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Artículo de investigación

Update for the biodiversity and inflows of Araz River (Azerbaijan)

Nuevos datos sobre la biodiversidad e hidrología del río Araz (Azerbaijan)

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Abstract

The article provides updated information about the hydrological characteristics, biodiversity and the influence of these and other anthropogenic factors in the Araz River and some of its tributaries in Azerbaijan.

Its is revealed that concentration of such unnatural components as heavy metals, phenols, oil products and other pollutants in the water of the river highly increased during last 50-60 years. As a result, the proportion of dissolved oxygen in the water is partly decreased, while the degree of water mineralization increased 2-4 time. Ten species of macrophytes, 34 species of fishes, 28 species of zooplankton organisms belonging to 3 ecological groups and 95 species of macrobenthic organisms, belonging to 14 systematical groups, were found in Araz River. 6 groups (60 species) of macrobenthic organisms were revealed in the faunas of Okhchuchay River and Hakarichay River.

Key words: Araz river, Azerbaijan, limnology, biodiversity, macrophytes, fishes, zooplankton.

Resumen

Este artículo aporta información actualizada sobre las características hidrológicas, la biodiversidad y la influencia de los factores antrópicos en el río Araz y sus tributarios. Los datos revelan altas concentraciones de metales pesados, fenoles, productos derivados de los hidrocarburos y otros productos en el agua del río, que se han incrementado notablemente en los últimos 50-60 años. Como resultado de dichas perturbaciones se han producido ciertos cambios en la composición físico química del agua, particularmente por ejemplo en los niveles de oxígeno disuelto, que han disminuido, así como en los valores de la conductividad, que se han incrementado, entre 2 y 4 veces. La biodiversidad del río Araz incluye 10 especies de macrófitos, 34 de peces, 28 de zooplancton (que pertenecen a 3 grupos ecológicos) y 95 de macroinvertebrados (pertenecientes a 14 grupos sistemáticos). En el caso de los ríos Okhchuchay y Hakarichay, se determinaron 60 especies de macroinvertebrados (pertenecientes a 6 grupos).

Palabras clave: río Araz, Azerbaijan, limnología, biodiversidad, macrófitos, peces, zooplancton.

INTRODUCTION

The growth of population and increasing agricultural and industrial areas within river basins as well as ineffecient use of natural resourses frequently result in water pollution (Abell *et al.*, 2017). For example, the Copper-Molybdenum mining companies Agarak, Gajaran and Gafan located within Okhchuchay River basin each year discharge thousands tonns of waste water into this river which then polluts Araz River. The average concentration of heavy metals (copper, zinc, lead, molibden etc.) and phenols in this water 15 - 40 time exceeds the legal limits in the country. The water in middle and lower parts of Okhchuchay River resembles a mixure of grey-yellow-brown colours and has unpleasant technogenic smell.

Araz River flows across the territories of several countries, Turkey (catchment basin 29.9%), Armenia (16.6%), Iran (39.2%) with Azerbaijan (21.3%) being the last area where pollutants accumulate at highest degree. While during the period of natural regime (first half of XX century) the mineralization degree of water in Araz River varied within 300 - 500 mg/dm^3 depending on the season of the year, at the present time this parameter increased to 800 - 2000 mg/dm^3. In the composition of water and bottom sediments the toxic antropogenic matters were found.

The proceeding physicochemical changes of water and sediments result in transformation of diversity and biomass of hydrobionts inhabiting various biotopes (Mammadov, 2006).

Investigation of hydrofauna of Araz River has started over a hundred years ago. The first data on benthos of the river could be found in works of different authors (Rosen, 1914; Martynov ,1938; Petrov, 1938; Kirichenko, 1938; Zaitsev, 1946a; Alizade, 1945 and Gasimov, 1972). Up to date only 37 species of macrobenthic organisms were recorded in the fauna of Araz River, some of wich are not found at present time. This information is very important from the point of temporal transformation of the fauna. The fishes of Araz River was studied by Gasimov (1972). Further information is provided by Mammadov (2010) who recorded 37 species of fishes from water reservoirs of Araz.

The goal of our investigation was to determine on the base of field and laboratory data the biodiversity of species and their seasonal population dynamics in the middle and lower parts of Araz River and its left-side branches Okhchuchay and Hakarichay rivers.

MATERIAL AND METHODS

The following methods were used for sampling and treatment of hydrobiological material: representatives of benthic organisms were determinated using Zhadin (1956), zooplankton species by Kiselyev (1956) and higher water plants by Katanskaya (1956), which are widely accepted key books for identification of these groups of organisms. Hydrochemical assessment was made based on classification proposed by Alekin (1970). The water samples were characterized by the following physicochemical parameters: macro and micro components, percentage of dissolved oxygen, pH, temperature of water (^{0}C), turbidity and the presence of pollutants.

The material was collected in two periods: 1990-1991 and 2011-2012 years in various biotopes of studied rivers. In the period 1990 – 1991 the material was sampled in the territory from Minchivan Village to the Mil-Mugan waterworks (Middle Araz) and in the period 2011-2012 in the territory from Bahramtepe waterworks to the Lower Araz bordering with Kura River. In Hakarichay and Okhchuchay rivers material was sampled 10 km higher from drainage system (see Fig. 1 for the studied rivers, areas and periods of investigation).

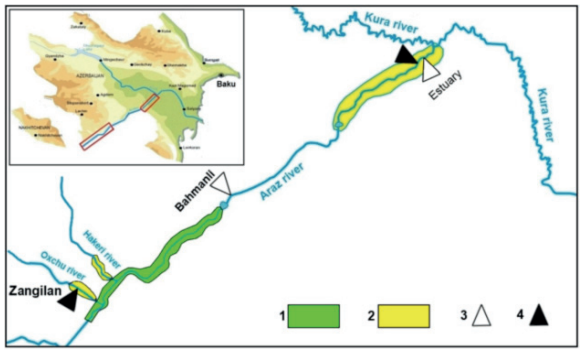

Figure 1. Studied rivers: areas in green (Middle Araz) and yellow (Lower Araz, Okhchuchay and Hakarichay) and periods of investigation (1. Lower Araz; 2. Middle Araz; 3. Research area; 4. Branch of Araz river)

Figura 1. Ríos estudiados: áreas en verde (curso medio del Araz) y amarillo (curso bajo del Araz, Okhchuchay y Hakarichay) y períodos de investigación (1. Curso bajo del Araz; 2. Curso medio del Araz; 3. Área investigada; 4. Tributario del río Araz)

The information on physicochemical parameters of the water of rivers is based on our own field measurements and also on the data obtained by monitoring with the help team of the Ministry of Ecology and Natural Resourses of Azerbaijan Republic.

The water samples were taken at different intervals during 1984 – 2012 period.

RESULTS AND DISCUSSION

First of all, we provide information about hydrological and hydrochemical characteristics of the studied rivers.

Araz River is the biggest inflow of Kura River and takes its beginning from northern slope of Bingel mountain ridge in Turkey. Its length is 1.072 km and the area of reservoir is 102.000 km^2. A long-standing analysis indicates that the natural river water flow (300 m^3/s) was reduced by ≥ 50% since it has been widely used in agriculture. In the spring thawed snow and rains increase the transfer of water to 1.500-2.000 m^3/s that was the reason of strong floods (e.g. 1868, 1896, 1942, 1964, 1969, 2010 years). For effective management and use of river Mil-Mugan and Bahramtepe waterworks and Araz (volume 1.35 km^3) and Hudaferin (volume 1.6 km^3) reservoirs were built on Araz River. After construction of reservoirs the minimal water flow in the river increased while the maximal flow decreased. Regarding with the chemical composition of the river water, calcium carbonate is the most common element found it. The degree of water mineralization exceeds the norm during most time of the year (Table I).

Two other studied rivers Hakarichay and Okhchuchay are both left-side branches of Araz. The source of Hakarichay River is at altitude of 2.580 m. The length of this river is 113 km, the basin of 2.570 km^2. The annual average of water transfer is 10 m^3/s and the river flow is formed by groundwater (62%), thawed (23%) and rain (15%) waters. There are floods in the spring and 60 - 70% of annual volume of a water stream of the river fall on this period. The average monthly temperatures of water vary between 1.5-2.5^{o}C in winter and 15-17^{o}C in summer. The concentration of dissolved oxygen in water is always high as is typical of Mountain Rivers. The chemical composition of the river water is mostly calcium carbonate. The mineralization degree of water is between 100-300 mg/l (Mammadov, 2010).

After the mixing up process of Araz River with Kura River the water of Araz is considered another waterbody.

The source of Okhcuchay River is situated at 3.285 m.a.s.l. The river flows across the territory of Armenia and Azerbaijan. The length of the river is 83 km (43 km in the territory of Azerbaijan), the basin of 1.175 km^2 (455 km^2 in Azerbaijan). The average annual water transfer is 8-9 m^3/s. There are floods in the spring and the average seasonal temperatures vary between 2.4-3.4^{o}C in winter, 5.4-10.7^{o}C in spring, 12.6-16.3^{o}C in summer and 14.5-6.5^{o}C in autumn. Related with the basin, the natural chemical composition of

Table I. Main physicochemical parameters of river waters
Tabla I. Principales parámetros físicoquímicos medidos en el río

N	Time of samples	pH	Water temperature ^{0}C	Proportion of issolved oxygen%	Concentration of ions mg/dm^3	Pollutants mg/dm^3		Microelements mcg/dm^3			
						Oil products	Fennols	Cu	Zn	Mn	Ti
Okhchuchay - Zangilan											
1	12/1984	8,60	10,0	98,8	468,6	0,05	0,009	5	12	5,1	6,0
2	05/1987	8,45	14,2	87,5	1018	0,09	0,013	15	13	5,9	6,8
Araz drainage											
3	12/1984	8,29	7,0	81,1	921,0	0,08	0,014	6	8	4,4	6
4	09/1987	8,30	21,0	59,5	1136	0,21	0,011	22	15	5,2	6
5	10/2010	8,37	19,8	65,0	1576	0,04	0,010	14	12	3,8	7
6	07/2011	8,60	22,7	64,2	1052	0,05	0,008	11	8	4,5	9
7	04/2012	8,40	10,2	48,7	1074	0,03	0,005	15	9	5,6	8

the river water is hydrocarbonate. Mineralization degree of water is between 200-300 mg/l (Mammadov, 2006). However, because of strong pollution of waters due to activity of the mining industrial companies, these figures have been strongly changed. Recently Okhchuchay is among most polluted rivers in Azerbaijan (Mammadov, 2010).

Beds of Araz, Okhchuchay and Hakarichay rivers are composed by pebble and grains of sand of various size. In Okhchuchay and Hakarichay rivers these are presented by pebble with a diameter of 10 - 100 mm, whereas in Araz River prevail grains of sand and pebble of the small size. In sediments of isolated meandr lakes of Araz River even smaller particles are deposited. In the part of river with slow stream unique diverse biotopes are developed. Here such macrophytes (most of them helophytes) as *Scirpus lacustris* Linnaeus, 1758; *Phragmites communis* Trin Ex. Steud, 1885; *Typha latifolia* Linnaeus, 1758; *Typha angustifolia* Linnaeus, 1758; *Lemna minor* Linnaeus 1758; *L. gibba*, Linnaeus 1758; *Potamogeton natan*s, Linnaeus 1758; *Potamogeton pectinatus* Linnaeus, 1758 and *Potamogeton crispus* Linnaeus, 1758, were found.

To obtain a more comprehensive information about macrozoobenthos of Araz River we continued investigation in 2011 – 2012 years in lower Araz in area from Bakhramtepe to Kura River. Twenty eight species of zooplanktonic organisms were revealed. Of these 10 species were represented by Rotatoria, 12 by Cladocera and 6 by Copepoda (Table II).

Table II. Number of species of zooplanktonic organisms in middle and lower parts of rivers.
Tabla II. Número de especies zooplanctónicas en las zonas media y baja de los ríos.

Rivers / Groups	Middle Araz		Lower Araz		Okhchuchay		Hakarichay	
	1990	1991	2011	2012	1990	1991	1990	1991
Rotatoria	6	8	9	10	2	2	8	9
Cladocera	10	9	11	12	1	0	6	7
Copepoda	4	5	6	6	0	0	5	4
Total	20	22	26	28	3	2	19	20

Investigation in Okhchuchay and Hakarichay rivers belonging to middle Araz basin, was conducted in two years (1990 – 1991). During the study period 20 species of zooplankton were recorded in Hakarichay river and 2 species in Okhchuchay river. In the middle Araz 20 species of zooplankton was found in 1990 and 22 species in 1991. In the lower Araz 26 species of zooplankton were recorded in 2011 and 28 species in 2012. In middle Araz in 1990 the biomass of zooplankton constituted 1,01 g/m^3. In lower Araz in 1991 biomass of zooplankton constituted 1,30 g/m^3, and density of organisms was 728-796 ind/m^3. In 2011-2012 in lower Araz biomass of zooplankton varied between 1,18-1,36 g/m^3, and its density between 824-868 ind/m^3. In Okhchuchay density of organisms was 24 ind/m^3 and their biomass constituted 0,02 g/m^3. In Hakarychay these figures equaled 374 ind/m^3 and 0,17 g/m^3 respectively (Table III: Quantitative dynamics (•m^3) of zooplankton organisms in middle and lower parts of Araz and Okhchuchay and Hakarichay rivers).

In two studied parts of Araz River which we arbitrually called the Middle (from Nakhchyvan water reservoir to Bahramtepe waterworks) and the Lower (from Bahramtepe to Kura River) in total 95 species of benthic organisms were recorded (Table IV: Species composition of benthic organisms of middle and lower parts of Araz River).

It is evident from Tables II – IV that diversity and density of organisms in highly polluted Okhchuchay river is several times lower as compared to the fauna of Hakarichay river in better conditions.

During the period of investigation 167 species of organisms belonging to 4 ecological groups (10 macrophytes, 34 fishes, 28 zooplanktic, 95 macrozoobenthic) were found in Araz River and its left branches (Fig. 2).

In Middle Araz 70 species were found in 1990 and 77 in 1991. In Okhchuchay and Hakarichay 6 and 60 species of benthic organisms were found respectively. Investigations in Lower Araz were conducted in 2011 – 2012 years. In 2011, 52 species were recorded while in 2012 only 44. Mollusca and Trichoptera predominated among collected organisms. The hydrofauna of Okhchuchay River is very poor because its water is strongly polluted by activity of industrial enterprises. In middle Araz the most numerous taxa are: *Nais communis* Piquet, 1906; *Stylaria lacustris* (Linnaeus, 1767); *Piscicola geometra* (Linnaeus, 1761); *Lymnaea stagnalis* (Linnaeus, 1758); *Lymnaea auricularia* (Linnaeus, 1758); *Corbicula fluminalis* (Müller,

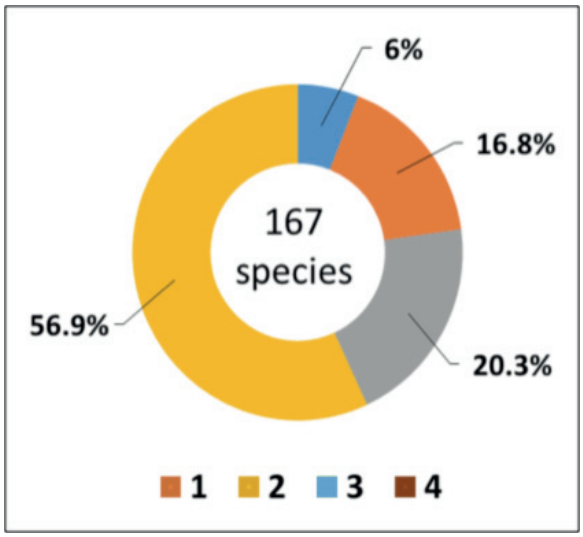

Figure 2. Species composition of biodiversity of Araz River (1. Orange, zooplanktic; 2. Yellow, macrozoobenthic; 3. Blue, macrophytes; 4. Grey, fishes).
Figura 2. Composición de la biodiversidad de especies en el río Araz (1. Naranja, zooplancton; 2. Amarillo, macrozoobentos; 3. Azul, macrofitas; 4. Gris, peces).

1774); *Dikerogammarus haemobaphes* (Eichwald, 1841); *Ecnomus tenellus* (Rambur, 1842); *Helius sp.* and *Helobia sp*. In lower Araz the dominant species are: *L. stagnalis; L. auricularia; Physa acuta* Draparnaud, 1805; *Planorbis planorbis* Linnaeus, 1758; *Gammarus lacustris* G. O. Sars, 1864; *Euxinia sarsi* (Sowinsky, 1898); *Hydropsyche instabilis* (Curtis, 1834) and *Limnephilus flavicornis* (Fabricius, 1787). All these species are found in very high densities.

In Araz River the most divers benthic groups are Mollusca (19 species) and chironomid larvae (17 species). Other animal groups are represented by 2 – 6 species. Forty two species are common for both studied parts of Araz watershed. Aditional species were found only in one or another of these areas. Sixteen species of widely distributed benthic organisms form dense populations were found in the puddles loceted in the bed of the river. At the same time there are many rare benthic species in some of which only 1-2 individuals were observed.

In Middle Araz (up to Bhramtepe) biodiversity of aquatic invertebrates is high because of the presence of various different habitats in this area. In contrast, in other part of rhe river from Bahramtepe to Kura River, sandy biotopes are mostly predominate so results show a decreased in diversity of species in that area. Quantitative models make it possible to precisely predict the future behavior of the system so for this reason in the table III it is presented the results for the calculations of quantitative dynamics ($\bullet m^3$) of zooplankton organisms in middle and lower parts of Araz, Okhchuchay and Hakarichay rivers. Also in the table V it is presented the quantitative dynamics ($\bullet m^3$) of benthic organisms in Araz River and its branches.

During the period of investigation in Middle Araz the density of benthic organisms varied between 748 -1.072 ind./m^2 (on average 910 individuals per square meter) and biomass varied between 2,25 g/m^2 – 3,01 g/m^2 (on average 2.48 g). In 1991, in this part of Araz River, maximal density was observed in Mollusca (120 ind./m^2), followed by Trichoptera larvae (116 ind./m^2), and chironomid larvae (102 ind./m^2). But regarding the biomass, the most important group was Trichoptera with a density of 0,39 g/m^2 (Table IV). In 1991 the most abundant group was again Mollusca (166 ind/m^2) followed by Trichoptera larvae (144 ind/m^2) and Amphipoda (126 ind/m^2) as indicated in Table V

In relation with biomass, the most predominated group was Mollusca (0,40 g/m^2) and Trichoptera larvae (0,40 g/m^2). On the base of two-year study of different groups of benthic organisms

Table III. Quantitative dynamics ($\bullet m^3$) of zooplankton organisms in middle and lower parts of Araz, Okhchuchay and Hakarichay rivers.
Tabla III. Dinámica cuantitativa ($\bullet m^3$) de organismos zooplanctónicos en las zonas media y baja de los ríos Araz, Okhchuchay y Hakarichay.

Periods / Groups	Middle Araz		Lower Araz		Okhchuchay	Hakarichay
	1990	1991	2011	2012		
Rotatoria	250/0,42	280/0,50	344/0,70	376/0,78	14/0,010	118/0,07
Cladocera	294/0,46	310/0,60	256/0,32	274/0,36	10/0,010	164/0,06
Copepoda	184/0,13	206/0,20	224/0,16	218/0,22	-	92/0,04
Total	728/1,01	796/1,30	824/1,18	868/1,36	24/0,020	374/0.17

Table IV. Species composition of benthic organisms of middle and lower parts of Araz River.
Tabla IV. Composición de especies bentónicas en las zonas media y baja del río Araz.

№	Subject and periods of study / Groups	Total number of species	Middle Araz		Lower Araz		Okhchuchay	Hakarichay
			1990	1991	2011	2012	1990	1991
1	Oligochaeta	3	2	3	3	2	-	4
2	Hirudinea	3	2	3	-	1	-	2
3	Mollusca	19	11	16	9	7	1	8
4	Amphipoda	6	4	5	5	3	-	5
5	Decapoda	5	3	3	2	1	-	6
6	Odonata	4	4	3	1	-	-	4
7	Ephemeroptera	7	7	7	5	4	1	5
8	Hemiptera	6	5	6	3	3	-	4
9	Coleoptera	5	5	5	4	3	1	4
10	Trichoptera	8	8	8	7	6	1	6
11	Diptera	7	7	6	4	6	-	5
12	Chironomidae	17	8	9	7	6	2	5
13	Ceratopogoniae	2	2	2	2	2	-	-
	Total	**92**	**68**	**76**	**52**	**44**	**6**	**58**

Table V. Quantitative dynamics (•m^3) of benthic organisms in Araz River and its branches.
Tabla V. Dinámica cuantitativa (•m^3) de organismos bentónicos en el río Araz y tributarios.

№	Study period / Taxa and area	Middle Araz		Lower Araz		Okhchuchay	Hakarichay
		1990	1991	2011	2012	1990	1991
1	Oligochaeta	74/0,14	98/0,20	38/0,08	46/0,12	-	48/0,12
2	Hirudinea	-	30/0,09	20/0,06	14/0,05	-	18/0,04
3	Mollusca	120/0,32	166/0,40	70/0,18	84/0,20	3/0,02	66/0,24
4	Amphipoda	102/0,26	126/0,30	56/0,10	58/0,16	-	48/0,18
5	Decapoda	2/0,28	2/0,30	-	4/0,50	-	3/0,48
6	Odonata	44/0,12	66/0,14	20/0,07	28/0,11	-	36/0,08
7	Ephemeroptera	20/0,08	36/0,08	-	38/0,14	2/0,01	52/0,12
8	Hemiptera	42/0,12	74/0,18	-	46/0,16	-	28/0,07
9	Coleoptera	38/0,14	82/0,28	16/0,07	30/0,10	-	38/0,10
10	Trichoptera	116/0,39	144/0,40	82/0,20	72/0,22	-	50/0,12
11	Diptera	68/0,14	92/0,26	60/0,15	52/0,16	-	24/0,08
12	Chironomidae	102/0,20	124/0,28	40/0,12	80/0,18	-	34/0,10
13	Ceratopogonidae	20/0,06	32/0,10	0	20/0,07	-	22/0,04
	Total	**748/2,25**	**1072/3,01**	**396/1,03**	**572/2,04**	**7/0,05**	**-**

it could be concluded that benthos of this part of Araz is formed mostly by three groups of animals, Mollusca (166 ind/m^2, 0,40 g/m^2), Trichoptera larvae (130 ind/m^2, 0,40 g/m^2) and Amphipoda (116 ind/m^2, 0,39 g/m^2). In lower Araz the density of benthic organisms varied between 572 -396 ind/m^2 (on average 434 individuals per square meter) and biomass varied between 1,03 - 2,04 g/m^2 (on average 1,57 g). In 2011 in this part of Araz River the dominat group both by biomass and density was Trichoptera larvae (82 ind/m^2, 0,24 g/m^2). In general in the benthic fauna of lower Araz the most important groups (both by biomass and density) are Mollusca, Amphipoda, Trichoptera

and Chironomidae larvae. Of which the dominant taxon is Amphipoda (56-58 ind/ m^2, 0,10-0,16 g/ m^2). There are also other taxa as some Coleoptera in the area (Zaitsev, 1946b).

It is very likely that present data on macrobenthos of Araz River do not reflect its actual biodiversity. Nevertheless the present work and previous publications will play a significant role as a basis for further studies of hydrofauna of Araz River.

CONCLUSIONS

Since the second half of the 20th century, as a result of construction of reservoirs and other waterworks in the basin and the watershed, and also dumping water with municipal and industrial garbage, the hydrological and hydrochemical regimes in middle and lower parts of the Araz River and its left-side inflows, Okhchuchay river and Hakarichay river was impacted and altered because of this anthropic pressures. These processes had resulted a negative impact on hydrofauna of these rivers.

In this paper the results of the status of the biodiversity in the river were presented. 167 species of organisms were found in hydrofauna of Araz River and its left tributaries. These were were represented by 10 species of macrophytes, 34 species of fishes, 28 species of zooplanktonic organisms and 95 species of macrobenthic organisms. Only 9 species were revealed in highly polluted Okhchuchay River, while 80 ones were found in relatively clear water of Hakarichay River.

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