International Journal of Aquatic Science
ISSN: 2008-8019
Vol. 4, No. 1, 62-73, 2013

IJAS

-Review-

The assessment of organic contamination of the Aras reservoir based on hydrobiological indicators

Adil Aliyev[1], Reza Ahmadi[2,3]*, Akif Bayramov[4], Masoud Seidgar[3] and Mahir Maharramov[4]

1) Inistitute of Zoology, Azerbaijan National Academy of Sciences, Baku, Azerbaijan

2) Baku state University, Baku, Azerbaijan

3) Iranian *Artemia* Research Center, Urmia, Iran

4) Inistitute of Nakhchivan Bioresources, Azerbaijan National Academy of Sciences, Baku, Azerbaijan

Received: 26 May 2012 **Accepted:** 17 July 2012 **Published:** 14 January 2013

Abstract: According to the long term hydrobiological survey on the Aras reservoir based on phytoplankton, zooplankton and zoobenthose indices, the organic contamination of water was evaluated. Regarding its biological indicators, the saprobic quality of Aras reservoir was determined as (1.6-2.0 or β-mesosaprob). The higher saprobic indices (3-3.5 or α-mesosaprob) were observed on its deeper areas. In spring increased of water flow may mitigate the saprobic condition and change the related indicators to a lower level in the reservoir.

Key Words: Aras reservoir, hydrobiological indicators, organic contamination, saprobic indices

The Aras reservoir was constructed on the Aras River behind of electrical joint dam between Iran and Azerbaijan in 1970 (Anonymous, 1957). This reservoir is a large water resource which situated on the lands between Nakhchivan Autonomous Republic and Islamic Republic of Iran (Anonymous, 1978). It has an area about 145 km^2 and a volume about 1.35 km^3 when its water level is higher than 778 meters above the sea level. The reservoir is 52 kilometers long and 6.1 kilometers wide. The average depth at normal water level is 18.2 meters (http://www.ecogeodb.com). The reservoir has provided irrigation water for 400,000 hectares of arable lands in Azerbaijan and Iran, including about 60,000 hectares in Dasht-e Moghan area (Mclachlan,1988; Filipuzzi and Faramarzi, 2007). Aras River has a large economic role in the region (Collard, 1971). The content of water shared to West Azerbaijan Province from Aras

(✉) rezaahmadi1342@gmail.com

dam reservoir is 2 $m^3.s^{-1}$ (Foroutan and Barshandeh, 2011). The main resources providing the water of this reservoir are the Zangmar River, Sariso River, Ghotour River, Hajilar River, Kalibar River, Ilghena River, Darreh River and Balha River from Iran on the south (Mohsenpour Azari *et al.,* 2009). In Turkey the Ghareso River inflow from it's the west (Fatih, 2004). The Akhurian, Metsamor, Hrazdan, Azat, Vedi, Arpa, Vorotan, Voghdji and Megri Rivers inflow from the Armenia in the north side (Ewing, 2003). The Khachin River, Okhchi River, Kuri River and Kandlan River flow into the reservoir from the north side, Azerbaijan (UN, 2000; Bayramov, 2007). The Aras River is located on the border lines of Turkey, Armenia, Iran and Azerbaijan. Due to its boundary situation, its hydrobiology regime in down and middle areas has not completely studied except for few cases as the joint study with collaboration of Iran and Azerbaijan (Aliyev and Ahmadi, 2010). The annual changes in the water level of this reservoir is about 11-13 meters (UN, 2000). The maximum and minimum height is observed in May-June and early September, respectively. Due to specific hydrological regime of this reservoir its dry parts is covered with temporary forage twice a year (Bayramov, 2011). The geographical situation of Aras River and its boundaries is shown in Figure 1.

Fig. 1: The geographical situation of Aras River Origen and its combination part with Kura River (Zeeb, 2010).

Fifteen fish species were observed in the Aras reservoir included 15 species belonging to Cyprinidae 86%, Siloridae and Percidae individually 7% (Azadikhah *et al*., 2008). More than 2500 ton fish is harvested from this reservoir annually (Esmaili *et al*., 2011) Furthermore, *Astacus leptodactylus* is the most economic non-fish species whose origin is from Anzali lagoon on the north of Iran from where it is translocated and introduced to the Aras reservoir (Gorabi, 2003). It has reported that 240 tons Crayfish is harvested annually but the mollusk has not exploited (Hossienpour and Karimpour, 1999). In spite of their economical and exporting importance harvest of these animals is not consistent with the scientific methods and this may lead to damage of aquatic resources specially Crayfish (Mohsenpour Azari *et al*., 2009). Almost all of the catches are exported to European countries (Nekuie Fard *et al*., 2011).

Metallurgical and mining sites in Armenia and Turkey are of particular concern for the Aras River. Magnesium and heavy metals are discharged into the river, including copper, molybdenum and iron (Filipuzzi and Faramarzi, 2007). This adds to the high heavy metal content in the river caused by the natural occurrence of chromium, copper and nickel (UNDP, 2007). The concentration of metals at the confluence of Aras exceeds permissible levels by up to nine times. The concentration of phenols is six times higher. Mineral oil and sulphates are two and three times higher, respectively (Ministry of Nature Protection of the Republic of Armenia, 1998).

The study on water quality in the river basin concluded that a large portion of shared contaminations resulted from former Soviet time. This included a massive use of pesticides, chemical fertilizers and defoliants which were used in Azerbaijan's agriculture and the use of polluting chemical production factories in Armenia (Ministry of Nature Protection of the Republic of Armenia, 2010).

The analysis of water samples from headspring to the Aras reservoir shows that the ecological crisis of this river reaches to its maximum level in August and September when its water level reduces to its minimum value. In this period the amounts of some toxic materials such as phenol, ammonia, nitrite and chrome in the water of the river exceed up to 500 fold more than their permitted values. It is evident that heavy metals had crucial role in polluting the Aras River and consequently the reservoir (Ewing, 2003). The bioaccumulation of heavy metals in different aquatic animal tissues was occurred and evaluated in *Astacus leptodactylous* (Naghshbandi *et al*., 2007). The results indicated that more than 120 $\mu g.g^{-1}$ Zn which was higher than that of Iranian standard acceptable level observed in *A. leptodactylous;* 50 $\mu g.g^{-1}$ (ISIRI, 2005). Unfortunately, it reduces the means of total length and weight to the lower than standard commercial size (120 mm) and weight (50 gr) in Crayfish (Asem *et al*., 2012). The sever contamination of Aras River specially on headspring parts has investigated using satellite methods and the results obtained from ecological and geographical researches confirmed these contaminations (Babayev, 2004b).

Long term evaluations indicated that the contamination level of this river with radionuclide and their dynamism may create a sever crises for this region. Repair of Armenia Atomic power reactors for electricity generation and providing their fuels have affected the river. This may create long term harmful effects in this ecosystem. In spite of harmful possible pollution which made by the accumulation of nuclear wastes on the mud of Aras reservoir, the filtration effect of the sediments can lead to protection of downstream of the river to some extent (Babayev, 2004a,b). Sediment samples from Aras River and its aquatic plant flora showed that the activity concentrations of ^{137}Cs, ^{238}U, ^{234}U, $^{239+240}Pu$, ^{238}Pu, ^{90}Sr and ^{241}Am, were relatively low, and in most cases below the detection limit (Sansone *et al*., 2008) It seems that the main source of radioactive contamination in the study area was related to historical nuclear weapon tests carried out during the Soviet period (IAEA, 2005).

Obtained samples from upstream of the river showed that the civilian source contamination of south east parts of Armenia which inflow to the river by a raceway called Shirarkhi that situated between Sadarak and Nakhchivan cities were polluted to harmful chemicals and other unknown contaminations. Other sources of contamination of Aras River are the waters inflow from Okhchochay River in Mehri region of Armenia which contains neighboring civilian sewages and mineral production units (Quliyev *et al*., 2011).

Not only Aras reservoir is contaminated with organic materials of neighboring civilian sewages that increase the nitrate and phosphate concentration (Alizadeh *et al*., 2008), but also simultaneously is affected with minerals and organic fertilizers irrigated from the agriculture farms of Einiyadli playa. These sewages without any primary refinement inflow directly to the middle of this reservoir by a drainage raceway, which produce the variety of sever changes in biological life of this reservoir. Due to sever organic pollution in whole or on a part of the reservoir a new ecological condition was produced which can create the prerequisite for growth and development of certain species of phytoplankton and aquatic invertebrates. It should be mentioned that the huge accumulation of fishes have observed frequently in the raceway that irrigate the Nakhchivan civilian sewages into the Aras reservoir (Bayramov, 2011). In Aras reservoir the diatoms (Bacilariophycea) biodiversity is high which characterizes the southern parts of the reservoir (Mohebbi *et al*., 2011). *Volvox aureus* has extended in the shallow southern parts of the reservoir from 1987 and has defined as one of the key species that has an important role in water contamination. In September 1986 at the late phase of mentioned algal bloom, oxygen depletion resulted in mortality of large size carps in this reservoir (Salmanov, 2004). Increased growth of certain groups of phytoplankton especially blue green algae can result in deoxygenating of the water leading to fish deaths (Mohsenpour Azari *et al*., 2011).

The aim of this research was to determine the saprobic condition of Aras reservoir based on available data from long-term study according to acceptable hydrobiological methods and analysis.

Up to now, 71 zooplankton species (Mammadov, 1990), 97 macrozoobenthose species (Aliyev and Ahmadi, 2010) and 22 fish species (Mammadov and Quliyev, 2000; Esmaili *et al*., 2011) have been identified. According to the number of zooplankton species, Rotifera (37 species) and macrozoobenthose species Chironomidae (35 species) were the prevalent species (Aliyev and Ahmadi, 2010). Among the zooplankton *Polyarthra vulgaris*, *Asplanchna priodonta*, *Daphnia longispina*, *Chydorus sphaericus*, *Acanthodiaptomus denticornis*, *Cyclops strenuus*, *Cyclops visinus*, *Acanthocyclops vernalis*; from macrozoobenthose *Chironomus plumosus, Chironomus nubeculosus*, *Chironomus defectus*, *Procladius ferrugineus*, *Nais communis*, *Ophidonais serpentina*, *Tubifex tubifex*, and among the fish species *Rutilus rutilus caspicus*, *Cyprinus carpio*, *Aspius aspius*, *Stizostedion luciperca*, *Abramis brama* and *Silurus glanis* were the dominant species. The mean biomass of zooplankton and macrozoobenthose were 1.8-2.4 $g.m^{-3}$ and 9.5-12.4 $g.m^{-2}$, respectively.

According to the number of species and biomass, the blue green algae (Cyanobactria) were the prevalent group of algae in the reservoir from July to October. In this reservoir since 1977 (August-September) *Microcystis aeruginosa* (β-mesosaprob) and *Aphanizomenon flos-aquae* (β-mesosaprob) (Kitner and Poulícková, 2003) have bloomed. This can lead to various degrees of pollution which have been taken place in the reservoir (Díaz-Pardo *et al*., 1998) In several years the wet biomass of these species increased up to 3.5 $Kg.m^{-3}$ in the reservoir.

To determine the organic contamination level of water based on zooplankton indicators (Beaugrand, 2004), 31 indicator species which forms 44% of all zooplankton species were used. The long term water quality assessment of this reservoir has shown that the monthly mean of saprobic index of the reservoir was about 1.55-2.15 (β-mesosaprob).

Based on assessed indicators the annual mean of contamination of these reservoir without any sever fluctuations was changing from 1.75-1.85 (β-mesosaprob) (Mammadov, 1990).

Calculated data showed that in open parts of this reservoir, the permanent contamination level enjoyed of more stability 1.66-1.89 (β-mesosaprob). The maximum pollution of the water 1.89-1.99 (β-mesosaprob) was recorded from August to September in shallow parts of the reservoir.

With huge bloom of blue-green algae, the by products from their degradation and metabolism acts such as an organic contamination source results in increased indicator communities such as *Polyartra vulgaris, Chydorus sphaericus, Daphnia pulex, Cyclops strenuus, Cyclops vicinus* and other β-mesosaprob species.

In early winter the organic contamination of water reaches to about more than the mean annual value and was decreased gradually until spring (Table 1).

It has been shown that the benthic invertebrates or macrobenthoses have a specific position among other saprobic bioindicators (Abakumov, 1977). They have more tolerance and lifespan compared to other aquatic organisms (Mohammadi Roozbahani, 2010). For these reasons, among various biosenoses, species diversity and related abundance of macro benthic indices usually could be the best and unique indicator for determining the bed and water bodies' contamination (Makruşin, 1974). Also, due to accumulation of the great portion of organic matters that always accumulated dynamically in water bodies, on the mud and on the other biotopes, so accurate assessment of the contamination level, the indicator organisms study on the bed and water bodies should be performed integrated (The water secretary of USSR,-1977).

Tab. 1: Water saproby indices of Aras reservoir based on zooplankton*

Months	**2009**		**2010**	
	shallow parts	**deep parts**	**shallow parts**	**deep parts**
March	-	-	1.83	1.80
April	1.89	1.82	1.86	1.85
May	1.77	1.66	1.78	1.71
Junauary	1.73	1.72	1.56	1.86
July	1.60	1.73	1.55	1.88
August	1.70	1.99	1.71	1.89
September	1.75	1.89	1.85	1.90
October	1.83	1.71	1.75	1.86
November	1.66	1.77	2.15	1.85
December	1.80	1.90	1.82	1.88
Mean indices	1.75	1.80	1.79	1.85
Saprobic zone	**β-mesosaprob**	**β-mesosaprob**	**β-mesosaprob**	**β-mesosaprob**

*Methodology by: Pantle and Buck, 1955

With altitude increasing, the residual vegetation in the reservoir's bed was affected by various physical and biological factors and the primary sources needed for detritus formation are created (Carvalho *et al*., 2005). These biosenoses support diverse invertebrate communities including aquatic, semi aquatic and terrestrial species such as certain mosquitoes and a number of terrestrial insects including some beetles, moths and butterflies that feed only on plants (Ahmadi *et al*., 2011).

Since the growth and development of oxygen dependent invertebrate animals (*Crusta-cea*, *Odonata*, *Ephemeroptera*, *Coleoptera* and others) depends on clean habitats, temporary occurrence of these populations at 100 km^2 of the surrounding peripheral area which periodically drying on Aras reservoir indicates the clean condition of these areas. In this zone the β-oligosaprob (7-8%) and β-mesosaprob (24.7%) species construct the prevalent population. The calculated saprobic indices for these lands change from (1-1.8) α- oligosaprob to β-mesosaprob.

The low level of contamination was observed in the spring of rainy years. There was no important recorded difference between the amount of organic matters exist on bed layers (mean=24%). Generally, in this reservoir from its more shallow areas to deeper parts, α-oliqosaprob indicator species such as *Baetis rhodani*, *Baetis* sp., *Hydroporus planus*, *Haliplus variegatus* were exchanged by the β-mezosaprob indicator species such as *Notonecta glauca, Ilyocorus cimicoides, Helophorus granularia, Hydrophilus fuscipes, Chironomus plumosus, Limnodrilus variegatus.*

The highest contamination level (3.0-3.50) *α*-mezosaprob was recorded from beds of deep areas. Muddy biotops with pelophil organisims due to their high quantity indicators severly differs from other biotops (Leman and Chebanova 2005). In this zoobenthosenose population the polysaprob indicator species such as *Tubifex tubifex* and *Chironomus plumosus* are highly privalent based on their density and biomass (Mackie, 2004). The development of tubificidae chironomidae comunities are depended on their high saprobic indices (Kucuk and Alpbaz, 2008), the high organic matter ammonts that accumolated in the mud (Ford, 1962) and their active physiological reactions against environmental pollutions (Schonborn, 1995). In the bed of the deepest biotopes of this reservoir, the existing organic matters based on their dry weight enjoy the maximum of 36% and the mean of 6.8%. In the research period the sever depletion of O_2 and evidence of H_2S was observed above mud layer (Bayramov, 2002).

Conclusion

The community of phytoplankton, zoo-plankton and macrobentose that exist in different layers of water and inhabit on bed layer of the river showed different reactions against organic contamination (Sandin and Hering, 2004). Like the other freshwater ecosystems, Aras reservoir was affected by primary and secondary organic pollutants. The primary pollution is defined as natural death of phytoplankton, zooplankton, deep layers fauna and fishes on the reservoir or other decayed material that are transferred from the river (Wegman *et al*., 1989). Due to their decomposition, the organic matter of water is increased that leads to self purification process. The organic matters are degraded to biogenic elements (N, P, Si and Fe) and finally return to mineral element cycles (Hanamachi *et al*., 2008). Secondary pollution is dependent on human activities in the region.

The studies carried out Turkish territory parts showed that the Aras River and it's related branches from Bingol, Karasu, Arasguneyi Mountains and the branch from Kars pastures ecologically was not undergone so much changes (Fatih, 2004). The most pollutants of Aras river related to Zangi, Karachay, Axurchay and Getap rivers and other urban sewages that enters from Armenia territory and the river who enjoys the most pollutants is formed the Iran-Azerbaijan boundary (Ozaran, 2008; Quliyev, 2011).

It is important to note that the creation of contaminations on Aras river from urban and industrial activities of Armenia was indicated by Salmanov in 1960s-1980s which described this part of Aras river ecologically critical (Salmanov, 2004; 2005).

It is important to mention that the sewage inflow at the middle parts of deep mud layers has stimulated the growth and development of especial macrobenethic senoses on it, and has shown their specific influence on all indices. In mud biotops, it is shown that the oligochaeta species like *Tubifex tubifex* commonly have the higher densities on deeper mud biosenoses, but Chironomidae are found in higher densities on shallower mud biosenoses (Ahmadi *et al*., 2012). In the center of Aras reservoir, due to the inflow and distribution of these sewages, the density and biomass of pelophil fauna (Tubifex and chironomid) was increased. Also, their individual length, color and energy content as a prey compared to the habitants of same biotops on the proximal and distal parts is high as 1.2-1.5 fold.

Therefore, regarding the long-term recorded data of biogen elements from phytoplankton, zooplankton and zoobenthose, the situation of Aras reservoir tends to be eutroph. Based on saprobic indices, its water quality is acceptable and can be considered as β-mesosaprob (1.6-2).

This reservoir with its biological self purification processes regulates its ecological saprobic balance and maintains itself at an acceptable level. In these processes the role of bacteria, fungi, together with protozoa on the changing of organic matters were crucial as the role of zooplankton, zoobenthose and the fish fauna. The geographic situation of the reservoir, its favorable topography, water temperature and its oxygen regime, water waves, also high volume water streams are the environmental factors that faciliate the purification proccess. Althogh, the present saprobic status of the Aras reservoir is not as critical to be classified as endangered poly saprob ones, but according to the World Health Organization (WHO, 2003), there is a probability of adverse health effects in application of such waters in fisheries or recreational activities, when cyanobacterial densities exceed 100,000 cells.ml^{-1} or chlorophyll levels dominated by cyanobacteria exceed 50 μg.l^{-1}. In Aras reservoir these levels were frequently higher than WHO standards (Mohebbi *et al*., 2011). When a moderate probability of health effects is suspected, the WHO suggests that on-site risk advisory signs should be posted. In the summer, dense surface scums of cyanobacteria are observed on the Aras reservoir and there is the potential for acute poisoning, potential long-term illness and short-term adverse health outcomes. Under these conditions the WHO recommends prohibition of water contact activities and public health follow-up investigations.

In the Caucasus ecorigin, Aras reservoir regarding its biodiversity richment and primary production is one of the large and important fresh water ecosystems. As an structural unit of biosfer, it's valuable ecological conservation need complementary legitimate from neighbering goverments. The entrance branch of Aras river, near of Sadarak city on the border of Azerbaijan and Armenia should be assessed based on chemicals, organic matters and radionuclotided complexes. Because this area of the river regular monitoring specially biological monitoring should be considered. The bacterio-benthoses and bacterioplanktons of the reservoir should be identified, the role of microorganisms and functional destructive proccesses in the biological life of the reservoir should be monitored; To maintain a stable water quality of the reservoir, special attention to its self-purification should be payed. Finally, the regular ecological monitoring of the river and the reservoir should be considered.

References

- ✓ Abakumov V.A. (1977) The monitoring of water quality based on hydrobiological indices in hydrometeorological service system. Proceedings of scientific monitoring of superficial water based on hydrobiological indices. Hydrometeozidat, 92-100.
- ✓ Ahmadi R., Aliyev A., Seidgar M., Bayramov A. and Ganji S. (2012) Macroinvertebrate Communities Differences on Riverine Parts and Reservoirs of Zarrineh River, American Journal of Agricultural and Biological Sciences, 7(1): 71-75.
- ✓ Ahmadi R., Mohebbi F., Hagigi P., Esmailly L. and Salmanzadeh R. (2011) Macro-invertebrates in the Wetlands of the Zarrineh estuary at the south of Urmia Lake (Iran), International Journal of Environmental Reserch, 5(4): 1047-1052.
- ✓ Aliyev A. and Ahmadi R. (2010) Biodiversity of benthic invertebrates in Aras river. Iranian Scientific Fisheries Journal, 19(2): 131-142.
- ✓ Alizadeh Zh., Mohsenpour Azari A., Seidgar M. and Alizadeh M. (2008) The study of nitrate and phosphate changes of Aras reservoir, proceedings of national symposium of Aquaculture and sustainable development, 217-221.
- ✓ Anonymous (1957) Agreement between Iran and the Soviet Union for the joint utilisation of the frontier parts of the rivers Aras and Atrak for irrigation and power generation.
- ✓ Anonymous (1978) International Boundary Study (The Geographer): Iran-U.S.S.R. Boundary No. 25 (Revised), pp. 10.
- ✓ Asem A., Mohsenpour Azari A., Mohebbi F., Yahyazadeh Y., Shiri S., Moghaddam M., Ganji S. and Dadashpour B. (2012) Sexual Length-Weight Dimorphism on *Astacus leptodactylus* in Aras Reservoir (NW; Iran), Aquaculture America 2012, Meeting Abstract
- ✓ Azadikhah D., Nekuiefard A., Mirzayi F., Nasrabadi S.A.

and Jalali J.B. (2008) On the less known Ancyrocephalidae (Bychowsky, 1937) (Monogenea, Polyonchoinea) species in freshwater and Caspian Sea fishes of Iran. . 6th internatl symposium on Monogenea Cape Town,South Africa.

- ✓ Babayev N.S. (2004a) The study of ecological condition on the upstream parts of the Aras river: PhD thesis on Geograph. Baku, pp. 30.
- ✓ Babayev N.S. (2004b) The civilization ecology in Aras river system, Nakhchivan history, its social aspects and natural resources learning, proceedings of science-practical conferance, Baku, Elm., 304-309.
- ✓ Bayramov A.B. (2007) The zoobenthose fauna on the Aras reservoir, Biol, PhD thesis on biology, Baku, pp. 22.
- ✓ Bayramov A.B. (2002) The hydrobiological analysis of contaminations on Aras (Nakhchivan) reservoir, proceedings of 5th international conferance, Sumqayıt, Sumqayıt state university: 5-7.
- ✓ Bayramov A.B., Maharramov M.M., Mammadov A.F. and Qasımov A.Q. (2011) The study of some bioecological charasteristics of Tubifex tubifex Muller (1774) on Aras (Nakhchivan) reservoir, Proceedings of 7th conference of Mezınarodnı vedesko-practika., Praha, Education and Science: 21-26.
- ✓ Beaugrand G. (2004) Monitoring marine plankton ecosystems (1): description of an ecosystem approach based on plankton indicators. Marine Ecology Progress Series 269: 69-81.
- ✓ Carvalho P., Thomaz SM. and Bini LM. (2005) Effects of temperature on decomposition of a potential nuisance species: the submerged aquatic macrophyte Egeria najas Planchon (Hydrocharitaceae). Brazilian Journal of Biology. 65(1) 51-60.
- ✓ Collard E. (1971). Middle East economic digest. 15. I.B.Tauris. 772.
- ✓ Díaz-Pardo E., Vazquez G. and López-López E. (1998) The phytoplankton community as a bioindicator of health conditions of Atezca Lake, Mexico, Aquatic Ecosystem Health & Management, 1(3-4): 257-266.
- ✓ Esmaili L., Peikaran N., Ganji S., Gorayshy M. and Shirvalilou M. (2011) A review on economic fish and other aquatic animals species on water resources of west Azarbaijan, Iran, Fisheries Journal of Shill, Tehran university, 3(10): 2-8.
- ✓ Ewing A. (2003) Water Quality and Public Health Monitoring of Surface Waters in the Kura-Aeaks River Basin of Armenia, Azerbaijan and Georgia. Water Resources program, University of New Mexico, New Mexico.
- ✓ Fatih I. (2004) The study of ecogeographical condition of Aras river catchement on Turkey, PhD thesis on Geograph. Baku: pp. 30.
- ✓ Filipuzzi S. and Faramarzi, M. (2007) The Science and Politics of Large Dam Project Aras river basin: dam facility and water management policy. An analysis on performance. Swiss Federal Institute of Aquatic Science and Technology
- ✓ Ford J.B. (1962) The vertical distribution of Larval Chironomidae (Dipt.) in the mud of a stream, Hydrobiologia, 19(3): 262.
- ✓ Foroutan S. and Barshandeh S. (2011) case study on productivity of water supply potentials on Aras reservoir, ICID 21st International Congress on Irrigation and Drainage, 23 October, Tehran (Iran), 279-285.
- ✓ Hanamachi Y., Hama T. and Yanai T. (2008) Decomposition process of organic matter derived from freshwater phytoplankton, Limnology, 9(1): 57-69.
- ✓ Hossienpour N. and Karimpour M. (1999) A preliminary study on fecundity of fresh water crayfish (*Astacus leptodactylus*) in Aras water reservoir. Iran. J. Fish. Sci., 1: 1-9.
- ✓ IAEA (2005) Radiological Survey of the Aras and Kura Rivers Azerbaijan, IAEA Technical Cooperation Project AZB/9/004.
- ✓ ISIRI (Institute of Standard and Industrial Research of Iran)-(2005) Canned-Shrimp in tomato sause specifications and test methods. No. 7634, 1st Edn.
- ✓ Kitner M. and Poulícková A. (2003) litoral diatoms as indicators for the eutrophication of shallow lakes, Hydrobiologia, 506-509(1-3): 519-524.
- ✓ Kucuk S. and Alpbaz A. (2008) The impact of organic pollution on the Kirmir Creek and Sakarya River in

Turkey, Water Resources , 35(5): 591-597.

- Leman V.N. and Chebanova V.V. (2005) Response of lithophilic zoobenthos to changes in the granulometric composition of grounds in the metarithral zone of a small river in the foothills of southwestern kamchatka, Russian Journal of Ecology, 36(2): 103-108.
- Mackie G.L. (2004) Applied aquatic ecosystems concepts, Kendall/Hunt Publishing Company. Second Ed. 784pp.
- Makruşin A.V. (1974) The analyses of water quality based on bibliographic indices. A list of polutant indicator organizems. L. USSR. Academy of science, zoology inistitution publications, pp. 53.
- Mammadov R.A. (1990) The zooplankton of Aras reservoir, PhD thesis on biology, Minsk, USSR, pp. 21.
- Mammadov T.M. and Quliyev Z.M. (2000) Commercial fishes of Nakhchivan autonomous republic, Baku, Araz-Magazin, pp. 50.
- Mclachlan, K.S. (1988). The neglected garden: the politics and ecology of agriculture in Iran. I.B.Tauris. pp. 135.
- Ministry of Nature Protection of the Republic of Armenia (1998) First National Communication of the Republic of Armenia. Under the United Nations Framework Convention on Climate Change, pp. 66. (http://unfccc.int /resource/docs/natc/armnc1e.pdf)
- Ministry of Nature Protection of the Republic of Armenia (2010): "Second National Communication of the Republic of Armenia. Under the United Nations Framework Convention on Climate Change, pp. 101 (http:// unfccc.int/resource/docs/natc/armnc2e.pdf)
- Mohammadi Roozbahani M., Nabavi M., Farshchi P. and Rasekh A. (2010) Studies on the benthic macro-invertebrates diversity species as bio-indicators of environmental health in Bahrekan Bay (Northwest of Persian Gulf) African Journal of Biotechnology, 9 (39): 8763-8771.
- Mohebbi F., Mohsenpour Azari A., Heidari M. and Asem A. (2011) Cyanobacterium Microcystis aeruginosa bloom in Aras Dam Reservoir, International journal of Environmental Research, 6(1): 309-312.
- Mohsenpour Azari A., Asem A. R., Motallebi A.A., Mohebbi F. and Shiri S.(2009) Length-weight freqyency and sexual ratio of crayfish, *Astacus leptodactylus* in Aras reservoir, west Azerbaijan (Iran), Iranian Scientific Fisheries Journal. 18(3). : 138-147
- Mohsenpour Azari A., Mohebbi F. and Asem A. (2011) Seasonal changes in phytoplankton community structure in relation to physico-chemical factors in Bukan dam reservoir (Iran), Turkish journal of Bottany, 35: 77-84.
- Naghshbandi N., Zare S., Heidari R. and Razzaghzadeh S. (2007) Concentration of Heavy Metals in Different Tissues of *Astacus leptodactylus* from Aras Dam of Iran, Pakistan Journal of Bioligical Siences 10(21): 3956-3959.
- Nekuie Fard A., Motalebi A.A., Jalali Jafari B., Aghazadeh Meshgi M., Azadikhah D. and Afsharnasab M. (2011) Survey on fungal, parasites and epibionts infestation on the *Astacus leptodactylus* (Eschscholtz, 1823), in Aras Reservoir West Azarbaijan, Iran, Iranian Journal of Fisheries Sciences, 10 (2): 266-275.
- Ozaran A. (2008) The comparative study of microbiological regime of Aras river catchement on Turkey and Armenia boundary. The news letter of scientific academy of Azerbaijan, biol.scientific series, (1-2): 146-151.
- Pantle R. and Buch H. (1955) Die biologische ubewachung der Gewasser und die Darstellung der Ergebnisse, Caz. und Waserfach., (96): 452-504.
- Quliyev Z.M., Aliyev A.R. and Seyid-Rzayev M.M. (2011) Bioresources of inland waters of Azerbaijan, biological sugestions to optimal use and increasing the resources. Baku, Elm publication, 107 pp.
- Salmanov M.A. (2004) The micribiological monitoring of Boundary rivers of Azerbaijan, proceedings of Azerbaijanian agriculture ecosystem conferance, Baku: 32-42.
- Salmanov M.A. (2005)the study of microbial ecology of Aras river on its external boundary parts of Azerbaijan, proceedings of microbiology inistitute, scientific Academy of Azerbaijan, Baku, Elm, 2:129-135.
- Sandin L. and Hering D. (2004) Comparing macro-invertebrate indices to detect organic pollution across

Europe: a contribution to the EC Water Framework Directive intercalibration. Hydrobiologia, 516: 55-68.

- Sansone U., Kim C.K., Kis-Benedek G., Schorn R., Zeiller E., Qaribov A., Huseynov V. and Chupov A. (2008) Natural and anthropogenic radionuclides in the rivers of Azerbaijan, Journal of Radioanalytical and Nuclear Chemistry, 277(2): 357–364.
- Schonborn W. (1995) Defensive Reactions of Stream Ecosystems in the Early Stages of Pollution. Ecological Importance and Possibilities of Ecosystem-Adequate Restoration Methods, International Revue on Hydrobiology, 80(4): 655-666.
- The water secretary of USSR (1977) Supplementary methods for water quality analysis, appendix II, Atlas of saprob organisms. Moscow. pp. 228.
- UNDP (United Nations Development Program) (2007) Kura-Aras River Basin, Transboundary Diagnostic Analysis. pp.113.
- UN (2000) Environmental Performance Review of Armenia United Nations Economic Commission for Europe, pp. 202.
- Wegman R., Melis P. and Josefsson B. (1989) Organic Pollutants in Water, C R C Critical Reviews in Analytical Chemistry, 16(4): 281-321.
- WHO (World Health Organization) (2003) Chapter 8: Algae and cyanobacteria in fresh water. Guidelines for safe recreational waters, Coastal and fresh waters. Geneva, WHO Publishing. 1: 136-158.
- Zeeb S. (2010) Adaptation to Climate Change in the Kura-Aras River Basin, River Basin Snapshot Draft for Discussion, Competence Center Water and Waste Management, pp. 46.
- http://www.ecogeodb.com