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POLLUTANTS AND WATER QUALITY INDICATORS IN THE FUNCTION OF WATER MANAGEMENT IN CONTEMPORARY SYSTEMS

Svetlana Stevović[1], Jelena Marković[2], Sabahudin Hadrović[3]

[1] Academy of Sciences and Arts Republic of Srpska, Bosnia and Herzegovina
[2] Academy of Technical-Educational Vocational Studies Nis - Vranje Department
[3] Institute of forestry, Belgrade, Serbia

[*] Corresponding author: svetlanas123@gmail.com

Abstract: Water on Earth is a vital element of living systems. Water is a medium that enables life and at the same time a medium in which a diverse eco systems exist. Natural waters contain dissolved gases, dissolved organic and inorganic substances and solid suspended materials. The quantities of dissolved and suspended substances are affected by: water temperatures, contact of water with the atmosphere, types of sediment the water is in contact, quantities of rainwater entering surface waters and quantities of waste substances, which are of anthropogenic origin. The results of water quality, according to the methodology of Eurowaternet - Lakes Aggregation of station data, were investigated and presented in a table form and by the location. The estimated value of water quality was obtained, expressed by the appropriate Water Quality Index. Water quality indicators are determined by the Serbian Water Quality Index method. The analyzes are presented by the frequency distribution of the indicators SWQI, nitrate, total phosphorus, ammonium and BOD_5. Related to that research, as a result of the applied methodology and the fact that modern water supply systems in the Republic of Serbia have predominantly relied on groundwater reserves, and lately more and more on water abstraction from reservoirs and their use after treatment, a proposal for the management of raw water quality was given.

Keywords: water resources, pollutants, water quality indicators, SWQI, water management.

1. INTRODUCTION

Numerous conflicting interests in the water management are outstanding due to a deficiency of drinking water and increase in population on the Earth, followed by extreme environmental problems (I. Stevović et al.). Supplying the population with hygienically correct drinking water is one of the preconditions for good health. At the same time, the right to have drinking water is one of the basic human rights. The right to use and the right to exploit water are not identical. The right to use entails irreversible water consumption (irrigation), and the right to exploit entails the right to use water mass (navigation). The legal regime of water use and exploitation depends on whether there are natural or artificial watercourses and receivers. Natural watercourses, natural lakes and other natural water collection facilities, including small watercourses, (S. Stevović et al. 2014), as well as natural springs, public wells and public fountains are considered as the goods in general use.

Water supply provides high quality water for households, industry, public needs and other users. The quality of the water supply service is of vital importance, not only because in this way consumers are provided with water for life, but at the same time the unwanted distribution of harmful and dangerous substances, as well as microorganisms can be prevented (Robles-Durazno et al. 2019).

The supply of drinking water from reservoirs, as sources for water supply, has recently been exploited in our country. This essential economic branch is managed by the Public Water Management Company Srbijavode. Significant use of reservoirs for water supply is in Zlatibor district (reservoirs "Vrutci" and "Zlatibor"), Šumadija district (reservoirs "Gruža" and "Grošnica"), as well as reservoirs "Ćelije", "Bovan", "Grlište", "Barje" and "Prvonek". Some multi-purpose reservoirs are already used for water supply today, and the capacities of built reservoirs used for hydropower production are also planned as water sources for water supply of the population ("Sjenica" and "Kokin Brod" on Uvac, "Vlasina" on Vlasina and "Zavoj" on Visočica river). Currently, the water supply systems "Stubo-Rovni" on Jablanica and "Selova" near Kuršumlija are being implemented in Serbia. The importance of reservoirs is reflected in their multifunctional role (small water improvement, irrigation, flood protection, water supply to the population and industry, hydropower, etc.). Figure 1 shows the current state of water quality in reservoirs in the Republic of Serbia for the period from 2005 till 2020. [Republic Hydrometeorological Institute of Serbia]. For the period 2005-2010, individual water quality indicators were calculated according to the instructions of Eurowaternet - Lakes Aggregation of station data and the estimated value of quality expressed by the appropriate WQI was obtained. Quality assessment is based on random samples taken once a year (June - November), by determining water quality indicators using the Serbian Water Quality Index. The analysis is represented by the frequency distribution of the indicators SWQI, nitrate, total phosphorus, ammonium and BOD_5.

Numerous problems are related to the construction, maintenance and operation of water supply reservoirs. Some of them are presented in the document Water Management Basis of the Republic of Serbia (Water Management Basis of the Republic of Serbia, Accumulations, back in 2001, pp. 191, 192) and are still current. These are problems with existing reservoirs, where some supporting documents have been missing since the project documentation phase, which could help to make better use of existing reservoirs. These are most often the missing connection to the information system, water management balance, cadastres, etc. At the same time, the obligations of users of reservoirs for research and examination of phenomena and processes in reservoirs and downstream of reservoirs, in order to prevent negative effects from them, have not been completely perfected.

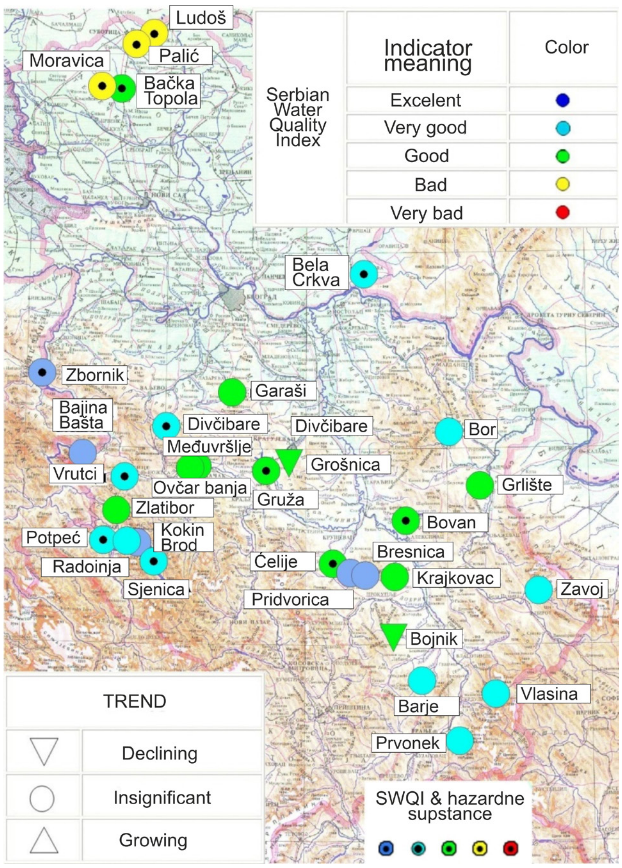

Figure 1. *Water quality in reservoirs (at measuring points along the dam) and lakes in 2015 expressed through SWQI and 2005-2020 trend*
Source: Serbian Water Quality Index

Examination of water quality of reservoirs is performed according to the depth (surface, middle of the vertical and bottom) at three critical points (at the dam, the beginning of the lake, the middle of the lake). Data from reservoirs were processed: Bela Crkva, Bačka Topola, Moravica, Zvornik, Grlište, Bor, Barje, Bojnik, Vlasina, Ćelije, Ovčar Banja, Međuvršje, Bovan, Krajkovac, Pridvorica, Zavoj, Bresnica, Divčibare, Bajina Bašta, Kokin Brod , Vrutci, Sjenica, Potpeć, Radoinja, Zlatibor, Gruža, Garaši, Grošnica and Prvonek, and lakes Palić and Ludoš.

The development of these springs has been more massive in recent decades. The reason for this is in the fact that this is the most reliable way to provide the necessary amounts of water to supply different categories of consumers. The formation of the composition of water in reservoirs takes place under the influence of external factors and processes in the reservoir system itself. Various inorganic and organic substances reach the accumulations as pollutants. In the conditions that are generated in the system itself, this leads to certain changes in the composition of water over time. Changes in water composition and ecosystems have short-term and long-term effects. For the purposes of assessing the condition of reservoir systems, as a basis for analyzes of processes that control water quality in these systems, some basic reference data are given below.

As a rule, the retention time of water in the accumulation is significantly shorter than other substances. In that way, nutrients are concentrated in the system, which creates preconditions for intensifying the process of organic matter production, and thus for intensifying decomposition and increasing the volume and concentration of organic matter in water. This is the basis of the inevitable process of eutrophication, which takes place through geological phases in some natural lake systems, and over decades in some lake systems under great anthropogenic influence.

Production and decomposition of organic matter in the lake system and the accompanying processes of physical and chemical changes in the content of inorganic matter in water occur on the basis of the flow of matter and energy that keeps the parts, and the system as a whole, at certain energy levels. Processes in a closed system take place spontaneously with a decrease in free energy, until the minimum energy is reached, which corresponds to the maximum entropy. In contrast, biological systems, as open systems, are able to increase energy potential provided they exchange matter and energy with the external environment.

Reservoir systems are characterized by high changes in water composition caused by the processes of production of organic matter construction in these systems. Correct analyzes of the condition include chemical, biological and bacteriological analyzes. Tests are needed at the level necessary to understand the processes being analyzed and the need for further interventions in the system or further stages of water treatment. Changes in water composition are most often a function of the thermal state of the system, the analyzed location in the lake and the weather (Sagi et al. 2020).

2. RESEARCH METHODOLOGY OF RAW WATER QUALITY

Water can be viewed as one of the basic foodstuffs and as a natural resource (Tantoh et al. 2021). Therefore, water should be used as carefully as possible and make sure that the quality remains at a certain level. Water on Earth is a vital part of living systems, as a medium that enables life and a medium in which a diverse living world exists. It covers 70% of the Earth's surface and is present in all spheres of the environment: in the seas and oceans as salt water, on the Earth's surface as surface water in the form of lakes, rivers and surface reservoirs, in the Earth as groundwater, in the atmosphere as water vapor, and on the poles of the Earth like solid ice. However, the problem of water scarcity is present in the world. Despite the high percentages in terms of covering the Earth's surface, the percentage of fresh, usable water for purification and drinking for humans, access to existing purification technologies is extremely low. Observed in the function of the forecast of population growth over time, this negative trend is even more pronounced. The amount of available water is decreasing on the planet Earth. An egregious example is the reduction of the Aral Sea over time, Figure 2.

Natural waters, in addition to the basic component of water, contain dissolved gases, dissolved organic and inorganic compounds and suspended solids. The amount of dissolved and suspended substances in water depends on a number of factors: water temperature, contact of water with the atmosphere, type of sediment with which water is in contact, amount of rainwater coming into surface waters and amount of waste substances. inputs to water (via wastewater and in other ways). "Salt" waters (sea and ocean waters) are far richer with dissolved salts than "fresh" waters. The content of oxygen, as a vital component for the living world in waters, is higher in clean mountain rivers than in other water systems.

Through their activity, people create large amounts of waste substances that reach the water systems to the greatest extent, either through wastewater, by rinsing surfaces with rainwater or in some other way. These pollutants change the composition and quality of natural water systems. Depending on the origin of pollution and the ways in which they cause pollution, water pollutants can be classified into several groups: waste materials that consume oxygen, pathogens, agents that promote the development of flora in water, inorganic compounds, sediments, synthetic organic compounds, petroleum and its derivatives, radioactive substances and heat (Son et al. 2020).

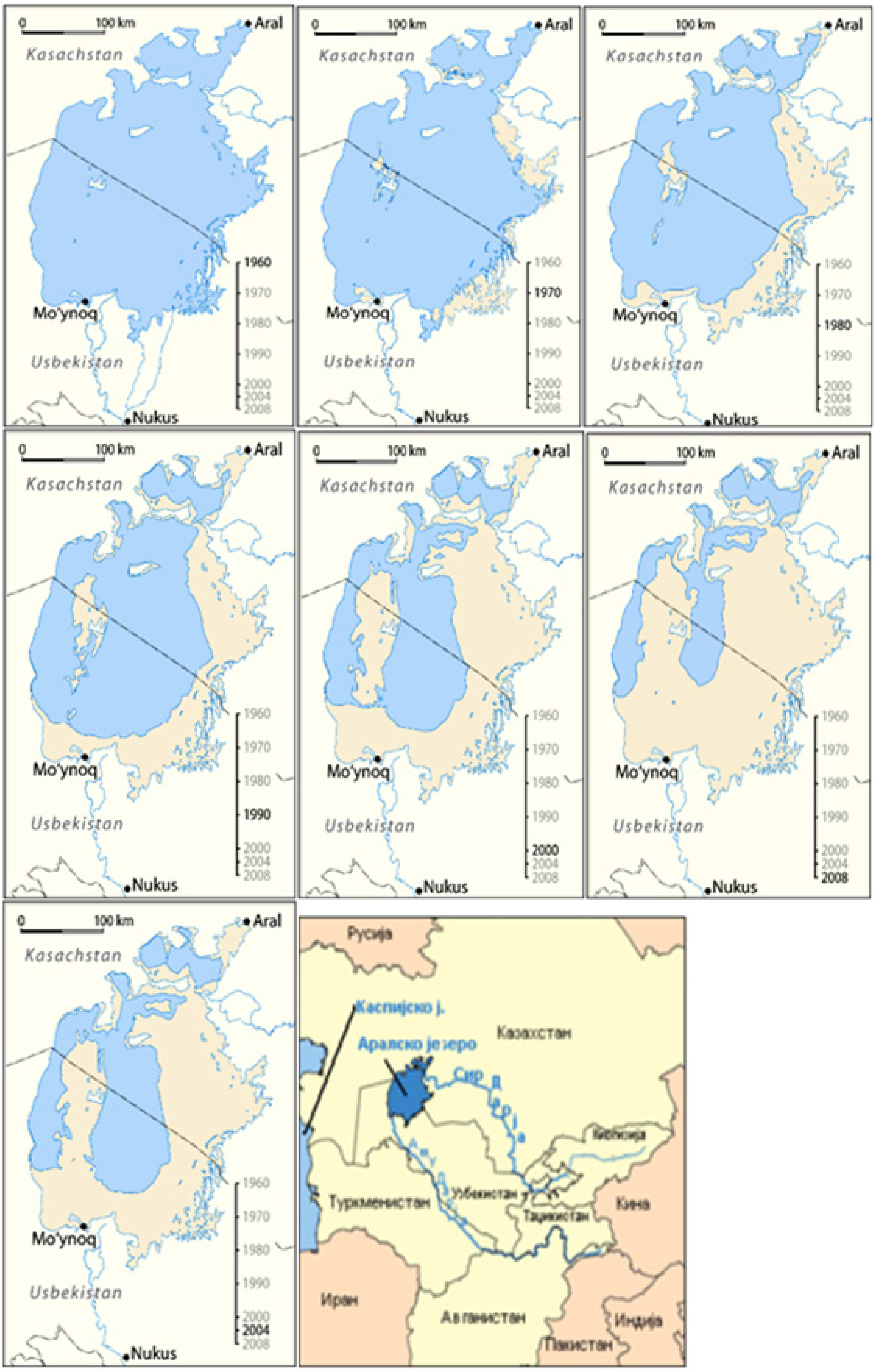

Figure 2. *Aral Lake*
Source: http://upload.wikimedia.org/wikipedia/commons/9/9f/Aralsee.gif

All natural waters in which man has not placed waste substances with his activity, can be conditionally considered as pure quality waters suitable for the development and life of various living world. The exceptions are some water systems that are naturally rich in mineral salts so that life in them is impossible. The example for this is the Dead Sea.

Chemically pure water (conditionally pure) is a transparent and colorless liquid, without taste and smell, but it seems bland due to the certain amount of minerals dissolved. It is bluish in the thicker layer.

"The natural composition of water today can significantly deteriorate due to the air and soil pollution with which water comes into contact in the hydrological cycle. The purest atmospheric water, in the zone of unpolluted nature, is a solution that contains CO_2, O_2, N_2, NH_3, etc., while in the polluted zones it also contains SO_2, H_2S, NxOy, HCl and soot. The composition of surface waters varies greatly. The waters of mountain streams and rivers are the cleanest, because they contain very few organic substances, microorganisms and dissolved salts. The quality of river waters, which people use the most, varies greatly, from relatively clean to highly polluted, which depends on the type, quantity and pollution of water that flows into them (Bernhardt et al. 2018).

The classification of natural waters should be performed on the basis of an integrated quality system. The water quality class is determined by physico-chemical tests (Calmuc et al. 2020), (Saal et al. 2021). Table 1 shows the limiting values of some quality indicators according to the applicable regulations for the quality of watercourses in the Republic of Serbia. The total organic matter content can be determined through the consumption of oxidizing agent (eg oxygen, potassium dichromate): Biochemical oxygen demand (BOD - Biochemical Oxygen Demand), Chemical oxygen demand, HPK (COD - Chemical Oxygen Demand) or by direct measurement of: Total Organic Carbon, UOU (TOC).

Table 1. *Limiting values of some surface water quality parameters*
Source: Baras, et al., 2015

Quality indicators	Class			
	I	II	III	IV
Dissolved O_2 (O_2 / l)	8	6	4	3
O_2 saturation (%):				
- saturation	90-105	75-90	50-75	30-50
- supersaturation	-	105-115	115-125	125-130
BOD5 (mg O_2 / l) to	2	4	7	20
HPK from $KMnO_4$ consumption (mg O_2 / l) to	10	12	20	40
Suspended matter (mg / dm^3) to	10	30	80	100
Dry residue of filtered water (mg / dm^3) to	350	1000	1500	-
pH	6,8-8,5	6,8-8,5	6,0-9,0	6,0-9,0
Most probable number of coliform bacteria in a liter of water:	2.000	100.000	200.000	-
- for bathing	-	20.000	-	-
Biological productivity level (for lakes only)	oligotrophic	moderately	eutrophic	
Liebmann degree of saprobity	oligosaprobic	betamezo-saprobic	alphamezosaprobic	polysaprobi
(for surface waters only)		saprobic	saprobic	saprobic
Toxic substances, temperature change and other indicators of harmfulness	They must not be found in any class above the prescribed limits.			

For the determination of organic matter in water, the consumption of oxidizing agent has been used for a very long time, which serves as a measure of the content of organic matter. The oldest method is the consumption of $KMnO_4$. BOD represents the amount of oxygen required by microorganisms of a water sample (or seeded microflora) to oxidize organic matter in water under aerobic conditions at a temperature of 20^{o}C, at a certain incubation time. BOD is the mass concentration of dissolved O_2, which under certain conditions is used for biological (biochemical) oxidation of organic and parts of inorganic substances in water. The standard method defines an incubation time of 5 days, which determines the so-called. BOD_5.

The analysis of the long-term trend of the quality of watercourses in the Republic of Serbia, expressed by the SWQI indicator, shows that at 18% of measuring points it is determined to be increasing, at 4% decreasing and at as much as 78% insignificant. The Water Exploitation Index (WEI) is an indicator that shows in a simple and vivid way the availability of water resources and comparability with other countries.

The water exploitation index represents the ratio of the total annual amount of affected water resources and renewable water resources. It is an indicator of the pressure of affected water resources on the sustainable use of renewable water resources at the national level. The water exploitation index is calculated when the annual amount of affected water resources is divided by the multi-year average of renewable water resources and multiplied by 100.

Continuous quality control of surface waters in the Republic of Serbia is performed in order to assess the quality of watercourses, monitor the trend of pollution and preserve quality water resources. Tests of water quality at springs and reservoirs are used to assess the correctness of water for the needs of water supply and recreation of citizens, aimed at protecting springs and public health (Bulajic et al. 2020), (Pantić and Milijić 2021).

3. RESULTS

Turbidity is one of the most important parameters of treated surface water, from the point of view of preserving quality on the way to the consumer. In groundwater, in addition to iron and manganese, it is also a color (Liu et al. 2019). Turbidity originates from the presence of particles of various substances, such as clay, sludge, colloids and plankton, and is a measure of light absorption and scattering. The numerical value of turbidity, which today is expressed in nephelometric units (formerly in mg/l SiO_2) depends mainly on the number of particles, size, shape, refractive index of light, as well as the wavelength of light. It is characteristic of surface waters. Removal of suspended particles from water, which we measure as turbidity, is performed in the processes of flocculation and sedimentation and finally, as a rule, on sand filters.

Particles that cause water turbidity are of different sizes, from 1 nm to 1 mm, most often clay with a diameter of up to 0.002 mm, as well as particles of organic matter that originate from the decomposition of plants and animal waste. The allowed value in drinking water is 1.0 NTU, and for settlements up to 5,000 inhabitants up to 5 NTU. For comparison, 1.0 NTU (more precisely 1.2) is equivalent to 5.0 mg/l SiO_2, while 5 NTU corresponds to about 20 mg/l SiO_2. The main problem with turbidity is water disinfection. High values of turbidity represent protection of microorganisms from the action of disinfectants. Coliform bacteria survive in water with a turbidity of 0.1 to 0.5 NTU at a chlorine content of 0.1 to 0.5 mg/l for at least 30 minutes (Keith et al. 2020).

The right measure of turbidity removal efficiency is the number of particles with a size from 1 to 100 microns per ml, which are counted with special counters. Although the measurement of turbidity used to be rough (Table 2), the use of these devices is increasing, as is their reliability, while the price is decreasing.

Table 2. *Results of turbidity measurements*

Number of particles larger than 2μ / ml	1	10	100	1000
NTU turbidity	0.01	0.08	0.12	0.14

In practice, turbidity after a 0.08 NTU (10,000 particles / l) filter cannot be easily reached and measured. Phyto and zooplankton, as well as parasites belong to this area of particle size, which indicates the great importance of this way of controlling the operation of the plant. In a well-designed and guided process, no more than 10 particles / ml are allowed. When this number is reached, the filter must be washed. In terms of efficiency, two-layer filters are much more efficient than single-layer filters, even when the upper layer is made of a coarser material, which is only 15 cm thick (Organization 2021a), (Organization 2021b).

Graphic presentation of locations where measurements of the Serbian Water Quality Index were performed on watercourses of the Republic of Serbia is given in Figure 3. Results with poor and very poor quality are marked as black dots.

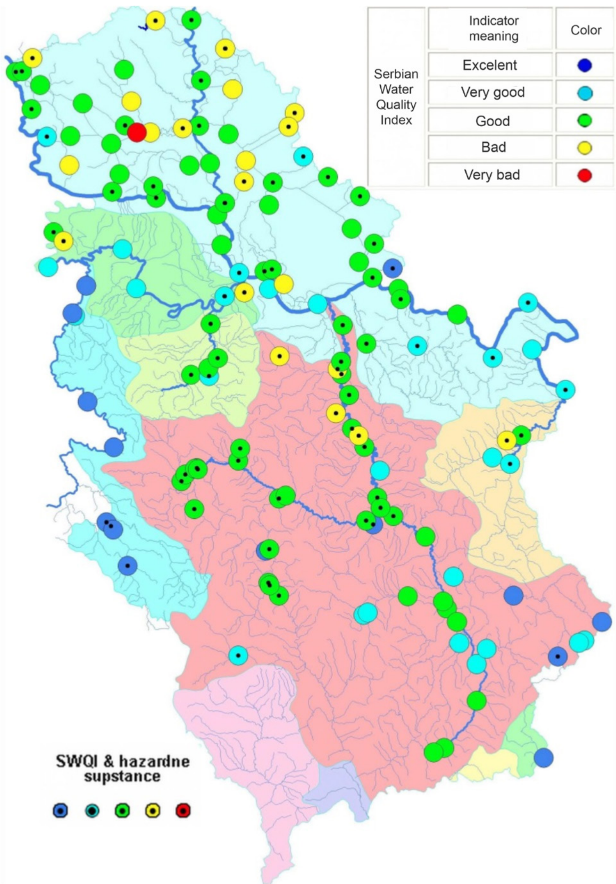

***Figure 3.** Measuring stations - "black dots"*
Source: Serbian Water Quality Index of Watercourses of the Republic of Serbia (2015)

The color originates from organic matter that is in decay, (Hu et al. 2022). High color content is found in surface and some groundwater. The color is created by extraction from wood, extraction of decaying plants and from organic matter in the soil. The amount of extracted substances depends on the temperature and pH values. Extraction is better at acid reaction and higher temperature. Humic acids, which are often found in colored waters, give the water an altered taste, interfere with normal chlorination, and degrade the sanitary side of the water with its altered appearance.

Colored water dissolves iron and manganese more easily and prevents successful coagulation, i.e., successful purification. It is a very important psychological moment in the appearance of colored water, because it causes violent reactions of users and compromises the public system for the supply of drinking water, (Shi et al. 2022). The allowed value of drinking water color is 5 units of Pt-Co scale. The pH value of natural waters ranges from 7 to 9 on a scale from 0 to 14. Weakly alkaline waters predominate due to the presence of carbonates and bicarbonates. The pH value of drinking water ranges from 6.5 to 8.5.

The content of iron and manganese is an important parameter and indicator of the quality of drinking water. According to the valid Ordinance, the content of iron in drinking water must not exceed 0.3 mg/l, and manganese not more than 0.05 mg/l.

3.1. Sources of water pollution

Intensive industrialization and urbanization, along with the development of agriculture, cause increasing water needs. The negative effects of these processes inevitably lead to pollution of both surface and groundwater, which is one of the most current problems of the modern world and a factor limiting the development of cities and entire regions.

People drastically disturb the natural balance in the aquatic ecosystems of inland waters and disrupts the processes of self-purification with their activities. Irrational use of water resources creates the need for large quantities of water of appropriate quality, and results in smaller and smaller quantities of available water, which also does not meet the prescribed standards from the point of view of quality.

Surface water sources (rivers, lakes, reservoirs) are a kind of ecosystems characterized by the presence of organic and inorganic substances that access them naturally or as a consequence of the action of anthropogenic factors. Imported pollutants differ as they can be biodegradable, bioresistant, or even toxic to aquatic life.

The most common type of division of pollutants present in water is based on their primary source, ie groups of compounds according to the places where they occur and where it is most effective to control them, (Aldas-Vargas et al. 2022). This approach enables the design of water supply control measures primarily in the direction of preventing or minimizing water contamination, in contrast to the approach based on measuring the level of contamination after water treatment, (Hegarty et al. 2022).

Water pollutants can be classified into two groups of pollutants: concentrated and bulk pollutants. Discharge of concentrated pollutants into watercourses is done through the sewage system. They most often come from urban settlements, industrial facilities (chemical, petrochemical, food, metal and other industries), energy facilities (thermal power plants, heating plants, nuclear power plants, oil refining, coal processing and hydropower facilities), agricultural facilities for livestock fattening, landfills (sanitary).

Table 3. *Sources of polluting chemical materials of drinking water*
Source: WHO (2004) Guidelines for Drinking-water Quality, 3rd ed., Vol. 1, Recommendations, Geneva.

Sources of polluting chemical materials	Examples of sources
Natural sources	Rocks, soil and effects of geological displacement and climate
Industrial springs and settlements	Mines (extraction industry), production and process industries, sewage, solid waste, atmospheric sewage, fuel spills.
Agricultural activities	Fertilizers, fertilization, intensive livestock, pesticides
Water treatment or materials in contact with drinking water	Coagulants, disinfectant by-products, pipe material
Pesticides that are dosed into water to ensure human health	Larvicides used in insect control as vectors of disease
Cyanobacteria	Eutrophic lakes

Figure 4. *Sources of pollutants in the Republic of Serbia*

Source: Republic Hydrometeorological Institute

The approach to the management of harmful and hazardous chemicals in drinking water should be adapted to situations, ranging from those where the quality of the source water is poor to those where chemicals and materials in drinking water from production and distribution processes are present. According to the recommendations of the World Health Organization - WHO, (Lindmark et al. 2022), the sources of polluting chemicals are divided into six groups, as in Table 3.

Sources of polluting chemical materials in drinking water are not always clearly separated: e.g. natural sources of pollution include many inorganic substances that can be found in drinking water as a result of dissolving rocks and leaching soil (natural processes). During these processes, some can become a problem due to the imbalance in the environment, as is the case, for example, in the mining areas. Figure 4 shows the sources of pollutants in the Republic of Serbia. The quality of surface waters is regularly monitored by the competent services of the Republic Hydrometeorological Institute according to the Program adopted annually by the Government.

3.2. Protection of water resources from contamination

In the system of measures for obtaining and delivering healthy and safe drinking water, the protection of springs is extremely important. Continuous and consistent quality control of raw water will provide insight into the condition of the source and timely indicate changes in the condition and enable staff to always operate the plant in optimal conditions.

One of the aspects of surface water protection is the prevention of activities that can be a source of water pollution in springs. For this purpose, an area is defined where the discharge of wastewater is not allowed, nor is it allowed to dispose of waste sludge from the sewage system, or from agricultural production. These are the so-called sanitary protection zones. If such a possibility exists as a potential danger, which may at some point endanger the safety of water supply - it is the obligation of enhanced quality control of raw water, (Ding et al. 2022).

Protecting natural waters is not an easy task. It is possible to protect an accumulation or a lake from harmful human activities, but the protection of watercourses can only be carried out by investing great efforts and significant resources, primarily by the state.

Interventions undertaken in the framework of preparatory works for construction include removal of humus layer and landscaping at the site of future accumulation on the river - the main watercourse, as well as on side tributaries, erection of barriers - small dams to retain sediment, thus preventing its accumulation in the reservoir, and thus its backfilling, ie reduction of useful volume, as well as reduction of the risk of intake of biogenic (trophogenic) salts. These measures are directly and indirectly in the function of protection and preservation of the accumulation as a facility and water resource (aquatic ecosystem) and protection of water quality and obtaining healthy drinking water at the processing plant in the water factory. In the immediate and narrower zone of sanitary protection, a number of measures should be taken - prevention of construction of cottages and houses with agricultural facilities (pig farms, sheep and cattle, fishponds) and accompanying agricultural activities (livestock, agriculture, fishing), industrial plants and other facilities that can to pollute the main watercourse and the catchment area as a whole. In order to reduce the degree of risk in terms of deteriorating water quality, the reservoir can be closed at the same time for sports and recreation (hunting, fishing, water sports, swimming).

4. RAW WATER QUALITY MANAGEMENT

The trophic level of aquatic ecosystems is an expression and function of their total bioproduction by components and represents the basis in the study of water typology. The intensity of organic production serves as a basis for comparison, rather than the factors that affect it, which is the basis of the concept of the trophic system. According to this concept, all surface waters, regardless of their size and ecological characteristics, can be classified into continuous series according to the principle of increasing trophic level. Hence, the terms oligo-, meso-, eu- and polytrophy, only denote the approximate size of production. In nature, these trophic levels overlap. In addition to the primary and secondary production of plants and animals, the process of decomposition and respiration should be taken into account, which also affects the level of total organic production of the aquatic ecosystem, since all these biogenic transformations of organic matter belong to the concept of trophic levels.

The level of trophy of an aquatic ecosystem is conditioned, above all, by its type. The type of aquatic ecosystem is related to the parameters of the abiocene, which include:

– morphometry (shape, depth, existence of profundals and littorals and their size),

– hydrology (flow rate, water level variability - astatics),

– air conditioning,

– physico-chemical characteristics of water (transparency, content of trophogenic salts, brightness), as well as

– biocene, directly and indirectly, through the impact that the living world has on the environment.

Thus, mountain streams, deep (high mountain) lakes and reservoirs in the upper parts of rivers (peak reservoirs) belong to oligotrophic systems, while large lowland rivers and their floodplains and artificial, multipurpose reservoirs in the lower regions belong to mesotrophic, eutrophic and hypereutrophic, as well as polytrophic ecosystems. Large amounts of biogenic salts, primarily phosphates and nitrates, which reach the water, often cause sudden and accelerated eutrophication of many aquatic ecosystems on the territory of Serbia. The result is enormous bioproduction in such waters and disturbance of the natural balance in the structure and functioning of the system, (Zhang et al. 2022).

The existence of plant and animal species, as well as the composition and structure of their communities, clearly indicate the degree of trophy, i.e., the stage of development of an aquatic ecosystem. Defining saprobity as one of the parameters of water quality, where it means the presence of certain amounts of organic matter subject to decomposition, it is stated that certain hydrobionts appear in surface waters of a certain quality and that their appearance clearly indicates water quality. Such plant and animal species are labeled as bioindicators. At the same time, with their life activity, they represent an active participant in the formation of water quality. Under the influence of various physical, chemical, mechanical and biological agents, aquatic ecosystems change their original properties. These changes are primarily reflected in:

– disturb the balance of the aquatic ecosystem

– reducing the power of self-purification

– changes in the composition and structure of aquatic communities

– disappearance of certain forms and

– mass development of forms that favor the survival and development of the newly created conditions in the aquatic environment.

The characteristic combination of plant and animal species has a bioindicator significance and is an indicator of the degree of pollution (saprobity), ie water quality. Increased nitrate content in groundwater and surface water, as a result of agricultural activities, is one of the first cases that chemical pollutants have caused public concern to health organizations and water utilities, according to Directive 91/676/EEC on protection of waters against pollution caused by nitrates from agricultural production, Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources, (Gómez et al. 2022).

Nitrates Directive - Directive 91/676/EEC aims to reduce the level of water pollution caused or increased by nitrates from agricultural sources and to prevent such pollution in the future. Member States shall, within a period of two years after notification of this Directive, designate all vulnerable zones in all known areas of land in their territories from which discharges into waters identified as complying and which contribute to pollution occur. notify the Commission within at least six months.

The natural level of nitrate in groundwater is generally below 10 mg/l NO_3. Elevated levels are caused by the use of nitrogen fertilizers and manure, although local pollution from industrial sources can occur. Nitrate is a significant problem in some parts of Europe. In northern Europe, nitrate concentrations are quite low (Iceland, Finland, Norway and Sweden).

"Farmers claimed that this directive violates the polluter pays principle, because they were required to bear the costs of reducing the concentration of nitrates in water, even though agriculture is only one of the sources of nitrate production. The ECJ has taken the view that the directive does not mean that farmers have to bear the burden of removing pollution to which they have not contributed. Member States must pay attention to other sources of pollution when applying the directive. In this particular case, farmers should not be required to eliminate unnecessary pollution elimination costs. The Court pointed out that, in this way, the polluter pays principle also reflects the principle of proportionality", (Golaki et al. 2022).

In untreated groundwater in more than 25% of the tested sites in 8 of 17 countries the level of 25 mg/l NO_3 was exceeded (Directive). In the Republic of Moldova, about 35% of the tested sites in the samples exceed the maximum permissible concentration of 50 mg/l NO_3. At the regional level, more than a quarter of the sampled sites have a higher nitrite concentration of 50 mg/l NO_3, in 13% of the 96 reported regions or underground areas, and in about 52% of the regions more than a quarter of the samples exceed 25 mg/l NO_3, (Tobin 2022).

Recently, the presence of natural chemical components in groundwater, such as arsenic and fluorides in increased concentrations, has caused large-scale exposure and unacceptable health effects in many countries. There are also examples around the world of water contamination for water supply as a consequence of uncontrolled discharge of industrial waste streams and sewage into water resources.

Water quality is determined by appropriate measurements and analyzes. In the general case, the quality of groundwater, especially from deeper aquifers, is better, and more stable over time, than the quality of surface water, especially water from watercourses; and that is generally known. Therefore, it is logical that the preparation of groundwater is in principle easier to report than the preparation of surface water, because the scope of changes in the quality of raw water in the case of groundwater treatment is much narrower. However, this still does not mean that one or two analyzes of groundwater and determining the yield of wells at one point (usually immediately after drilling a well) will be sufficient. There are cases where the content of gases in water, for example methane or hydrogen sulfide, changes abruptly and unpredictably, or that the content of natural organic matter varies considerably.

Surface water quality is a big problem, and therefore data for water quality must be available in conditions of sudden and large changes in certain water characteristics, such as:

- turbidity of water during high waters;
- summer maximum water temperature
- winter minimum water temperature
- increased concentration of algal metabolism products (usually in late summer and early autumn); and similarly.

Water in reservoirs changes its quality much more slowly than water in a watercourse (Michalec and Cupak 2022), and in that respect its preparation is a much easier task, however, there is a need to determine the extent of the consequences of some changes in water quality in the reservoirs expressed, such as the "overturning" of water and the massive growth of algae.

Rulebook on the hygienic quality of drinking water, hereinafter: Rulebook on drinking water, or Rulebook, does not condition the physical and chemical quality of raw water, while in terms of microbiological safety of raw water sets certain restrictions. From the aspect of water preparation, this practically means that drinking water can be obtained by treating raw water of any physical and chemical quality, while in microbiological terms it cannot be raw water of poor quality, which is from the aspect of water preparation and microbiological safety by preparing the obtained water. for drinking is very favorable, because the first barrier to the penetration of microorganisms dangerous to health is already placed at the source, (Lindmark et al. 2022).

Water quality management in reservoirs should be provided as part of overall activities to ensure drinking water quality standards. Measures to control the composition of water in reservoirs should be implemented continuously since the establishment of the system and during operation to the extent defined through the control system.

5. CONCLUSION

Water treatment technology must be set in relation to the water quality in the available source. Ignorance or insufficient knowledge of the quality of spring water makes it difficult or even hinders the correct definition of preparation technology and makes it impossible for a water treatment plant to be constructed with the best possible technical and economic characteristics, according to the rulebook on drinking water hygiene, (Wolf et al. 2022). When it comes to surface water sources, the degree of control depends on the possibility and importance of the problem in the given conditions, for example, upstream effluents from industry and settlements. In doing so, special attention should be paid to analyze conducted to determine pH, turbidity, chlorine consumption, alkalinity, and the presence of intestinal germs. These water quality indicators are the basis for the correct choice of raw water treatment technology.

The characteristic of surface water sources is that the water quality is subject to seasonal changes, or daily changes in the case of direct abstraction from the stream. The problem is significantly mitigated when capturing water from reservoirs. However, in the case of reservoirs, there is a seasonal change in water levels and in connection with that, changes in the levels of the oxidation and reduction zone. It is known that these zones differ, primarily in the presence of dissolved oxygen, which significantly affects water quality. Therefore, it is necessary to provide water intake at different levels that will enable monitoring of the oxidation zone.

It is essential to pay more attention to researching water quality problems and their provision to the population in sufficient quantities, of appropriate quality and delivery dynamics. Future research should focus on the development of technologies for testing water quality and their purification.

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ЗАГАЂУЈУЋЕ МАТЕРИЈЕ И ИНДИКАТОРИ КВАЛИТЕТА ВОДЕ У ФУНКЦИЈИ УПРАВЉАЊА ВОДАМА У САВРЕМЕНИМ СИСТЕМИМА

Сажетак: Вода на Земљи је витални део живих система. Вода је медијум који омогућава живот и истовремено медијум у коме егзистирају разнолики еко системи. Природне воде садрже у себи растворене гасове, растворена органска и неорганска једињења и чврсте суспендоване супстанце. На количине растворених и суспендованих супстанци утичу: температуре воде, контакт воде са атмосфером, врсте седимента са којим је вода у контакту, количине оборинских вода које долазе у површинске воде и количине отпадних супстанци, које су антропогеног порекла. Табеларно и локацијски су истражени и приказани резултати квалитета воде према методологији *Eurowaternet – Lakes Aggregation of station data.* Добијена процењена вредност квалитета воде је изражена одговарајућим Water Quality Index - ом. Индикатори квалитета воде су одређени методом Serbian Water Quality Index. Анализе су представљене расподелом учесталости индикатора *SWQI*, нитрата, укупног фосфора, амонијума и БПК$_5$. Везано са тим, као резултат примењене методологије и чињенице да су се савремени системи за водоснабдевање у Републици Србији доминантно ослањали на резерве подземних вода, а у последње време све више на захватање воде из акумулација и њихову употребу после третмана пречишћавања, дат је и предлог управљања квалитетом сирове воде.

Кључне речи: водни ресурси, загађујуће материје, индикатори квалитета воде, *SWQI*, управљање водама.

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