Informatics and Control Problems 39 Issue 2 (2019)
journal homepage: www.icp.az

Comparative analysis of qualitative indicators of Jeyranbatan reservoir

S.G. Hidayatzade*

Institute of Control Systems of ANAS, Baku, Azerbaijan

A R T I C L E   I N F O

Article history:
Received 30.10.2018
Received in revised form 28.03.2019
Accepted 22.05.2019
Available online 30.12.2019

Keywords:
Water reservoir
Geographic information systems
Ecosystem
Monitoring
Database
Physical and chemical parameters
Microbiological parameters

A B S T R A C T

The environmental safety. of the Jeyranbatan reservoir, which is a strategic object, directly depends on its protection, monitoring of water input/output parameters, laboratory tests and expert assessment. The issue is directly related to the ecosystem. The paper focuses on the creation of the database of physical, chemical and microbiological data affecting the quality of drinking water, as well as on the monitoring and data processing.

1. Introduction

The twentieth century was the age of scientific discoveries and the age of environmental pollution, which is considered a major problem for the world civilization in general and for every individual human being. Social, environmental, food, energy and water problems are the most relevant ones among the many problems facing humanity today. The first four of the mentioned problems cannot be solved if there is no acceptable solution to the water problem. For this reason, academics and statesmen in many countries around the globe regard the problem of water supply for growing population and economy as the most important one [1, pp.112, 115]. Year by year, the current state of water bodies, their regime and the quality of water cause a great concern for the future of the entire biosphere and humanity in particular. Water is the living blood of the planet, and the existence of life is based on it. In modern times, the need for wide use of computer technologies in various areas of human activity, especially environmental protection, is undeniable. Modeling of geographic information systems and associated natural and man-made processes, as well as the development of information systems, processing and analysis of their data are extremely important.

Geographic information systems (GIS) are actively used for solving various scientific and practical issues, including planning and management on the city, regional levels, as well as complex multi-aspect study of the natural and economic potential of regions, inventory of natural resources, planning transportation routes and oil pipelines, environmental monitoring, human safety and so on. The experience of using GIS in the professional activity of modern specialists confirms its wide range and effectiveness of application. The development of the society and the growing complexity of its infrastructure require a clear and well-balanced management of resources by adopting new tools and

**E-mail addresses:* seyyarehidayetzade@isi.az (S.G.Hidayetzade)

www.icp.az/2019/2-14.pdf

methods of information processing. These are methods of spatial information processing and analysis, methods of operational solution of management issues, evaluation and control of changing processes. Thus, methods and means of information processing that provide a high degree of visualization of various forms of information, and the power and usability of the tool set analyzing the actual data provided by geographic information systems are very important factors.

Growing interest in geographic information systems and increased efforts to use them in various fields, the wide range of application, their incorporation into a number of major state programs, the strategic value of geoinformatics make GIS one of the most promising information technologies.

GIS, on which decision support systems are based, play a special role in the field of nature conservation.

For environmental protection purposes, geographic information systems are used in the decision-making related to environmental data collection and processing during environmental monitoring, modeling and analysis of trends in environmental processes and their development, and environmental management. Thus, GIS is a powerful support tool for decision-making in the field of nature conservation.

A number of specialized programs are available today, which implement elements of GIS technology for professional activities in the field of environmental protection. They can be used to assess contamination and to link the result to a specific site. Such programs are based on a mathematical model of the process (e.g. the method of calculating atmospheric pollution based on the hydrodynamic model of weather front layers and the Monte-Carlo method for assessing the turbulent diffusion; it makes possible to calculate the risk of general contamination and toxic effects based on the superimposition of contaminated areas. The area of contamination can be calculated based on climatic characteristics, using the data related to the source of contamination (geographical location, volume, emission rate, etc.), and the results can be visualized with account for spatial information. The application of the standard calculation method allows using the obtained results in the management decision-making.

A GIS-based environmental monitoring system for large areas has a complex multi-layer structure and usually consists of two main levels.

The lower level of the system includes:

– federal, city and sub-systems of specialized monitoring (monitoring of atmosphere, surface waters, public health, etc.);

– territorial centers for data collection and processing.

These subsystems are responsible for collection and initial analysis of the information on the state of the environment.

The upper level of the environmental monitoring system is the information and analysis center. Its functions are as follows:

– operational assessment of the environmental situation in the region;

– calculation of integrated assessments of the environmental situation;

– forecast of the environmental situation;

– preparation of projects of control actions and evaluation of the results of the decisions made.

2. Problem statement

The above approach can be applied to bodies of water in general, in particular to the protection of drinking water. This problem is also relevant in Azerbaijan as it is across the globe. Arid climate prevails in most parts of our country. For this reason, many small and large bodies of water (reservoirs, water intakes, water ponds) were created to expand irrigated farming areas in arid zones, to supply vineyards and orchards with water, and to improve the quality of drinking water.

The number of reservoirs in the world exceeds 60 000. Their overall surface area is 400 000

km^2. There are more than 140 reservoirs in the territory of Azerbaijan, and only 61 of them contain 1 mln m^3 water. The overall volume of water in the reservoirs in the republic is 21.5 km^3. The largest of them are shown in Table 1.

Table 1
Large water reservoirs in Azerbaijan

No	**Reservoir**	**Area, km^2**	**Volume, km^3**
1.	Mingachevir	605	15.73
2.	Shamkir	116	2.68
3.	Yenikend	23.2	1.58
4.	Varvara	22.5	0.06
5.	Araz	14.5	1.254
6.	Sarsang	14.2	0.565
7.	Jeyranbatan	13.9	0.186
8.	Khanbulanchay	24.6	0.052
9.	Sirab	1.54	0.013
10.	Agstafachay	6.30	0.12
11.	Khachinchay	1.76	0.023

Kura, Araz and Samukh rivers are the source of drinking water in the Absheron peninsula. The focus of our interest in this paper is the Jeyranbatan reservoir (No 7 in Table 1). The Jeyranbatan reservoir feeds from the Samur-Absheron canal, and the water purification plant built on its shore supplies a large share of the drinking water to the Absheron peninsula. The capacity of the reservoir is 186 mln m^3, 150 mln m^3 is utilized. The maximum length of the reservoir is 8.74 km, the maximum width is 2.15 km, the shoreline length is 23.3 km, the maximum depth is 28.5 m, with the minimum depth registered at 14.5 m, and the water surface area is 1389 ha.

The environmental safety of the Jeyranbatan reservoir, which is a strategic object, directly depends on its protection (as a physical object), monitoring of water input/output parameters, laboratory tests and expert assessments. Creating a single-center management system for these functions is a relevant issue. Obviously, such a system should be equipped with subsystems, support systems, and databases and knowledge bases of various application. The paper focuses on the creation of a database of physical, chemical and microbiological parameters that affect the quality of drinking water, and on their monitoring and data processing.

3. Solution

Bodies of water require rational use and good protection. The main water pollutants are: hydrogen sulfide, chlorides, sulfites, methanol, certain substances in certain amounts formaldehydes and others [2, pp.67-70].

If we group the current regulations and norms of the water use legislation together, we can say that the chemical composition of drinking water must be safe in terms of epidemiology and radiation; the quality of drinking water not included in the distribution network must meet hygienic requirements; the composition of drinking water must meet the microbiological and parasitological standards (Table 2) [3, p.220].

Table 2
Standards for microbiological and parasitological parameters

Parameters	Unit of measurement	Standards	Safety class
Thermotolerant coliform bacteria	number of bacteria per 100ml	No	1
Common coliform bacteria	number of bacteria per 100ml	No	2
Total number of microbes	number of bacterial colonies formed 1ml	<50	2
Coliphages	number per 100ml	No	3
Spores of sulfite-reducing clostridia	number per 20ml	No	4
Lamblia cysts	number of cysts per 0ml	No	3

The following safety classes are identified:

- Class I – extremely dangerous;
- Class II – highly dangerous;
- Class III – dangerous;
- Class IV – mildly dangerous.

Frequency of quality control of microbiological and organoleptic parameters of drinking water is shown in Table 3:

Table 3
Control of chemical parameters

Population, '000 people	Number of checks a month
<10	2
10-20	10
20-50	30
50-100	100
>100	100+1 per 5 000 people, >100 000

Quality parameters of drinking water supplied to consumers in the Republic of Azerbaijan are determined in accordance with the regional standards adopted by the Commonwealth of Independent States (GOST 2874-82). The anthropogenic and natural factors that can affect the Jeyranbatan reservoir include the following:

- chemical, radiation, heavy metal pollution and other types of pollution;
- waste from industrial, agricultural and wellfare facilities nearby;
- natural factors: mud volcanoes, earthquakes, etc.;
- changes in the level of groundwater;
- natural climate change;
- biological contamination;
- erosion of the reservoir shoreline;
- changes in the vegetation, forest strip;
- types of land use in the areas around the reservoir, etc.

Fig.1. Jeyranbatan reservoir

According to GOST 2874-82, more than 35 organoleptic, physical and chemical, microbiological, parasitological and radiological parameters of drinking water are studied. At present, water withdrawn from the sources is treated in accordance with GOST 2874-82 "Drinking water" and made available for consumers' use [4, pp.9-17].

.

The following should be considered when speaking of **physical parameters** of water in the Jeryanbatan reservoir:

1. Temperature – varies within a range of 1-27^{0}C. The temperature of drinking water must be 7-11^{0}C.

2. Transparency and turbidity of water – Transparency is measured by the device called Shell. The device is a glass tube with a height of at least 300 mm. The unit of measurement is cm. Water turbidity is measured by the device called photoelectric calorimeter (PEC). Turbidity of drinking water should not exceed 1.5-2 mg/l.

3. Color – Water gets its color from colloidal iron compounds, silver acids, industrial waste, etc. contained in it. Color of drinking water should not exceed 200 by GOST 2874-82. Color is measured by PEC.

4. Taste and odor – Water gets its taste and odor from ferric salts, manganic compounds, sulfides, organic compounds and other mixes contained in it. Taste and odor are determined by organs of senses. 4 types of taste of water are identified: salty, bitter, sweet and sour. Taste and odor are measured by a 5-point scale:

- 0 point – not detected;
- 1 point – detectable only by an experience analyst;
- 2 point – detectable by consumer;
- 3 point – easily detectable, causes complaints;
- 4 point – water has unpleasant strong odor and taste;
- 5 point – water is not suitable for drinking.

According to the national standards, the taste of drinking water should not exceed 2 points.

The information on the chemical parameters of the environment and drinking water, which is its integral part, can be found in [5, pp.34-43].

Speaking of the chemical parameters of the quality of water in the Jeyranbatan reservoir, the following should be considered in Table 4:

Table 4
Chemical parameters

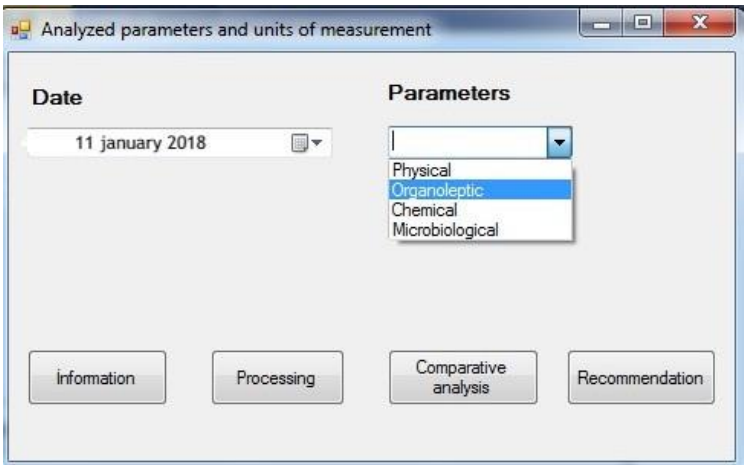
No	Parameters	Unit of measurement	World Health Organization	European Union	GOST	Average indicator for Absheron peninsula
1	Odor (20°; 60°)	point	-	-	2	0
2	Taste	point	-	-	2	0
3	Color 1. on Pt-CO scale	degree	15	20	20	0
	2. Dichromate CO scale	degree	15	20	20 (35)	0
4	Turbidity 1. formazin	NTU	5 (1)	4	2.6	0
5	Hardness (total)	meq/l	__	1.2	7.0	5
6	Electrical conductivity, 20°	μS/cm	__	2 500	__	450
7	Hydrogen carbonate, HCO3	Mq HCO3-/L	__	>30	__	130
8	Hydrogen	PH	__	6.5 –8.5	6 – 9	7.5
9	Aluminum (Al)	mg/l	0.2	0.2	0.5	0.1
10	NH3 and NH4+	mg/l	1.5	__	0.5	0-0.17
11	Arsenic (As)	mg/l	0.01	0.01	0.05	0
12	Iron (Fe2+,Fe3+)	mg/l	0.3	0.2	0.3	0-0.03
13	Silver (Ag)	mg/l	__	0.01	0.05	0
14	Hydrogen sulfide (H2S)	mg/l	0.05	__	0.003	0
15	Bisulfide (HS-)	mg/l	__	__	3.0	0
16	Chloride (Cl-)	mg/l	250.0	250.0	350.0	29-154
17	Chlorine 1. Free residual	mg/l	__	__	0.3 – 0.5	0.3
18	Chlorine 2. Fixed residual	mg/l	__	__	0.8 – 1.2	0.5
19	Chlorate ion (ClO3-)	mg/l			20.0	10.0

20	Potassium (K+)	mg/l		10.0	__	10
21	Calcium (Ca2+)	mg/l		100.0	250	60
22	Manganese (Mn, total)	mg/l	0.1	0.05	0.1(0.5)	0.005-0.02
23	Copper (Cu, total)	mg/l	1.0	2.0	1.0	0-0.03
24	Molybdenum (Mo, total)	mg/l	0.07	__	0.25	0.01
25	Magnesium (Mg2+)	mg/l	__	50	50	18.24
27	Sodium (Na+)	mg/l	200	200	200	45-97
28	Nickel (Ni)	mg/l	0.02	0.02	0.1	0.01
29	Nitrates (NO3-)	mg/l	50		45	3
30	Nitrites (NO2-)	mg/l	3	0.5	3	0
31	Polyphosphate ion (PO43-)	mg/l	__	__	3.5	1.1
32	Strontium (Sr2+)	mg/l	__	__	7.0	3
33	Zink	mg/l	5.0	5.0	5.0	0.01-0.9
34	Sulfates (SO42-)	mg/l	250	250	500	85-210
35	Cyanides (CN-)	mg/l	0.07	0.05	0.035	0.003

Table 5

Analyzed parameters and units of measurement

No	Water abstraction points	Analyzed parameters and units of measurement																									
		pH	Physical properties				Organoleptic parameters			Sulfides, S^{2-}, mg/l	Dissolved gases, mg/l			Chlorines, Cl_2, mg/l		Hardness, meq/l	Alkaline, mg/l	Basic ions, mg/l					Total dissolved solids, mg/l	Biogenic substances, mg/l			
			Temperature T, °C	Related substances, mg/l	Turbidity, NTU	Electrical conductivity, µS/cm	Color, degree	Transparency, cm	Odor, point		O_2 mg/l	O_2 %	CO_2	Free	total			Cl^-	HCO_3	CO_3^{-2}	Ca^{2+}	Mg^{2+}		NH_4^+	NO_2^-	NO_3^-	PO_4^{3-}
1	JR- By the water intake	8.3	13.1	1	1	645	<25	>30	0	0	11.0	100	3	0.06	0	4	173	46	145	0	37	26	429	0.11	0.011	0.4	3.52
2	JR- By the south pumping station	8.4	13	3	1	642	<25	>30	0	0	11.2	105	2	0.06	0	4	169	58	156	0	44	22	390	0.12	0.007	0.4	3.42
3	JR- Southwest dam, effluent water	8.4	12.9	3	1	647	<25	>30	0	0	10.9	107	2	0.06	0	4	169	88	167	0	43	23	410	0.11	0.009	0.4	3.84
4	JR- South dam, effluent water	8.3	13.1	2	1	646	<25	>30	0	0	11.0	109	3	0.07	0	4	173	92	168	0	46	21	412	0.11	0.011	0.4	4.1
5	JR- Northeast dam, effluent water	8.3	13.3	4	2	661	<25	>30	0	0	11.1	105	4	0.05	0	4	177	82	167	0	39	25	414	0.19	0.010	0.4	3.30
6	JR- Melioration pumping station entrance	8.4	14	6	1	656	<25	>30	0	0	11.3	109	3	0.03	0	4	163	52	163	0	36	22	413	0.18	0.011	0.4	3.80



The database is used for storing and accessing the information. The application programs or add-ons serve to process the variables in the database.

Many databases today are tabular, i.e. have a relational structure. Tables are an essential object of such a database. We shall create a database in the form of tables, which includes 6 physical and 35 chemical and microbiological parameters. Here, the rows indicate the 41 parameters, and the columns show periodic measurements. Such a database allows creating report forms in the most explicit format. A fragment of the report forms is given in Table 5 [6].

For the purpose of water quality monitoring, samples are taken from six points of the Jeyranbatan reservoir with the frequency indicated in Table 3. These points are located by the water intake, the south pumping station, the southwest dam (effluent water), the south dam (effluent water), northeast dam (effluent water), and the entry of the melioration pumping station. After having been entered in the database, the results of monitoring are processed by mathematical statistical methods. For instance, the data on the related substances concentration obtained through a 45 days long monitoring is given in Table 6.

Table 6

A fragment of the hydrochemical analysis of the Jeyranbatan reservoir

No	Water abstraction point	Number of points	Number of samples	Threshold concentration of related substances (mg/l)	Measurement date 10.10.2017 (mg/l)	Measurement date 22.11.2017 (mg/l)
1	Takhtakorpu-Jeyranbatan water canal	1	1	0.25 – 0.75	2 (2.66 times higher)	0
2	By the water intake	1	1	0.25 – 0.75	3 (4 times higher)	1 (1.33 times higher)
3	By the south pumping station	1	1	0.25 – 0.75	3 (4 times higher)	3 (4 times higher)
4	Southwest dam, effluent water	1	1	0.25 – 0.75	3 (4 times higher)	3 (4 times higher)
5	South dam, effluent water	1	1	0.25 – 0.75	7 (9.3 times higher)	2 (2.66 times higher)
6	Northeast dam, effluent water	1	1	0.25 – 0.75	4 (5.33 times higher)	4 (5.33 times higher)
7	Melioration pumping station entrance	1	1	0.25 – 0.75	2 (2.66 times higher)	6 (8 times higher)

The analysis of the samples taken from the Jeyranbatan reservoir shows that the amount of related substances in the water samples taken at the entry of the melioration pumping station exceeded the test results of other samples. In the water samples taken from the effluent water of the south dam, the concentration of orthophosphate ions $PO_4{}^{3}$ was 4.1 mg/l, 1.17 times higher than the permissible concentration of 3.5 mg/l. The permissible concentration of related substances in the samples taken from the southeastern part of the Qumyatag Lake (Fig. 1) was 2 mg/l, 2.66 times higher than the permissible concentration of 0.75 mg/l. The pH value was 9 against the threshold of 6.5-8.5.

4. Conclusion

The Jeyranbatan reservoir is a strategic object on the Absheron peninsula. It is an integral part of the peninsula's ecosystem. From this perspective, the environmental safety of the reservoir is closely linked to its protection (as a physical object) and laboratory tests of input/output parameters of water. Anthropogenic and natural factors that affect the Jeyranbatan reservoir are investigated in the paper, with water samples taken from 6 informative points. 41 physical, chemical and microbiological parameters determining the quality of water are selected, and a database is created based on this data. Data processing is performed and some of the results are demonstrated [6].

References

[1] В.С. Хомич, С.В. Какаренко, Т.И. Кухарчин и др., Пространственный анализ загрязнения водной среды городов, География и природные ресурсы. No.3 (2004) 107-119. [In Russian: V.S. Khomich, S.V. Kakarenko, T.I. Kukharchin et al, Spatial analysis of urban water pollution, Geography and natural resources].
[2] Gallardo-Mayenco Alfonso, Macias Sonia, Toja Julia, Efectos de la descarga en la calidad del agua a lo largo de un rio mediterraneo, El rio Guadaira (Sevilla), Limnetica. No.1-2 (2004) 65-78 (in Spanish).
[3] Svetlana Curcic, Ljiljana Comic, A microbiological index in estimation of surface water quality, Hydrobiology. No.1 (2002) 219-224.
[4] Telman Ağayev, Ceyranbatan su kəmərlərini kompleksi, 2016. [In Azerbaijani: Telman Agayev, Jeyranbatan water pipeline complex].
[5] Г.П. Беспамятнов, Ю.А. Кротов, Предельно допустимые концентрации химических веществ в окружающей среде, Л., Химия, 1987. [In Russian: G.P. Bespamyatnov, Y.A. Krotov, Maximum permissible concentrations of chemicals in the environment, L.: Chemistry].
[6] Analyzed parameters and units of measurement reports from Ministry of Emergency Situations

Reviewer: Associate Professor Garayev R.A., PhD (Engineering)