PROCEEDINGS OF THE YEREVAN STATE UNIVERSITY

Chemistry and Biology 2016, № 2, p. 55–58

COMMUNICATIONS

Chemistry

ANALYSIS OF ENVIRONMENTAL STATUS OF THE RIVER VOGHJI WITH ARMENIAN INDEX OF WATER QUALITY

A. G. SIMONYAN *

Centre for Ecological Safety YSU, Armenia

Water quality of the Rivers Voghji, Artsvanik and Geghi was evaluated by Armenian Water Quality Index (AWQI) for the first time. It was shown that from the source to the mouth of the river was observed the increase of the value of AWQI that indicates a decline in the water quality of the rivers from the 1st to the 2nd class of pollution. Correlation between the AWQI and other water quality indexes was established.

***Keywords*:** the Voghji River, water quality index, Armenian Water Quality Index, entropy, geo-ecological syntropy.

Introduction. The study of ecological status of RA rivers is important both for evaluation of water quality of those objects and for their further rational use. Development of water quality assessment methods using conventional indicators comprehensively taking into account various properties of surface water is an important issue. The complex evaluation is an extremely difficult task that requires a simultaneous consideration of a variety of properties of the water object. For evaluation of water contamination degree the comprehensive indicators are used, which make possible to evaluate the contamination of water at the same time on a wide range of quality indicators. Water Contamination Index (WCI), Canadian Water Quality Index (CWQI) and Specific-combinatorial Water Quality Index (SCWQI) are used for evaluating surface water quality in RA [1–3]. It must be noted that most developed complex characteristics of water object in one way or another are connected with the existing maximum permissible concentration (MPC). In the last years we suggest Entropic Water Quality Index (EWQI) for evaluating surface water quality [4, 5].

The aim of presented paper is evaluation of Voghji River and its tributaries by Armenian Water Quality Index (AWQI).

Determination Procedure. Different processes in hydroecological systems both with increasing and decreasing of entropy can occur. The concept of entropy has many interpretations in various fields of human knowledge. The system

* E-mail: Sim-simov@mail.ru

interacts with the outside world as a whole. An open system can exchange with the environment by energy, material and, which is not less important, information. The last is necessary for the proper functioning of the system. C. Shannon was the first, who related concepts of entropy and information [6]. He was suggesting that entropy is the amount of information attributable to one basic message source, generating statistically independent reports. Getting any amount of information is equal to lost entropy amount. Information entropy for independent random event x with N possible states is calculated by the equation:

$$H = -\sum_{i=1}^{N} p_i \log_2 p_i,$$

where p_i is the probability of an event occurrence frequency.

Entropy general equation of Shannon has been used for the first time by MacArtur in 1955 for evaluating the degree of structuring biogenesis [7]. In 1957 R. Margalef postulated theoretical concept that meets a variety of entropy for a random selection of species from the community [8]. As a result of these works widespread and universal recognition received Shannon index H sometimes referred to as a Shannon information index of diversity [5]:

$$H = -\sum n_i / N \log_2 (n_i / N).$$

Pollution of water systems can be represented as a system of hydro-chemical parameters (elements), the concentration of which exceeds the MPC. Then, in the Shannon equation p_i is the probability of the number of cases of MPC excess of *i*-substance or water indicator of total cases of MPC (N), $p_i = n_i / N$.

$$H = \log_2 N - I,$$

where $I = \sum n \log_2 n / N$ is the geo-ecological syntropy [9].

The following computation algorithm is used for determination I, H, EWQI and AWQI values:

1. Determines the number of cases of MPC excess (n) of *i*-substance or indicator of water;
2. Estimates the total amount of cases the maximum permissible concentration: $N = \sum n$;
3. Computes $\log_2 N$, $n \log_2 n$ and $\sum n \log_2 n$;
4. Determines geo-ecological syntropy I and entropy H;
5. Then EWQI is determined: $G = H / I$;
6. The total amount multiplicity MAC exceeds are estimated: $M = \sum m$;
7. Computes $\log_2 M$;
8. Armenian Water Quality Index was obtained: AWQI $= G + 0.1 \log_2 M$.

Results and Discussion. The Voghji River is the left tributary of the Aras River. It rises near the town of Kajaran in Armenia from the merger Rivers Kadzharants and Kaputdzhur. The River is 85 *km*. Two monitoring posts located on the River Voghji: № 91 – 1.7 *km* above the City of Kajaran, № 92 – 1.8 *km* below the City of Kajaran, № 93 – 0.8 *km* above the City of Kapan, № 94 – 0.8 *km* below the City of Kapan. The Artsvanik River is the left tributary of the Voghji and has 17 *km* length. On Artsvanik River located positions № 95 – 0.5 *km* above the tailings the Artsvanik and № 96 – 3.0 *km* above the City of Kapan. The Geghi River is the left tributary the Voghji. On the River Geghi located positions № 97 – 0.5 *km* above the Adzhabadzha and № 98 – at the estuary.

It was established that the water of the River Voghji regularly exceeded the value of BOD_5 and concentrations of nitrite and ammonium ions, due to water pollution by domestic wastewater. It was shown that water of the Voghji River is also contaminated by some metals. Thus, the concentration of copper, zinc, vanadium, aluminum, cobalt, manganese and selenium regularly exceed MPC in river water. For example, in the position № 92 of the Voghji River BOD_5, NO_2^-, NH_4^+, V, Cu, Al, Mn and Se exceed MPC 6, 5, 9, 3, 12, 6, 5 and 9 times, respectively. The amount of excess cases of MPC $N = 55$, $\sum n \log_2 n = 159.07$, $I = 159.07/55 = 2.892$, $H = \log_2 55 – 2.892 = 2.891$, $G = 2.891/2.892 = 1.0$. The total amount of the multiplicity of MPC exceeds $M = 19.1$, AWQI $= G + 0.1 \log_2 M = 1.486$ (see Tab. 1).

Table 1

AWQI for the Rivers Voghji, Artsvanik and Geghi (2009)

Positions	91	92	93	94	95	96	97	98
N	14	55	24	79	11	95	8	17
$\sum n \log_2 n$	38	159.07	68.54	250.71	23.51	329.65	16	43.97
I	2.714	2.892	2.858	3.173	2.131	3.47	2.0	2.586
H	1.086	2.891	1.734	3.131	1.317	3.046	1.0	1.495
G	0.4	1.0	0.607	0.987	0.618	0.878	0.5	0.578
$M = \sum m$	5.5	19.1	12.8	119.1	8	63.1	5.3	6.0
$\log_2 M$	2.46	4.86	3.54	6.83	3.0	5.9	2.4	2.58
AWQI	0.646	1.486	0.961	1.67	0.918	1.475	0.74	0.836

Table 2

EWQI and AWQI for the Rivers Voghji, Artsvanik and Geghi (2009–2012)

Positions	2009		2010		2011		2012	
	EWQI	AWQI	EWQI	AWQI	EWQI	AWQI	EWQI	AWQI
91	0.4	0.646	0	0.2	0	0.158	0.61	0.98
92	1	1.486	0.8	1.3	0.88	1.39	0.94	1.49
93	0.607	0.961	0.3	0.71	0.33	0.74	0.96	1.30
94	0.987	1.67	0.73	1.41	0.92	1.66	1.03	1.77
95	0.618	0.918	0.49	0.79	0.74	1.04	0.84	1.12
96	0.878	1.475	0.82	1.37	1.02	1.56	1.17	1.77
97	0.5	0.74	0	0.07	0.43	0.73	0.87	1.24
98	0.578	0.836	0.32	0.51	0.33	0.58	0.25	0.51

The obtained data are indicating that along the river from springhead to estuary water quality decreases. The River Voghji quality index increases after passing the Cities of Kajaran and Kapan, this indicates the water quality decline caused by pollution of domestic wastewater.

The Rivers Voghji, Artsvanik and Geghi water quality was evaluated comprehensively by other indexes too (see Tab. 3).

Table 3

Water Quality Indexes for the Rivers Voghji, Artsvanik and Geghi (2009)

Positions	AWQI	EWQI	WCI	CWQI	SCWQI
91	0.646	0.4	0.87	86.05	1.21
92	1.486	1	6.84	61.26	2.79
93	0.961	0.607	1.77	79.48	1.71
94	1.67	0.987	16.68	48.68	2.89
95	0.918	0.618	1.3	85.75	1.19
96	1.475	0.878	3.69	54.03	2.67
97	0.74	0.5	0.73	88.69	1.34
98	0.836	0.578	1	84.24	1.83

Analysis of obtained data indicate that AWQI has liner dependence upon WCI, SCWQI, EWQI and an inverse dependence upon CWQI:

$$\text{AWQI} = (0.845 \pm 0.108) + (0.059 \pm 0.017) \cdot \text{WCI}, \quad R=0.82579, \ N=8,$$
$$\text{AWQI} = (0.088 \pm 0.140) + (0.514 \pm 0.067) \cdot \text{SCWQI}, \quad R=0.95168, \ N=8,$$
$$\text{AWQI} = -(0.082 \pm 0.093) + (1.686 \pm 0.129) \cdot \text{EWQI}, \quad R=0.98297, \ N=8,$$
$$\text{AWQI} = (2.824 \pm 0.164) - (0.023 \pm 0.002) \cdot \text{CWQI}, \quad R=0.97505, \ N=8.$$

Conclusion. For the first time the quality of water of the Rivers Voghji, Artsvanik and Geghi has been evaluated using AWQI. It was shown that from the source to the mouth of the river there is an increase in the value of the AWQI, which indicates the decline in the quality of water of the rivers from the first to the second class of pollution. After the Cities of Kajaran and Kapan AWQI increases, indicating a decrease in water quality due to pollution of the River Vohchi water by domestic wastewaters. Correlation between AWQI and other water quality indexes was established.

Received 23.05.2016

REFERENCES

1. **Nikanorov A.M.** Scientific Basis for Water Quality Monitoring. St. Peterburg: Gidrometeoizdat, 2005, 577 p. (in Russian).
2. **Margaryan L.A., Minasyan S.G., Pirumyan G.P.** Comparison of the Canadian and Specific Combinatorial Indexes of Water Quality in the Estimarion of the River Razdan Pollution Density. // Water and Ecology: Problems and Resheniya, 2008, № 3, p. 57–64 (in Russian).
3. **Shitikov V.K., Rosenberg G.S., Zinchenko T.D.** Quantitative Hydroecology: Methods, Criteria, Decisions (2 Books). M .: Nauka, 2005, Book 1, 281 p. (in Russian).
4. **Simonyan A.G., Pirumyan G.P.** Entropy Approach to Evaluating the Ecological State of the River. Geology of the Oceans and Seas: Proceedings of the XXI International Scientific Conference (School) on Marine Geologii. M.: GEOS, 2015, v. 4, p. 196–199 (in Russian).
5. **Simonyan A.G., Pirumyan G.P.** Analysis of the Ecological State of Aghstev Using the Entropy Index. // Science Bulletin, 2016, № 1 (7), p. 191–195 (in Russian).
6. **Shannon C.** Works on Information Theory and Cybernetics. M.: IL, 1963, 830 p. (in Russian).
7. **MacArthur R.M.** Fluctuation of Animal Populations and Measure of Community Stability. // Ecology, 1955, v. 36, № 3, p. 533–536.
8. **Margalef R.** Information Theory in Ecology. // Gen. Syst., 1958, v. 3, p. 36–71.
9. **Simonyan G.S.** Assessment of Hydrogeological Systems in the Light of Information Theory Synergistic. // Proceedings of the All-Russian Scientific Practical Conference. Environmental Safety and Nature: Science, Innovation, Management. Mahachkala: ALEPH, 2013, p. 275–280 (in Russian).