6,7
3	**101**	14	20	**19**	160	48	117	**2,0**	32	**513**	6,4
4	**123**	21	28	4	**317**	60	83	0,4	39	**676**	7,0
5	27	6	9	1	30	31	28	0,2	17	148	**5,8**
6	12	2	2	1	15	23	10	0,1	5	70	**5,2**
7	29	6	11	1	83	22	30	0,2	7	190	**5,6**
8	48	10	8	3	140	32	24	0,4	10	276	**6,2**
9-1	14	3	6	4	23	35	16	0,4	10	113	**5,5**
9-2	15	6	10	11	49	16	25	1,1	9	141	**5,7**
9-3	17	4	7	6	42	13	23	0,5	9	122	**6,1**
10	18	4	4	5	42	23	21	0,3	19	138	**6,4**
WHO	75	50	200	12	240	250	250	2	45	500	6,5-8,5





The main contribution to the formation of the water composition is made by the weathering of silicate rocks. [1] The shift of the points to the evaporite area indicates anthropogenic salinization of the territory.



Technogenic influence is also manifested in the increased content of NO_3^- in the waters of springs, which is associated with the widespread use of nitrogen fertilizers in agricultural farms and private households in the Shelkovsky district.

Conclusions

The studied spring waters are formed due to the interaction of atmospheric precipitation with soils and quaternary sediments.

Nitrogen compounds, chloride and sulfate ions, and an increased content of calcium are observed in the composition of waters, which is due to contamination of these deposits as a result of human activity. The content of these ions in individual springs is higher than recommended by WHO. Deviations from the recommendations for TDS and pH values were also found.

We assume that the main sources of exposure are agriculture, deicing reagents and sewage leaks.

References

Gaillardet J., Dupre B., Louvat P., Allegre C.J. Global silicate weathering and CO2 consumption rates deduced from the chemistry of large rivers // Chemical geology – 1999. – T. 159. – №. 1-4. – C. 3-30.

Gibbs R. J. Mechanisms controlling world water chemistry //Science. – 1970. – T. 170. – №. 3962. – C. 1088-1090.

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.

Zhang, H., Wang, Z., Wang, X. et al. Hydrochemical characterization and health risk assessment of different types of water bodies in Fenghuang Mountain Area, Northeast China. Environ Geochem Health 46, 292 (2024)