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**Original Research Paper**

# Zoning of the Southern Coastal Region of the IRAN Based on Water Resources Pollution (Case study: Minoo Island)

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**Abstract**

The purpose of this study is assessment and zoning of water resources pollution in the Minoo Island. This research is of applied type and the method of data collection is library, field and laboratory. Therefore, the study area was networked and the networks that had an aquatic ecosystem were selected as the study area. Sampling of water (surface and underground) in the area was performed and transferred to a certified laboratory. The results showed that there are 3 types of water resources in the study area; Arvand River, surface rivers and groundwater. The Arvand River is more polluted than other sources. The average of TDS was between 1100-1600 parts per million (ppm). The highest levels of AS, Fe, Mn, Cr and Al are 0.425, 0.585, 0.883, 0.102 and 2.22 mg / l, respectively. The pH is normal and will not be a problem for sensitive plants. Also, groundwater resources located in the northern half of the study area show the highest level of pollution.

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## 1. Background

Water pollution is the most important threat to developed and developing countries(Fataei et al., 2011; Fataei et al., 2013). In 2003, about one billion people in the world did not have access to clean drinking water, and it is likely that in the last half century, about 2 to 7 billion people will live in water-scarce countries (Peng et al., 2009). Today, the protection of water resources is the first priority of environmental organizations. Access to clean drinking water will be one of the greatest human challenges in the coming years. (USEPA, 2017; Cool et al., 2010).

Coastal areas are the border between land and sea. This environment represents a dynamic ecosystem that plays a vital role in the local economy due to its high fertility and rich species diversity. Today, many human communities as well as industries live near the coast, so that 38% of the world's population lives about 100 km from the coast. It is obvious that the concentration of development activities in such an area can threaten the stability of the coastal ecosystem (Manikannan et al., 2011). The source of coastal pollution is from the sea or land. Pollutants are land, ports and anchorages, oil terminals, factories, power plants, urbanization, commercial activities, weeding, fishing, agriculture and military activities. Sources of marine pollution also include: offshore oil and gas facilities, offshore mines, navigation, water sports, fishing, dredging and land reclamation. The main pollutants that come from these sources are: oil, waste, waste, pesticides, toxic chemicals, heavy metals, radioactive waste, refrigerants, etc (Jhajharia et al., 2011).

One of the most dangerous pollutants is heavy metals. Heavy metals are highly stable in aquatic environments (Imanpour Namin et al., 2011; Fataei et al., 2010).

HMIs widely exist in all kinds of environments which could accumulate in the human body to a high concentration through the food chain from contaminated water (Ghomi Avili et al., 2021).

Given the importance of heavy metals in aquatic environments, it is necessary to determine the concentration of these metals in environments such as freshwater rivers (Oihang et al., 2015). Regarding the amount of heavy metals in aquatic ecosystems and their consequences, several studies have been conducted worldwide, including the following: Huang et al. (2015); Investigated the effects of electrical waste disposal on aquatic environments in Ghana. The results showed that the amount of heavy metals such as lead, cadmium, copper and zinc in aqueous samples is very high. The rate of heavy metals and pollutants released from electronic wastes that adhere to sediments and enter aquatic environments is highly dependent on pH (Huang et al., 2015; Hajjabbari and Fataei, 2016)). Song et al. (2013); Investigate the environmental impact of heavy metals released from e-waste recycling in China. They concluded that four types of heavy metals, copper, lead, cadmium and chromium, were released from electronic waste. Electronic waste recycling operations must be controlled to protect the environment (Song et al., 2013). Goa et al. (2009); Concentrations of Cu, Pb, Ni, Cd, Hg and as were collected in samples collected from the Liangyang River. The results showed that the concentration of heavy metals increases in the rainy season and will decrease in the dry season. Compared to China's environmental standard, first cadmium and then Hg, Pb and copper were identified as the most harmful elements. The concentration of copper in sediment samples was 3.2 to 429 times the standard concentration and after copper, Ni, Hg, Pb, Cd and As had the highest concentrations, respectively (Guo et al., 2009). Mahdi et al. (2021) started to zone the sewage in Bojagh International Wetland. The research findings indicate that the study area is ecologically sensitive.

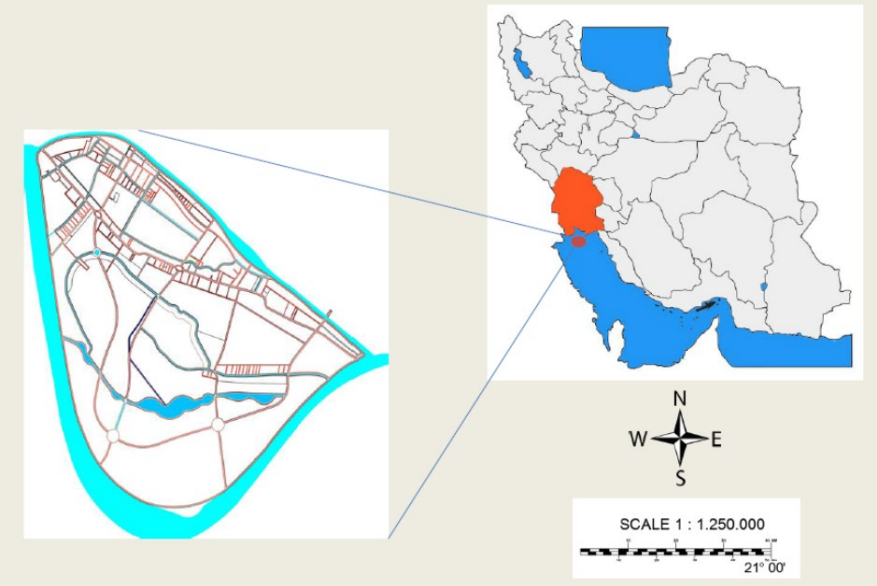


**Figure 1.** Location of Minoo Island in the country and Khuzestan province (Scale: 1: 250000)

Of course, the degree of ecological sensitivities varies in different places. The results show that only 3 parameters of nitrite (1.2 mg/l), Potassium (8.1 mg/l) and Co (0.8 µg/l) are in the standard range and the rest of the measured parameters are higher than the allowable limit. Also, the amount of TDS (450 mg/l) and nitrate (0.9 mg/l) was evaluated as average compared to the standard.

Accordingly, the control of environmental pollution is considered very important. Environmental protection and prevention of pollution include the use of processes, working methods, materials or products that avoid, reduce or control pollution, which can include recycling, treatment, process modification, control mechanisms, optimal use of pollution (Sadegh Ali et al., 2021).

Given the importance of pollution of coastal ecosystems (aquatic-terrestrial), this study focuses on the zoning of water resources pollution in the island of Minoo.

Minoo Island is located in the geographical coordinates of 1810000 and 930000 UTM. This island is located between Abadan and Khorramshahr and is surrounded by two branches of the Arvand River. This island is 10 km away from Khorramshahr. The largest diameter of the island is 2.6 km and its area is about 2000 hectares. Minoo shahr is a small city in which it is located and is the largest settlement on the island (Comprehensive War Tourism Plan, 2016). The population of this city is 12,000 people. This city is considered a resort for the people of Abadan and Khorramshahr. There are 5 streams on Minoo Island, 2 of which branch off from the Jurf River (Arvand Saghir) and the other 3 from the Arvand River (Arvand Kabir). The island is one of the few places in the world where irrigation is done by the rising and falling of water, and no special equipment is required for this. The island is covered with groves, which is a good habitat for migratory birds. Its dense reeds are also a haven for wild animals such as boars. Figure (1) shows the location of Minoo Island on the map.

The results of the topographic situation in the study area indicate that the area has no significant elevation and the rate of elevation changes is less than 5 meters. The study of land slope status indicates that the slope is less than 5% and the slope direction is below 10% (FAO, 2009).

The rivers of Minoo Island include the two rivers which surround the island. The approximate length of the streams is 14,000 meters and the approximate width of the streams is 10 to 12 meters. The total area of the rivers is equal to 70,000 square meters. The length of main streams is 4000-500 meters and their width is 2 to 20 meters and their depth is 2 to 6 meters (Ghanadpoor et al., 2010).

Examination of satellite images shows that the lands along the rivers and reeds today cover an area of 210 hectares in the island and flooded lands with a predominance of reeds occupy an area of about 140 hectares. Even now, the predominant cover is Palm Island. According to the areas surveyed in the present study, 1584 hectares include grove lands, which, of course, are destroyed in many areas (Borna et al., 2010). There are vast meadows along the Arvand River that are home to birds and other animals from Minoo Island. 28 plant species from 15 families have been identified and registered from the region so far (Armanshahr, 2015).

The water of this river in Iraq acts as the main drainage of lands. Therefore, its water quality is affected by land washing and in the future, the salts in it will increase more. On the other hand, the effect of the tide of the Persian Gulf and the infiltration of sea water into the Arvandrud River also increases the salinity of the river water during the Gulf tide, leaving its effects on the irrigation of the region's groves. It should be noted that most of the irrigation of groves and other crops is done by using the rising water of the river in times of fashion and riding on groves. The infiltration of saline seawater completely affects the lands. In the current situation, there have been drastic changes in the quantity and quality of inflows to Minoo Island. The construction of many dams on the Tigris and Euphrates in the lands of Turkey and Iraq has reduced the receipt of fresh water entering the Arvand and its tributaries from the mentioned rivers. Its tributaries have caused the flow of fresh water to the region to decrease from this part as well. As a result of these two interactions, the effects of the tidal and tidal currents of the Persian Gulf increase, which has gradually led to increasing salinity of the waters entering the island of Minoo and its outskirts, result in the island's groves due to the economic existence and nature of tourism resources. It is considered to be a serious threat. However, no protection measures have been considered, including the obvious ongoing plans to dredge only the Arvand River from the remnants of the war. Another issue that threatens the environment of the region to some extent is the industrial activities in the Arvand Free Zone, which due to its immediate proximity to Minoo Island, and if the environmental rules and regulations are not observed, may cause great damage to the island's ecosystem. It will be Minoo. In the current situation, none of the land and water areas of Minoo Island are among the special environmental areas. The closest environmentally sensitive area to this island is the protected area of Shadegan wetland and Hur al-Azim wetland. These two wetlands are safe for birds with high conservation value. The short distance between the mentioned wetlands and the island provides the possibility of short-term movement and migration for some birds (Armanshahr, 2015).

According to the morphology of these rivers, the water resources and irrigation of the groves of Minoo Island are affected by quantitative and qualitative changes in Karoon and Arvand water, and the numerous dams closed on these rivers in Iran and Iraq affect its discharge. In addition, because the Arvand River is the main drainage of land in Iraq, the salts in it are high and expanding. Another factor affecting the surface water quality of Minoo Island is the tidal currents of the Persian Gulf waters and its influence on the Arvand River during the tide, which increases the salinity of the river water and its consequences, are reflected in the irrigation of the groves of Minoo Island. Expansion of various industrial activities the entry of industrial and agricultural effluents, including sugarcane cultivation and industry into Karoon has caused quantitative and qualitative changes in water.

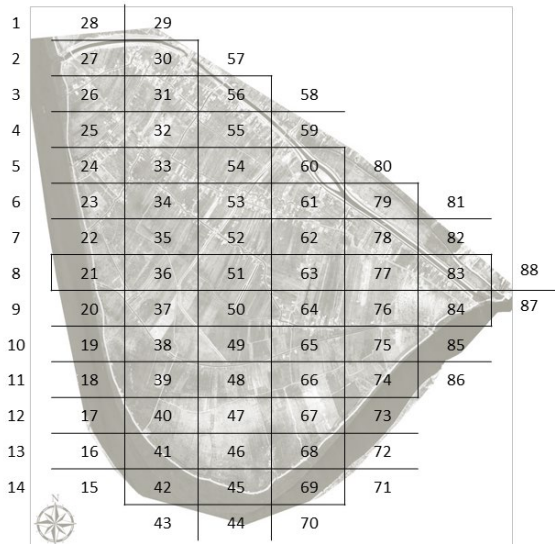


**Figure 2.** Study area networking for sampling

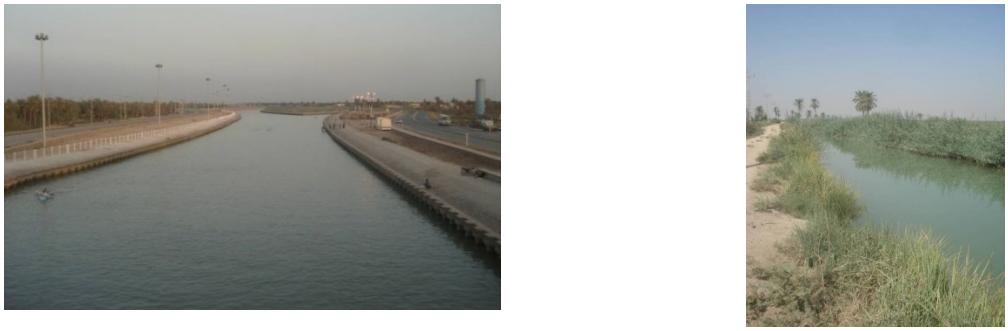

**Figure 3.** Images of aquatic ecosystems in the study area (Photo by the author)

## 2. Materials and methods

This research is of applied type and the method of data collection is library, field and laboratory. Various data such as large comparative satellite images, 1:25000 series maps of the surveying, field inspection and ground control points have been used. Initially, the type and scale of land use in the study area were identified separately. Then Minoo Island was divided into equal networks (88 grids 500 meters by 500 meters) and water resources were sampled. The number of samples is 42 and networks that have an aquatic ecosystem have been used (meaning river, spring or water canal). The collected samples were prepared in accordance with the International Instruction 2016 (Standard method) and transferred to a trusted laboratory (Arvand Free Zone). Figure 2 shows the networking of the study area and Figure 5 shows some of the water resources in the area.

## 3. Result

### *3.1. Determining the soil characteristics of the study area*

The results of soil sampling in the study area showed that this soil has a heavy texture and high specific gravity and due to low porosity, its density is medium to high. Due to the low permeability of soils (which is usually less than 20 mm per hour), difficult drainage and land washing are difficult. The amount of calcium carbonate in the soil is 21 to 37%. In order to investigate the contamination of sediments in the region with respect to heavy metals, samples of lead, nickel, cadmium and zinc were sampled. The average concentration of metals in the sediments of the region was compared with the average concentration of sediments in different standards. The table below shows that the concentration of metals in the sediments of the region is lower than other standards (except for the USEPA, Bowen threshold) and this indicates the lack of critical status of heavy metals in the sediments of the region (Table 1).

### *3.2. Determining the quality of water resources in the study area*

Three types of water sources were studied in the study area. The Arvand River, groundwaters and small surface rivers. High using of chemical fertilizers increases the nitrate concentration in groundwater, which can cause dangers to human health(Farhadi et al., 2020; Fataei, 2020; Shahmorad Moghanlou and Fataei, 2015). The Arvand River, which is associated with the island of Minoo, is in poor condition (Table 2). The average salinity (TDS) of Arvand River was between 1750-940 parts per million (ppm).

**Table 1.** Average concentration of heavy metals in micrograms per gram in sediments with some global standards

| Elements | USEPA, 1999 Bowen, 1979 | | CCME, 1999 | | USA Standard NOAA[1] (Long et al., 1995) | | Current research |
|---|---|---|---|---|---|---|---|
| | LAL[2] | HAL[3] | PEL[4] | ISQGS[5] | ERM[6] | ERL[7] | |
| Zn | 5 | 410 | 271 | 124 | 410 | 150 | 11.4 |
| Cd | 0.04 | 9.6 | 4.2 | 0.7 | 9.6 | 1.2 | 0.18 |
| Pb | 2 | 218 | 112 | 30.2 | 218 | 46.7 | 8.86 |
| Ni | 3 | 50 | 42.8 | 15.9 | 51.6 | 20.9 | 3.12 |

1. National Oceanic Atmospheric Administration
2. Lowest Alert Level
3. Highest Alert Level
4. Probable Effects Level
5. Canadian Interim Marine Sediment Quality
6. Effects Rang medium
7. Effects Rang Low

**Table 2.** Elements and chemical compounds of surface resources Arvand River water

| Chemical elements and compounds | | | | | Test location |
|---|---|---|---|---|---|
| Cl (mg/liter) | $SO_4$ (mg/liter) | Na (mg/liter) | EC (micromhos/cm) | TDS (mg/liter) | |
| 225 | 180 | 140 | 4580 | 1100 | Arvand River |
| 200 | 76 | 110 | 1720 | 1300 | Island surface waters |
| 116 | 99 | 95 | 720 | 1600 | Groundwater |

In Arvand River, TDS time series always shows an increasing trend with slight fluctuations. The range of TDS changes in the Arvand River (300-2800 mg/l) has been more than twice the range of TDS changes in the Karoon River (450-1400 mg/l). The TDS seasonal fluctuations of this river indicate that the amplitude of spring and winter fluctuations is greater than the amplitude of summer and autumn fluctuations (Figure 4).

Figure 5 shows a comparative diagram of heavy metals in the studied water resources.

As can be seen in the diagram, it can be seen that the Arvand River is more polluted than other water sources.

The results of research on the Arvand River indicate that the level of COD in the river in winter is very high compared to other seasons. Acidity, electrical conductivity, total soluble solids, and salinity and total hardness of the estuary are higher than in other areas. The pH is normal and will not be a problem for sensitive plants. The maximum mean of TDS parameters exceeds the allowable limit and is lower than the allowable value only in the minimum value. Also, the parameters of sulfate, chloride, magnesium and sodium exceeded the allowable limit.

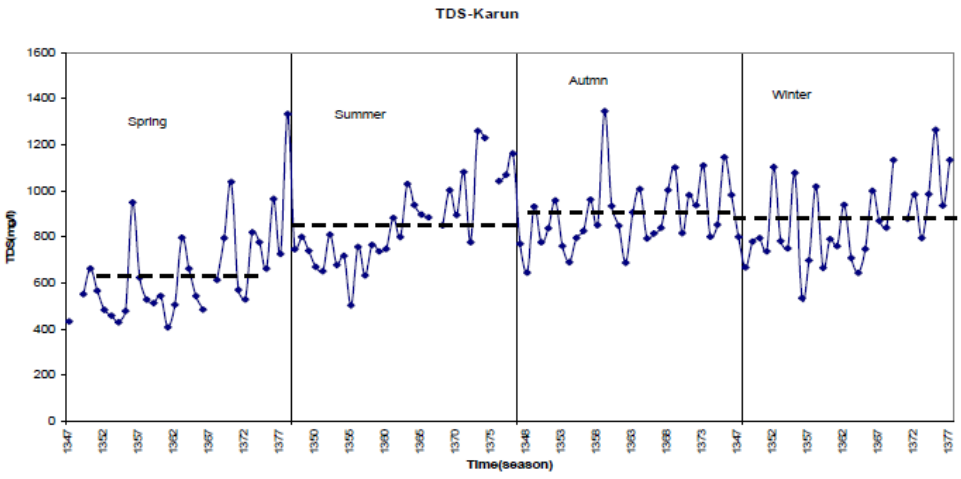


**Figure 4.** Seasonal changes of TDS of Arvand River

According to the results of the research, it is possible to draw a zoning map for the studied environmental pollutions in Minoo Island (Figuers 6 to 12).

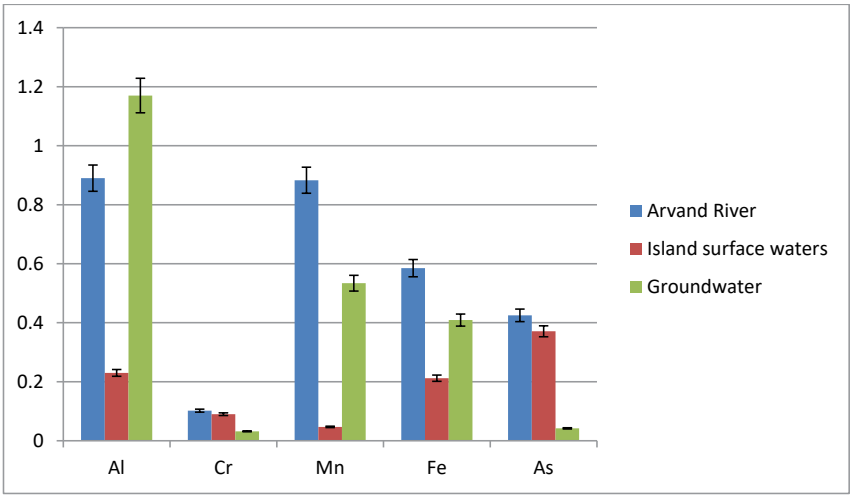


**Figure 5.** Comparative diagram of heavy metals and toxic elements in the study area (mg/l)

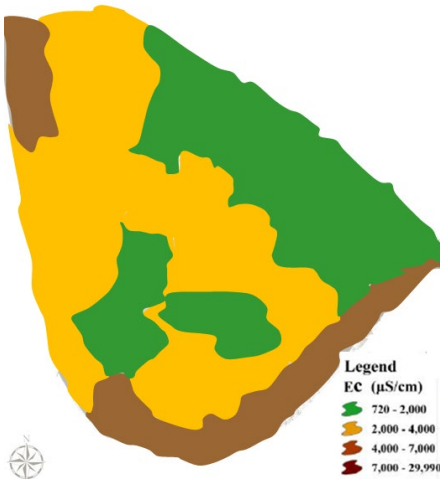


**Figure 6.** Zoning of EC in the study area

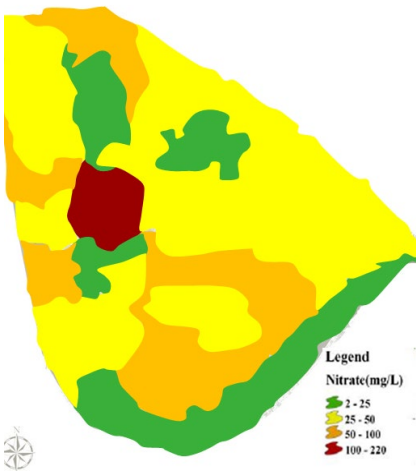


**Figure 7.** Zoning of Nitrate in the study area

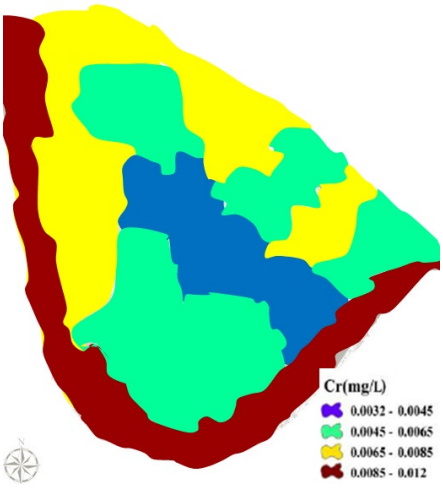


**Figure 8.** Zoning of Cr in the study area


**Figure 9.** Zoning of Fe in the study area

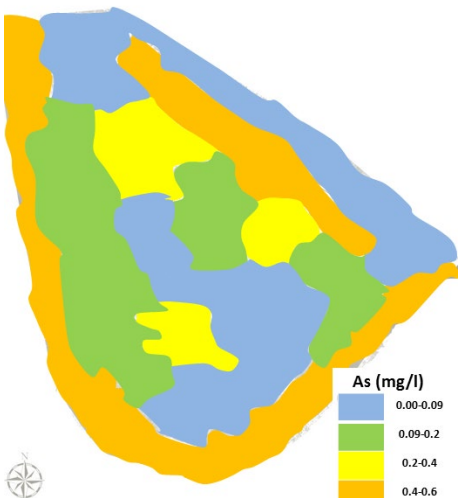


**Figure 10.** Zoning of As in the study area

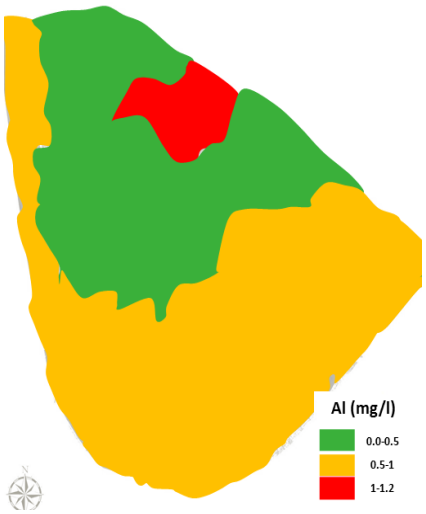


**Figure 10.** Zoning of Al in the study area

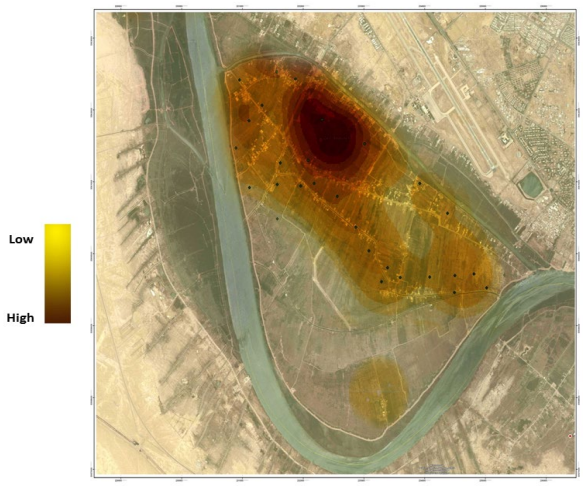


**Figure 11.** Production and emission of municipal wastewater in the study area

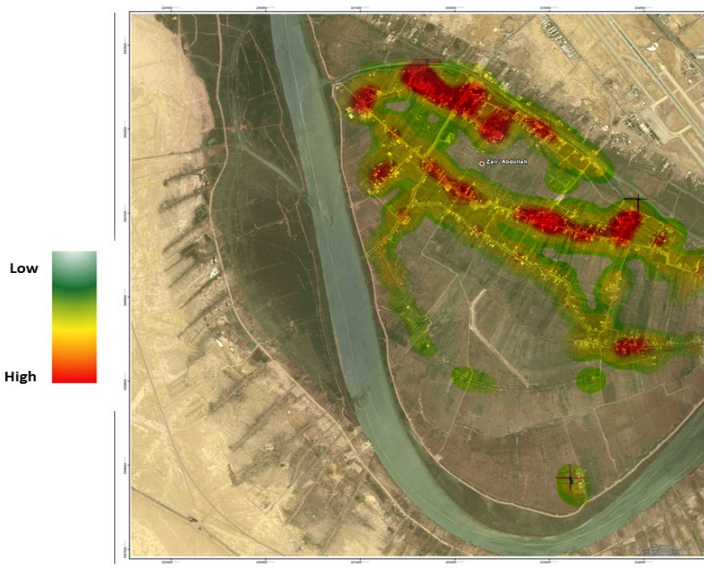


**Figure 12.** Production and emission of agricultural wastewater in the study area

## 4. Discussion

Pollutant sources are mainly related to various types of municipal pollutants. Multiple settlements located in Arvand catchment area that directly and indirectly enter their effluent into the river. These population centers include the two cities of Abadan and Khorramshahr upstream and the cities adjacent to the Tigris and Euphrates rivers in Iraq, which in the current situation discharge their municipal sewage without any specific mechanism and supervision. Investigation of pollutant sources of Arvand river shows that the most important type of pollutants are various pollutants, especially chemical pollutants of Abadan refinery, Abadan petrochemical and Khorram Noush soap and Khorramshahr soap production company. Heavy metals in the effluent of these centers have caused rapid and important changes in river water(Jalalzadeh et al., 2020). Also, the existence of industrial complexes, agricultural lands, construction of dams in Turkey and Iraq and large canals, includes the Saddam Canal (formerly) with a potential capacity of 500 cubic meters per second are among the factors that reduce the inflow of water and increase pollution of the Tigris and Euphrates has been adversely affected. Agricultural waste is the most important source of pollution on the island's rivers, which account for 48% of the waste entering the rivers. After agricultural waste, municipal wastewater is the second most polluted river with 26%. Among the plants immersed in the water of the Arvand River, we can mention reed, mace, seven-leaf clover, leek water (bolagh oti), sazo (tanjdsuf), aviarslam, palm swamp and sharp, which while supplying oxygen to water as a rich source of nutrients. Aquatic uses are placed. Frogs with different characteristics and sizes and different types of turtles are other river creatures that are usually seen in canals and irrigation networks. Laboratory results indicate that the water quality of Arvand River is in poor condition.

The results related to the degree of salinity of water resources in the study area indicate that the EC of the Arvand River is equal to 4580 micromoles and the internal stations are 1720 micromoles. This is while the EC standard of water is 1500 micromoles. This level of salinity is harmful for people suffering from high blood pressure or other related diseases.

On the other hand, as the salinity of water increases, the effect and property of chlorine decreases and its disinfectant property also disappears.

In the current situation, there have been drastic changes in the quantity and quality of inflows to Minoo Island. The construction of many dams on the Tigris and Euphrates in the lands of Turkey and Iraq has reduced the receipt of fresh water entering the Arvand and its tributaries from the mentioned rivers. And its tributaries have caused the flow of fresh water to the region to decrease from this part as well. As a result of these interactions, the effects of the tidal and tidal currents of the Persian Gulf increase, which has gradually led to increasing salinity of the waters entering Minoo Island and its outskirts, resulting in the island's groves that are economic existence and the nature of tourism resources to the number seems to be under serious threat. This is while no protection measures have been considered; among the obvious projects in progress, only the dredging of the Arvand River is a remnant of the war. Due to the low permeability of soil, drainage is slow, so the use of appropriate irrigation methods such as sprinkler irrigation and ponds and leakage, control of irrigation frequency and agricultural operations such as proper plowing and softening and increasing soil permeability and rotation. The use of unsuitable fertilizers to enrich the vegetation is justified. One of the man-made environments is the construction of agricultural streams. These streams are dug for irrigation and agricultural use and start from the banks of the Arvand River and sometimes continue for long distances. Due to the difference in low height of these streams with the ground, in addition to irrigation, it is also used to drain surface water(Ajami Fataei, 2015. The mentioned streams irrigate agricultural lands with fashion and rising water level and drain and wash the soil at low tide. Traditional streams are not built to drain surface water and therefore do not have the necessary efficiency in this area, especially since they are not distributed throughout the city and only in limited parts of the city and usually in areas that have agriculture and horticulture (palm trees). Gradually, with the development of the city towards gardens and agricultural lands, these streams are filled. However, in some parts, the canals were reconstructed with the construction of a wall and a suitable cover, and one of the reasons for this reconstruction was the discharge of surface water. At the same time, precipitation with water flow causes non-disposal of sewage, runoff and overflow of canals. Sadat River, Abdul Imam River, Chomeh River, Naima River and Umm Al-Qasab River are the rivers of Minoo Island. In the past, these streams were the most important source of water for the island's agricultural lands and groves, which have now suffered a lot of damage due to the damage caused compared to the time before the imposed war. The growth of agriculture, industry and post-war reconstruction and the subsequent increase in population in the Khuzestan region and the influx of municipal wastewater into the river are the most important factors in this increase. In 1380, agricultural effluents accounted for 78% of all pollutants to Arvand in summer. However, the TDS value of Karoon River in 95% of cases averaged about 90% TDS of Arvand River, which shows the positive impact of Karoon River flow on Arvand River. Comparison of the results obtained from the quality of industries located in the basin with the standards of the Environmental Protection Organization shows that some of the parameters studied in the industrial wastewater in the basin are more than the standards of this organization. The influx of effluents and sewage from factories in the surrounding cities (Abadan and Khorramshahr) has increased the severity of pollution, for example, the influx of industrial effluents from Khorramnoosh Company and Kalismin Company and soap factories and Pasargad Chemical Company from the Pasargad River into the river, surface in the pollen area. Khorramshahr

soap factory effluents endanger aquatic life and increase downstream agricultural lands that directly use river water by increasing the rivers organic load, decreasing DO, and the entry of cast iron compounds such as glycerin into the river, which is accompanied by soap scum. These conditions hurt. According to the reports of inspectors and officials of the Environment Department, Shuniz Plant Company does not have a wastewater treatment system and the resulting effluents containing fatty substances are discharged directly into the Karoon River.

## 5. Conclusion

Considering the types of pollutants in Minoo Island as well as the variety of pollutants in water resources, it can be interpreted that the study area in terms of water resources suffers from chemical and physical pollution. Of course, if control and management measures are not taken, there is a possibility of increasing the amount of contamination.

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