VALUATION METHOD OF ECOHYDROLOGY CONDITIONS IN HIGH MOUNTAIN AREAS: AN EXAMPLE OF LAKE BAIKAL BASIN

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INTRODUCTION

One of the urgent problems of hydrological and ecological research in mountain countries is the evaluation of the condition of natural environment subjected to human impact and forecasting of its condition. It can be done on the basis of the analysis of carrier and transformation processes of polluting substances, as well as by revealing indicators of environmental conditions.

Representation of territorial Landscape Geochemical Systems (LGS) can serve as the basis of landscape hydrology division into districts possessing determined levels of geochemical immunity, i.e. self-regulation of migratory processes and "refining" technical genesis. It is necessary to note that the landscape is considered not only as the effect of interaction of natural processes, but also as a system carrying out the work of this interaction. Each such system is characterised by specific interaction of its elements or blocks: precipitation - vegetation - soils - mountain rocks, surface and underground waters, creating individual features characteristics for such a system of migration, transformation, and accumulation of weighted and dissolved substances. The identification of afore-mentioned processes is effectively revealed on the basis of spatial-temporal variability research of the contents of chemical elements in waters of the rivers, which are controlled by landscape structure pools, drainaged by a river network. According to its organisation it is possible to subdivide LGS into elementary and cascade. Elementary LGS form lower steps and represent lithologically similar territories, covered by the same types of soils and, hence, certain vegetation communities. Such territory can be considered as an indivisible landscape-individual. The channels of communication between the components of an elementary landscape are migration flows, consisting of the carrier (moisture flows) phase and the dissolved or firm substances phase. Elementary LGS sets form cascade LGS, where each elementary landscape is part or block of a columbine system.

The flow formation in river pools is determined in general by two main processes, ensuring the transformation of atmospheric precipitation, and accumulation of moisture and its drainage. (Stepanov et al. 1987). The volumes of migration of dissolved substances and their chemical composition, can reliably indicate predominant types of vegetation communities, and soils for periods of mixing in river.

Information about space distribution of other area indicators were used, e.g. physical and mechanical properties of soils, geological formations, and thermal properties (temperature including those of frozen ground). Area characteristics are model predicators (arguments), on which spatial-temporal variability of flow characteristics depend on models for the evaluation of sizes of dissolved sustances are discussed in detail in the paper based on the following relation.

$$\sum_{i=1}^{n} M_i \cdot F_{i,j} = q_{i.f}$$

where $q_{i.f}$ = ionic flow with j-th of pool (mg/sec); M_i = module of ionic flow (mg/sec km^2) with i-th vegetation communities; F_i = its area in j-th river pool, km^2.

Data of 22 rivers falling into the lake Baikal are used, where study on the chemical composition of water is conducted. The majority of studied items are located at the mouths of the rivers. Therefore, the problem of revealing forming conditions of ionic structure of waters within the limits of various (LGS) parts becomes even more urgent. Sampling for separate months with the account of rivers' water drain value during selection of tests are conducted. Through normalisation method (Alekseev 1971) it was possible to establish correlation dependence, mineralisation and flow. On the basis of evaluations of equally assured (chance) sizes of these parameters monthly volumes of ionic flow were calculated. Such techniques of calculations are stipulated by security discrepancy of the average month charges of the rivers and mineralisation owing to nonlinear relations between them.

From the calculation it was possible to evaluate perennial middle size M_i and to calculate mineralisation flows in annual dynamics from 10 main types of floral communities. In all the cases the authentic solutions characterised by high coefficients of multiple correlation (R=0.96-0.98) and steady factors in regression equations (Khaustov 1991) are received. The heaviest size's module of ionic flow are characteristic for larch-pine mountain-taiga forests and make 42.3 tonnes/year/km^2, least from territories of meadow communities, in high mountains, and lowlands (2.74-5.38 tonnes/year/ km^2).

A significant role in the formation of river and ionic flow is played by dark coniferous mountain-taiga forests and their restoration asp-birch and larch-pine forests, appearing at human changes of natural complexes (e.g. radical vegetation on account of clearance, fires etc.).

Tranformation of geochemical stability of a natural system is reflected in quantitative and qualitative alteration of geochemical properties of a water body, formed within the limits of landscape. If M_i with dark pine forests and their restoration series are comparable (19 and 13-15 tonnes/year/km^2), mineralisation of this series sharply grows up to 109-126mg/l (for dark pine forests - 37mg/l). This fact is well traced in annual mode; in this connection there can be scheduled possible ways of forecasting hydrochemical landscapes mode changes as a result of economic activity.

The mineralisation calculation of waters is also conducted on the basis of offered model. The analysis of annual water flow for various LGS has revealed the tendency for water budget atrophy according to exponential rule, that corresponds to representations on drainage by the river network mechanism of the whole columbine.

In fig. 1 there are indicated hydrographes of river modules flow from territories of some predominant vegetation communities. Hydrograph with restoration series (Alekseev 1971) evidently reflects sharp reduction in maximum flow, its large dynamics at recession and low steady values in the cold period of a year. It is connected with the regulating ability of a landscape, because the heaviest scales of human factor in the pool of lake Baikal are connected with the clearing of forests. The suggested method enables us to evaluate the negative effect on quantitative parametres of water and ionic flow and to calculate possible economic damage from woods clearance.

For mineralisation values of river waters a sharp-cut seasonal course is observed, which consists of an available minimum (May-June), when inflows are formed by prevailing snow dissolved in water. Such minima correspond to vegetation communities of mountain tundra and dark-pine mountain-taiga forests in comparison with other communities. The mineralisation values here are close to those in atmospheric condensation, that testifies to the prevalence of surface genesis of waters in river flow with an extremely insignificant share of underground supply. The maximum mineralisation is observed in March, when atrophy of limited stocks of underground waters occurs.

For larch-pine vegetation communities, there exists higher mineralisation for minimum water amount, as well as for its maximum, that testifies to slowed-down character of water exchange within the limits of a territory of their distribution. The reason for this is the low hipsographical location of territories and increase of underground supply share. As a result of evaporation of M_i for a particular LGS, the data on sizes of ionic shown from hydrological unknown area of Lake Baikal were found out and are given in Table 1.

In relation to analysed metals, the received values can be submitted in a kind of number migration, Al-Fe-Cu-Cr-Pb-V, which do not correspond to standard circuit noncluster of chemical elements and vegetation of forest zones. However, this number reflects in the best way mobilisation of chemical elements in river waters of Baikal. The specified law is confirmed by the results of model calculation of the contents of listed elements (Table 2) by recalculating them according to sizes of concentration. Notwithstanding that for Pb and Cu increased accumulation in vegetable is characteristic, their presence in ionic flow can be explained by high clurk contents in soils and rocks of the region.

RESULTS

The proposed method permits us to take into account annual variation of dissolved chemical elements and to obtain the solution effectively, not depending on site and vegetation community combinations; to effectively generalise data by a single hydrogeochemical definition, when it is necessary to present received materials for the control and forecast of geochemical landscapes conditions; to evaluate the role of landscape-geochemical complexes in the formation of integrated flow of dissolved substances; to reveal the most dynamic reaction on humidifying and anthropogenic load of LGS, to study distribution of macrocomponents in LGS and to establish the forms and ways of migration of all generically dangerous species, as well as abilities for survival and maintenance of vegetation with the pupose of drawing up ecology-geochemical maps; to create base stations for background monitoring on representative sites of the main types of landscapes in mountain countries, to conduct searches of useful mineral on secondary aureole diffusion.

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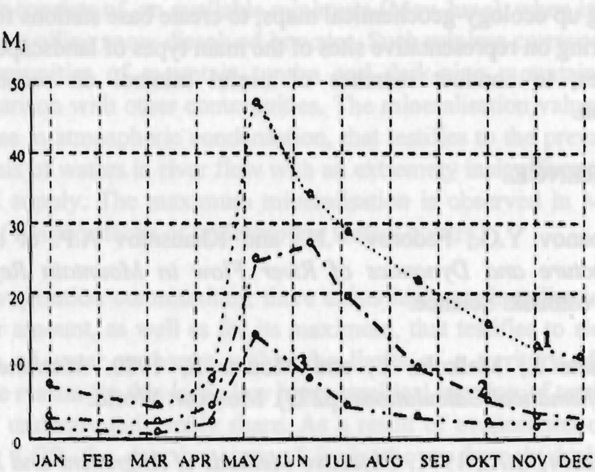

Fig. 1. Hydrograph of river flow with the most representative floral communities of Baikal region [4]
1 - dark-pine mountain-taiga; 2 - larch- pine mountain-taiga; 3 - birch restoration series from dark pine

Table 1. Ionic flow (thousand ton per year) from unstudied territories to the lake Baikal (on the data of floral communities) [4]

Months	Mountain edges					Total
	Primorsky	Baikalsky	Barguzinsky	Ulan-Burgasy	Hamar-Daban	
I	1.0	4.3	7.5	4.3	4.8	21.9
II	0.7	3.1	5.5	3.1	3.7	16.1
III	0.8	3.3	5.8	3.3	4.0	17.2
IV	1.3	4.8	8.8	5.0	4.7	24.6
V	3.8	14.5	26.2	14.7	19.5	78.7
VI	5.4	20.2	38.0	20.0	21.4	105.7
VII	4.9	18.5	31.9	18.0	18.6	91.9
VIII	4.9	18.7	32.4	18.6	19.7	94.3
IX	4.5	16.5	30.3	25.4	16.1	92.8
X	0.3	11.6	18.7	11.6	13.4	55.6
XI	1.6	7.3	10.4	6.1	5.5	30.9
XII	2.0	5.7	12.6	7.2	6.9	34.4
Year	31.0	128.5	228.4	137.4	138.3	663.6

Table 2. Sizes of modules flow (μg/s km²) and their concentration (μg/l) in flows (under feature) from the territory of the lake Baikal floral communities basin in October 1978 [4]

№№	Cu	Pb	Al	V	Cr	Fe
1	24.8	3.4	1440.0	1.4	6.5	770.0
	0.68	0.09	39.7	0.04	0.21	21.5
2	2.1	0.4	307.0	0.3	1.4	173.0
	0.84	0.16	124.0	0.12	0.57	70.0
3	12.7	1.8	830.0	0.7	3.6	428.0
	0.68	0.1	44.9	0.04	0.19	23.1
4	24.7	6.7	5960.0	6.0	28.2	3360.0
	1.17	0.32	280.0	0.28	1.34	159.0
5	6.8	4.0	3910.0	1.6	14.9	1770
	1.28	0.75	738.0	0.3	2.81	334.0
6	0.1	1.0	1260.0	1.1	5.9	698.0
	0.1	0.3	420.0	0.37	1.98	233.0
7	16.9	2.1	623.0	0.4	2.3	276.0
	0.63	0.08	23.4	0.01	0.09	10.4
8	2.1	0.5	349.0	0.14	1.3	154.0
	0.7	1.66	116.0	0.05	0.43	51.3

Note. 1 - mountain tundra; 2 - alpine meadows; 3 - dark pine thin forests on slope valley; 4 - dark pine mountain-taiga forests; 5 - larch-pine mountain-taiga forests; 6 - larch-pine series from dark pine forests; 7 - cedar brushwood; 8 - larch-pine mountain-hollow forests