# The Feasibility of Groundwater of Aras River Margin for Aquaculture in Iran

**Shahmohammadi-Kalalagh Sh.[1,*], Jafarvand-Azarkhiavi Gh.[1], Ghasemi H.[2]**

[1] Department of Water Sciences and Engineering, Tabriz Branch, Islamic Azad University, Tabriz, Iran

[2] East Azarbaijan Agricultural and Natural Resources Research Center, Tabriz, Iran

*corresponding author:

e-mail: shahmohammadi_sh@iaut.ac.ir

**Abstract** This study investigated the feasibility of trout fish farming using groundwater at the Aras river margin, Eastern Azerbaijan, Iran. Along with the purpose of the study, the wells at the Aras river margin, river bed and border, location for digging observation wells, different types of water quality in the intended area, soil studies and experiments of water qualitative properties were considered. Experiments conducted on the qualitative properties of the experimental wells during a one-year period (2016) focused on the investigation of the followings: water temperature, dissolved oxygen, carbon dioxide, acidity (pH), total hardness of water, alkalinity, total minerals of the solution, electrical conductivity, carbonate, bicarbonate, chloride, sulfate, calcium, magnesium, sodium, potassium, nitrate, nitrite, ammonia, phosphate, iron, manganese, copper, zinc and lead. The results showed that different anionic and cationic combinations, despite their high concentrations, did not cause uncontrollable limitations for aquaculture. Regarding heavy metals, it was found that the recorded amounts of some heavy metals were higher than the specified standard limit in some measurement locations of the experimental wells and in some seasons. In general, it can be maintained that the groundwater quality of the Aras river margin did not cause uncontrollable limitations for aquaculture.

**Keywords:** Groundwater, Aras river, qualitative indexes, aquaculture, Observation wells.

## 1. Introduction

Iran is considered to be one of the semi-arid countries of the world. Hence, the available groundwaters of this country are of high importance. The development of aquaculture in any region requires an examination of its feasibility where all the available potentials and barriers with regard to ecological, economic and social aspects and infrastructures are examined. The selection of apt locations which are highly potential for aquaculture helps reduce possible risks and costs and also enhance efficiency (Halwart, 2005). The degree of the production of aquatic organisms depend upon the surrounding environmental conditions. One of the most critical environmental conditions which can impact on the growth of aquatic organisms is the quality of water. Groundwater is a preferred choice in aquaculture since this source is usually more reliable and sustainable throughout time than surface water. Furthermore, groundwater is free from wild fish, spawn and different forms of predacious insects. Also, it should be noted that the pollution of groundwater is less than surface water though this condition may vary in the future (Afsharnasab *et al*., 2014). During a year, the temperature of groundwater remains almost fixed and this feature can be exploited as a merit and advantage in some cases. However, groundwater also has demerits and disadvantages which might lead to the limitations in their use in certain regions. The biggest drawback of groundwater is the lack of sufficient oxygen. Hence, before they can be used, they should be aerated. Indeed, groundwater might have high density soluble iron which gets out of water as a result of water aeration (Afsharnasab *et al*., 2014; Janbazi and Gorjian 2013). The hardness of groundwater is specified based on the geological characteristics of the given area. For developing aquaculture in groundwater, a thorough chemical analysis of the intended groundwater is needed so as to specify the type and the required degree of purification. Well water is regarded as the best supply for aquaculture and the quality of well water is principally higher than that of surface water (Jafari Bari 2001; FAO 2012). Regarding the feasibility of the development of aquaculture, some research studies have been conducted which are briefly reviewed below.

It should be noted that carrying out feasibility studies on aquaculture in the area of Aras river is of high significance since they can elaborate and shed light on the status and conditions of Aras water ecosystems in terms of developing fish farming. Hence, the present study was aimed at identifying the available opportunities and threats in relation to aquaculture activities at the margin of Aras river.

## 2. Materials and methods

### *2.1. Case study*

The intended research location and site was the northern area in eastern Azerbaijan from the latitude of 39 degree to 39 degree and 25 eastern minute and the length of 45 degree and 26 minutes to 47 degree and 21 northern minute in the southern margin of Aras river. The length of Aras river within the above-mentioned area is 225 kilometers. Aras river basin is located in the north of eastern Azerbaijan which incorporates an area about 7500 square kilometers. Hence, it can be argued that all the areas across Jolfa town and some section of the towns of Kaleybar, Ahar, Varzigan and Marand are included within the respective area. Water regime of this river is mainly attributed to snow melt. Also, the water flows resulting from rainfall and natural springs played notable roles in the water potentials of this river. The average water discharge of this river was reported to be about 183 cubic meters per second and the maximum water flow in this river is related to April and May (Fig. 1).

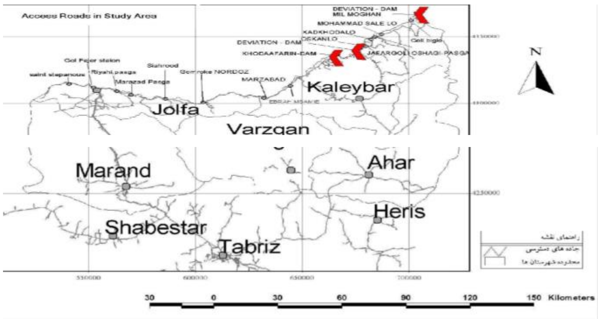


**Figure 1.** Accessibility and position of the studied area

*2.2. Weather and climate*

The margins and surrounding areas of the Aras river in north of eastern Azerbaijan are divided into three main sections in terms of precipitation: the northwestern margin of the river which is stretched from Aras dam downstream to the western areas of Jolfa town. The average annual precipitation in this area is 250 millimeters. The central section of the margins of Aras river is stretched from the east of Jolfa to the Khodafarin dam which has the average annual precipitation of 300 millimeters. The central part of the area is mountainous and in the highest areas, the average annual precipitation ranges from 400 to 500 millimeters. Furthermore, the north eastern section of the intended area begins from the downstream of Khodafarin dam to Aslandouz town. In this part, the river moves towards the east of the mountainous heights. The average annual precipitation in this area is about 250 millimeters. The average temperature in the spring season is 16.6 degrees Celsius, it is 26.6 degrees in the summer, 7 degrees in the fall and 0.5 degrees in the winter. The average lowest temperature in the coldest month of the year varies from 0 to -5 degrees Celsius. The coldest month of the year in the studied area is January. Furthermore, the average minimum temperature in the coldest month of the year was related to the heights facing Aras river valley (less than -5 degrees). Using the modified Domarten equation, the aridity index obtained (11.7), it can be argued that the climate of the investigated area was cold semi-arid.

## 3. Results and discussion

*3.1. Soil studies*

Variation in the type of soil in the respective area were not so diverse and it seems that the topographical factor and parental materials and rocks have had the greatest impacts on the soil of the studied area. According to the topography factor, the soils of the studied region can be divided into three groups: plain soils and valleys, plateau soils and the soils of foothills and mountainous areas. Different types of soil can be observed in each of the above-mentioned soils which are attributed to the following major factors: changes in elevations and heights, slope, hillside direction, degree of humidity and vegetation.

*3.2. Results of qualitative parameters of water*

The results of the qualitative features of water in the observed wells were measured which are given in Table 1. As shown in Table 1, the results of measuring heavy metals and the fluctuations were related to iron, manganese, copper, zinc and lead, respectively. The analyses indicated that in some periods of sampling, the amount of iron was higher than the standard level. On the whole, it can be argued that the fluctuations were within the standard range and through effective management, no limitations can occur. The highest concern was related to iron which can damage the installations and settings of the fish farming project. Furthermore, regarding the metal of manganese, in some samplings of the mentioned metals, it was noted that it was higher than the optimal level. Indeed, it can cause some limitations for aquaculture. However, it was not the case for the other areas. With regard to the fluctuations recorded for the metal of manganese in other areas of the study and based on the investigation of the geological formations and the pollutant resources, it can be maintained that highness of manganese can probably be attributed to human errors in measuring it. Regarding the metal of copper, in some dry seasons of the investigation, it was observed that the maximum copper value exceeded the optimal level which is considered to have limitations for aquaculture. Concerning zinc, some limitations were found and its increase in the spring season was remarkable since such an increase is in a humid season not in a dry season when the densities of minerals and metals are high. In contrast, in other areas, the fluctuations of zinc were within the optimal range, except for minor cases in some areas in the dry season of the year. With respect to the density of lead, it was found that the fluctuations were higher than the standard range in most of the cases. Nevertheless, it should be noted that the higher values were related to the dry seasons which gradually disappeared. Indeed, all the recorded values for the metals should be taken into consideration and managed. The presence of pollutants in the investigated areas and its significant increase in groundwater, though it is temporary, can intimidate fish farming projects.

**Table 1.** Values for the qualitative parameters of water in the experimental wells

| **Areas*** | **1** | | **2** | | **3** | | **4** | |
|---|---|---|---|---|---|---|---|---|
| **Parameters** | Minimum | maximum | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum |
| **Temperature ($C^o$)** | 9 | 22 | 10 | 26 | 10 | 20 | 12 | 19 |
| **DO (ppm)** | 6.7 | 11 | 5.1 | 10.5 | 6.1 | 11 | 6.5 | 10 |
| **Carbon dioxide (ppm)** | 6.5 | 39.5 | 4.7 | 70 | 10 | 51 | 5.5 | 47 |
| **pH** | 7.1 | 7.95 | 6.8 | 8 | 7 | 7.7 | 7.1 | 7.9 |
| **Water hardness (ppm)** | 370.5 | 1446 | 247 | 1000 | 268 | 1480 | 292.5 | 2534 |
| **Alkalinity (ppm)** | 225 | 440 | 175 | 535 | 215 | 482.5 | 175 | 525 |
| **TDS (ppm)** | 653 | 2298 | 390 | 1590 | 447 | 1975 | 1053 | 4550 |
| **EC (mmhos/cm)** | 1005 | 3535 | 600 | 2446 | 688 | 3039 | 1620 | 7000 |
| **Bicarbonate (meq/l)** | 2.55 | 8.8 | 3.5 | 10.7 | 4.3 | 8.65 | 3.5 | 10.5 |
| **Chloride (meq/l)** | 1.1 | 10.61 | 0.2 | 10.7 | 1 | 15.7 | 3.85 | 14.5 |
| **Sulfate (meq/l)** | 2.1 | 21.8 | 0.35 | 10.8 | 1.1 | 23.5 | 4.8 | 52.1 |
| **Phosphate (ppm)** | 0.02 | 0.6 | 0.02 | 1.25 | 0.03 | 0.21 | 0.03 | 0.125 |
| **Calcium (meq/l)** | 3.5 | 13.2 | 3 | 10 | 2.7 | 15 | 3.25 | 47 |
| **Magnesium (meq/l)** | 3.5 | 13.5 | 1.75 | 9.5 | 2.65 | 13.6 | 3.65 | 16.5 |
| **Sodium (meq/l)** | 1.38 | 12.64 | 0.22 | 10.08 | 0.13 | 8.55 | 5.61 | 31.25 |
| **Potassium (meq/l)** | 0.07 | 0.33 | 0.04 | 0.32 | 0.01 | 0.27 | 0.07 | 0.98 |
| **Nitrite (ppm)** | 0 | 0.038 | 0 | 0.12 | 0 | 0.065 | 0.004 | 0.11 |
| **Nitrate (ppm)** | 1.5 | 12 | 1.5 | 18.5 | 1.5 | 14.5 | 2.5 | 19 |
| **Ammonia (ppm)** | 0 | 0.3 | 0 | 16 | 0.03 | 0.65 | 0.03 | 2.5 |
| **Iron (ppm)** | 0.014 | 0.246 | 0.004 | 0.405 | 0.03 | 0.161 | 0.024 | 0.092 |
| **Manganese (ppm)** | 0.004 | 16 | 0.003 | 0.398 | 0.006 | 0.098 | 0.004 | 0.044 |
| **Copper (ppm)** | 4 | 131 | 2 | 223 | 2 | 198 | 5 | 69 |
| **Zinc (ppm)** | 6 | 165 | 2 | 356 | 3 | 1055 | 5 | 139 |
| **Lead (ppm)** | 1 | 73 | 5 | 90 | 7 | 71 | 9 | 62 |

* Area 1 including wells of W1 to W5, Area 2 including wells of W6 to W17, Area 3 including wells of W18 to W25 and Area 4 including wells of W26 to W29.

## 4. Conclusions

The results and findings of the present study can be summarized as follows:

- According to the modified Domarten equation, the aridity index obtained 11.7 at the Aras river bank along the flowing path of the river in eastern Azerbaijan province. It can be argued that the climate of the investigated area was cold semi-arid.
- Variation in the type of soil in the respective area were not so diverse and it seems that the topographical factor and parental materials and rocks have had the greatest impacts on the soil of the studied area.
- According to the collected data and information and the recorded qualities in this investigation, it can be maintained that the available potentials in the studied areas can be utilized, especially in case appropriate strategies and approaches are used to control different factors about the water entering the fish farms. Also, the quality of waste waters leaving the farms should be controlled so that they are within the standards of optimal water.
- Supplying dissolved oxygen for water in resources with a recorded temperature higher than 19 degrees C can be done through aeration

equipment in temperate and cold months and oxygenation should be done in hot months. In this way, dissolved oxygen fluctuations resulting from temperature changes can be controlled throughout the fish farming period.

There are numerous effective criteria for locating and identifying pools for rainbow trout fish farming, namely economic, social and local issues should be considered in such developing such fish farming projects. The specific emphasis of the present study was on the quality of water in which various issues, as discussed in this paper, should be taken into consideration and weighed in GIS. As a result of feasibility studies like this, the development of aquaculture can be implemented more effectively and efficiently.

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