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Waste Water Pollution zoning of sensitive coastal-marine areas with an environmental protection approach (Study area: Boujagh International Park and International Wetland)

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Abstract: Sensitive coastal areas are one of the most valuable habitats in the world. The purpose of this study is to zoning of wastewater pollution in Boujagh International Wetland. This research has been done by field method. At first, in order to facilitate the research work, using the networking technique, the whole study area was divided into 33 cells or 500 hectare assessment units (2.2 × 2.2 km networks). Then each criterion was quantified through scoring method (weighing). Quantifying the criteria was done by numeral weighing with restricted domains. Scoring criterion was done in six-step domains from at least 0 to at least 5. The ArcView software was used to draw maps. The research findings indicate that the study area is ecologically sensitive. 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. In order to control the entry of sewage pollution into the wetland and its surrounding votes, it is necessary to take legal and administrative measures immediately.

Keywords: Waste water pollution, Zoning, sensitive coastal-marine, Boujagh

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1. Introduction

The term Sensitive Sea Areas has been around for less than three decades in the world's marine environmental literature. The importance of marine sensitive areas was first raised by the Environment Committee of the World Maritime Organization in response to the resolution of the International Conference on Tanker Safety and Prevention of Marine Pollution (1978). Since 1986, the International Maritime Organization (IMO) has included a program to identify sensitive marine areas. Until 1991, this led to guidelines for identifying areas that are sensitive and vulnerable to international maritime activities for ecological, socio-economic and scientific reasons. The World Maritime Organization, in accordance with its responsibilities, has specifically identified and protected sensitive marine areas against international maritime activities. IMO has defined these areas as follows (IMO / MEPC, 2001): "A marine sensitive area is a region that, for ecological, socio-economic or scientific reasons and vulnerability to maritime activities, requires special support from the International Maritime Organization." However, this issue has been considered in Iran beyond the framework of IMO and with regard to any actual and potential source of pollution, destruction or threat of land or sea origin on the coasts and marine areas of the country. Marine Sensitive Areas by the Marine Sensitive Working Group of the country, which in 2001 and 2002 was in charge of developing a plan to protect these areas, according to the definition provided by the IMO and its expansion with respect to potential and actual threats to coastal and marine areas. Country is defined as: "A maritime sensitive area is a

zone of sea or coastline that is vulnerable to natural conditions or human activities, especially maritime activities, due to its ecological, social, economic, and educational importance, or for scientific reasons, and needs special protection." (Majnoonian, 2003). Coastal-marine areas on planet Earth are ecologically and socio-economically vital ecosystems (Harley et al., 2006). In other words, these areas are the intersection of land and sea ecosystems that are both adversely affected by the ecological characteristics of land and sea (Beatley et al., 2002). These sensitive areas create a dynamic environment with interactions between sea and land that create a unique area with diverse coastal ecosystems, in other words, coastal areas are zone with independent biological characteristics that have been achieved by their Eco-tonic position (Danehkar & Majnoonian, 2004). Sensitivity of these areas due to biodiversity, richness of organisms, existence of endangered, vulnerable and rare species, occurrence of vital communities on the verge of ecological tolerance, sensitivity to pollutants, slow environmental repair, damage and problems caused by cleaning from environmental pollutants is created (Danehkar, 2002).

Accordingly, coastal-marine protected areas are designated for the management of coastal and marine areas with the aim of conserving biodiversity and protecting marine biological resources (Pascual et al., 2016).

The first action in identifying sensitive marine areas in Iran began in 1994, less than a decade after the start of the program at the World Maritime Organization in the Environmental Protection Agency. But due to the fact that the subject mentioned in IMO was also evolving at that time, this identification is based on the initially known characteristics of the introduction of these areas, which was based on the location of mangrove forests, coral reefs, mammal and sea turtle habitat and waterfowl. And important areas in terms of fishery aquatic reproduction were established. Due to the ecological importance of the vital habitats of the coastal and marine areas of the country, this effort was made from the beginning of explaining and defining the issue at the national level with a cross-sectorial approach and formulating a protection plan to deal with all polluting centers or destructive or threatening actions.

Subsequently, the working group of the country's marine sensitive areas started working in the Environmental Protection Organization and in the first step, prepared a draft work plan for the identification and protection of marine sensitive areas and discussed its topics, axes; topics and provisions finalized this program. For the first time, this measure should provide a comprehensive and national definition of the country's sensitive marine areas and the initial criteria for identifying these areas according to global experiences and national requirements should be prepared and implemented in a work plan (DOE, 2002).

Marine Environment Office of the Environmental Protection Agency with the aim of zoning the environmental sensitivity of coastal areas and also to identify protected areas on the coast of the country according to global experience, especially the criteria provided by IMO (2001) to identify sensitive coastal areas. The IUCN (1999) criteria for the identification of coastal-marine protected areas as well as the Salm & Clark (1984) criteria and the Salm & Price (1995) criteria for the selection of coastal and marine protected areas include criteria including 15 main criteria and 31 sub-criteria. The above criteria were evaluated for the northern coastal areas of the country and its efficiency and effectiveness were approved by provincial experts according to the existing protected areas as well as their applicability. The necessity of human social life requires optimal resource management and pre-crisis control of resource scarcity, the issue of "water" and consequently "pollution of water resources" is one of the major challenges facing human life, especially in Iran. These challenges in the future can threaten the areas of public order and social services at large levels and therefore require the presence, intervention and supervision of the government.

Pollution generally means the penetration of harmful, toxic or energetic substances (thermal or sound) into the environment of humans, animals or plants, in excessive amounts and beyond their biological capacity, which endangers and endangers biological resources. It becomes the life and health of living things (Rostamabadi & Jalali, 2014). Water quality of wetland ecosystems is an important environmental and health concern because it is one of the major sources of fresh water for human consumption (Simeonov et al., 2004). Water pollution is the most important threat to both developed and developing countries. Large-scale industrial activities and the production of various chemical compounds have reduced the quality of the environment globally (Cool, 2010).

Considering the limited fresh water around the world and the role of human activities in reducing water quality, the protection of these water resources has been considered as a top priority in the 21st century (USEPA, 2007).

Today, the protection of water resources is the first priority of environmental organizations. Access to safe freshwater will be one of the greatest challenges facing humanity in the years to come. In 2003, about 1.2 billion people in the world did not have access to clean drinking water, and it is estimated that in the last half century, about 2 to 7 billion people will live in water-scarce countries (Cool, 2010). Surface water quality provides important data on the resources available to support life in this ecosystem (Manikannan et al., 2011).

The entry of pollutants into aquatic ecosystems endangers both natural areas and the health of the inhabitants of the surrounding area. Pollutants that enter the environment from mining activities and effluents containing heavy metals penetrate into the soil and groundwater aquifers and have negative effects on the health of the region and the people. Ignoring such contaminants will not only endanger the

health of local people, but also endanger the health of a large part of the community. Heavy metals refer to any metal chemical element that has a relatively high density and is also toxic at low concentrations. Heavy metals are the building blocks of the earth's crust and do not degrade or erode. These metals, which are environmental pollutants, enter our bodies in very small amounts through food, drinking water or air and can cause chronic and sometimes acute poisoning (Jhajharia et al., 2011). Heavy metals are highly stable in aquatic environments (Imanpour Namin et al., 2011). 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). Numerous studies have been conducted worldwide on the number of heavy metals in aquatic ecosystems and their consequences, including the following:

A group of researchers studied concentrations of mercury, cadmium, nickel, lead, copper and arsenic in samples collected from the Liangyang River. The results showed that the concentration of heavy metals was high in the rainy season and low in the dry season. The concentration of copper in the surface waters of the region was 2.4 to 131 times the reference concentration and after copper, nickel, cadmium, lead, mercury and arsenic had the highest concentrations, respectively. However, compared to China's environmental standard, first cadmium and then mercury, lead and copper were identified as the most harmful elements. Copper concentration in sediment samples was 3.2 to 429 times the reference concentration and after copper, nickel, mercury, lead, cadmium and arsenic had the highest concentrations, respectively (Guo et al., 2009). Other experts have studied the effects of electrical waste disposal on aquatic environments in Accra, Ghana. The results showed that the number of heavy metals such as lead, cadmium, copper and zinc in aqueous samples is very high. Also, the old methods of recycling electronic waste led to the release of these heavy metals. 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., 2014).

The Caspian Sea is the largest land area enclosed by land in the world with an area of about 737555 square kilometers in the world, which has many valuable biological and non-biological reserves (Chen et al., 2017). According to studies, Boujagh International Park and International Wetland is one of the most sensitive coastal-marine habitats in the country (Yousefi et al., 2013).

The purpose of this study is to investigate Waste water pollution and their zoning in the biologically sensitive area of Boujagh Wetland. Initially, an attempt was made to assess the degree of ecological sensitivity in the study area. Then, sewage pollution was measured in the area. Finally, data analysis was performed.

Study area

The studied region has two sea and land borders. Sefid Rood River, located in the center of the area, plays a key role in the area. The sea border of the region consists of the mouth of Sefid Rood River and Oushmak River. The land border consists of the paddies and the orchards in the south of Kiashahr and Zibakenar to the extremity of Fakhr Abad and Mohsen Abad villages. The geographical position of the region is 37º 22′ 30″ to 37º 28′50″of the northern width and 49º 49′ 45″ to 50º 1′ 15″ of the eastern length, having an area of 11470 hectares. Boujagh National Park and Boujagh Protected Area are located in the northern sea-coastal part of the studied region. According to the latest information from the Bureau of Wildlife Habitat & Protected Areas, Iran Department of Environment (June 2004), Boujagh National Park with an area of 3176 ha and Boujagh Protected Area with an area of 100h were ratified in 2001 and 2004 respectively. These two areas occupy the northern and northeastern parts of the studied region. Boujagh National Park, located in the north of Kiashahr along the southern coastline of the Caspian Sea, is one of the wetlands in Gilan Province in the north of Iran that welcomes more than 110 species of the birds yearly. Firstly, this park, with 800 hectares in area, was managed as a forbidden hunting district. Later the park was promoted as a national park in 2001 because of its special features such as wetlands, pastures, coastal sands and the proximity of Oushmak and Sefidroud Rivers, adjacency to the Caspian Sea, and adjacency to 22-Bahman Wetland in Kiashahr (pond of Kiashahr). It is now in the list of the four areas under the management of Iran in Gilan Province (Yousefi et al., 2013). Sefid Rood River plays a very significant role in the province in terms of protecting Acipenser sp and Rutilus Frisiikutum habitat. On the other hand, Kiashahr Ponds, in the eastern part of the region as one of the most significant recorded sites in Ramsar Convention, make the park important. Kiashahr and Zibakenar Ports are the most significant human centers. Figure (1) shows the location of the studied region, and the locations of Boujagh National Park and Protected Area respectively.

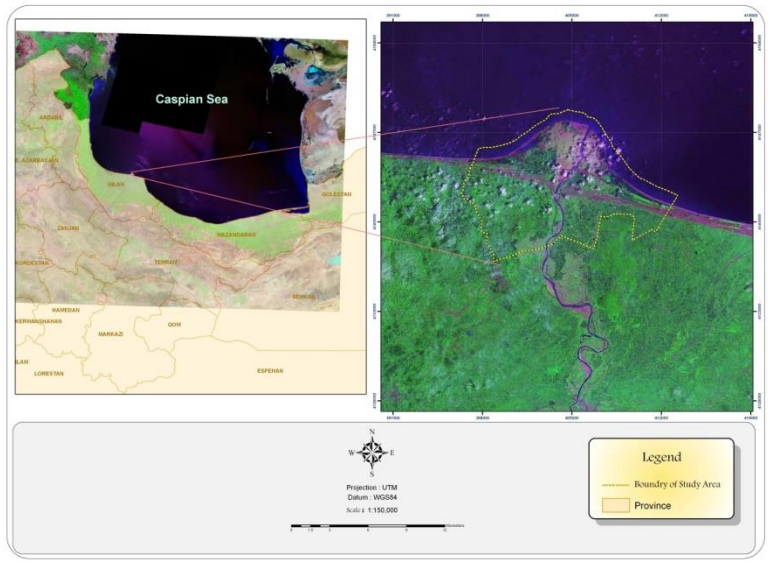

Fig. 1- Location of the study area in Iran

2. Materials and Methods

This research is of applied type and the data collection method is field type. For this purpose, two common types of pollution in the area, including solid waste and waste water, have been studied. At first, in order to facilitate the research work, using the networking technique, the whole study area was divided into 33 cells or 500-hectare assessment units (2.2 × 2.2 km networks). In this regard, during a detailed field visit to the study area and interpretation of image data (aerial and satellite), the characteristics of each cell in the framework of selected criteria have been examined separately. Figure (2) shows the study area based on selected cells (smaller study areas).

To measure water pollution in the study area, the following compounds and elements were measured: NO3-, NO2, EC, pH, Na, Ca, TDS, Pb, Cd, Cu, Mn, Cr, Co, Fe, Zn. According to the method standard, water samples were first taken from each cell and sent to a trusted laboratory. The experiments were repeated twice. The results of each cell were entered separately in an Excel file and analyzed. For this purpose, national and international standard were used.

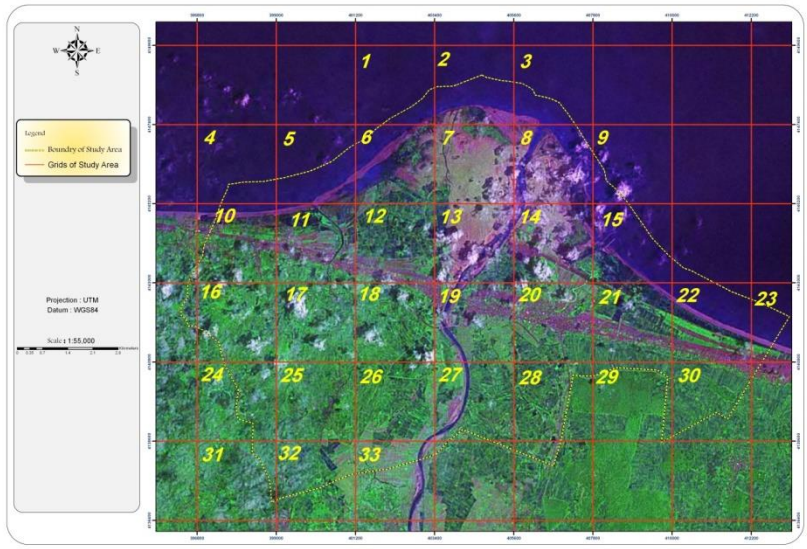

Fig. 2- Study area networking

The method was used to assess habitat sensitivity (Yousefi et al., 2013). Then each criterion was quantified through scoring method (weighing). Quantifying the criteria was done by numeral weighing with restricted domains. Scoring criterion was done in six-step domains from at least 0 to at least 5. According to its variation and occurrence within the region, each criterion was divided into 3 to at least 6 categories and achieved score within the numeral domain. The compiled criteria change between 9 and 150. Accordingly, the necessary scope of the score to be achieved was identified in order to determine the title and the importance of an area for environmental management (Table 1). Some members of Indigenous Non-Governmental Organizations (NGOs) assisted the research team in conducting the fieldwork. By identifying the amount and type of infection related to each cell, a distribution map of each type of infection was prepared and then by combining the layers in the GIS system based on the total score of the criteria assigned to each cell, was drawn and analyzed. In this research, Erdas, Arc map and Arc view software have been used to extract information and map the required data from satellite imagery and aerial photography.

The maps were interpreted using satellite imagery of the ETM sensor, the Landsat satellite of 2002, as well as the PAN sensor of the IRS satellite of 2004 and aerial photography (scale 1:50000).

Table 1- Standards and assessment criteria of the assessment of sensitive ecological coastal areas of the Boujagh wetland

criterion	Index
Biological geography	The area lacks any rare biological geography quality
	The area includes one rare biological geography quality
	The area includes 2-3 rare biological geography qualities
	The area includes more than 3 rare biological geography qualities
Virginity (Naturalness)	The area is a virgin land
	The area includes 1-5 human effective activities
	The area includes 5-10 human effective activities
	The area includes 10-15 human effective activities
	The area includes 10-15 human effective activities
Uniqueness	The district includes one unique kind of world important resources
	The district includes one of the world important resources
	The district includes a unique kind of national important resources
	The district includes one of the national important resources
Dependence	The district is important for 1-2 commercial /protected species
	The district important for 3-4 commercial /protected species
	The district is important for more than 4 commercial /protected species
Habitant value	The district is important for more than 10 species of aquatics
	The district is important for 5-10 species of aquatics
	The coastal district is important for 1-4 species of aquatics
	There is no information available about aquatics
Habitant variety	There are 1-2 habitats
	There are 3-4 habitats
	There are more than 4 habitats
Habitant scope	The habitat extends over 1000 meters from the coastal line
	The habitat extends about 500 -1000 meters from the coastal line
	The habitat extends about 300 -500 meters from the coastal line
	The habitat extends about 100-200 meters from the coastal line
	The habitat extends about 100 meters from the coastal line
Habitant integrity	The habitat includes total ecological integrity across its scope (100 percentage of integrity).
	The habitat does not include ecological integrity in one fourth of its scope (75 percentage of integrity).
	The habitat does not include ecological integrity in the half of its scope (50 percentage of integrity).
	The habitat does not include ecological integrity in three fourth of its scope (25 percentage of integrity).
Aquatics variety	The coastal district includes 2-5 species of edible fish and invertebrates
	The coastal district includes 5-10 species of edible fish and invertebrates
	The coastal district includes more than 10 species of edible fish and invertebrates.
Endangered Aquatics	The coastal water with no endangered species
	The coastal water with 1 endangered species
	The coastal water with 2 endangered species
	The coastal water with 3 endangered species
	The coastal water with 4 endangered species

Threatened Aquatics	The coastal water with 5 or more endangered aquatics
	The coastal water includes no threatened species of fish or invertebrates with decreasing population.
	The coastal water includes 1 threatened species of fish or invertebrates with decreasing population
	The coastal water includes 2 threatened species of fish or invertebrates with decreasing population
	The coastal water includes 3 threatened species of fish or invertebrates with decreasing population
	The coastal water includes 4 threatened species of fish or invertebrates with decreasing population
	The coastal water includes more than 4 threatened species of fish or invertebrates with decreasing population
Aquatics spawning	The coastal water does not include any spawning grounds of edible fish or invertebrates
	The coastal water includes spawning grounds of 1 species of edible fish or invertebrates.
	The coastal water includes spawning grounds of 2 species of edible fish or invertebrates.
	The coastal water includes spawning grounds of 3 species of edible fish or invertebrates.
	The coastal water includes spawning districts of 4 species of edible fish or invertebrates.
Fish farm	The coastal water lacks fish farm importance
	The coastal water is a fish farm of just 1 species
	The coastal water is a fish farm of 2 species
	The coastal water is a fish farm of 3 species
	The coastal water is a fish farm of 4 species
	The coastal water is a fish farm of 5 or more species
Threatened Birds	The coastal district lacks any threatened species
	The coastal district includes 1 threatened specie with decreasing population
	The coastal district includes 2 threatened species with average population
	The coastal district includes 3 threatened species with small population
	The coastal district includes 3 threatened species with sparse population
	The coastal district includes more than 3 threatened species
Endangered Birds	The coastal district lacks endangered species
	The coastal district includes 2 endangered species
	The coastal district, includes 3 endangered species
	The coastal district includes 4 endangered species
	The coastal district includes 5 or more endangered species
Birds population	The bird's population is less than 1000 in the coastal district
	The bird's population is 1000-5000 in the coastal district
	The bird's population is 5000-15000 in the coastal district
	The bird's population is 15000-25000 in the coastal district
	The bird's population is 25000-100000 in the coastal district
	The bird's population is more than 100000 in the coastal district
Birds variety	The bird's population lacks variety of species in the coastal district
	The bird's population includes 1 species in the coastal district
	The bird's population includes 1-2 species in the coastal district
	The bird's population includes 5-10 species in the coastal district
	The bird's population includes 10-20 species in the coastal district
	The bird's population includes more than 20 species in the coastal district
Birds procreation	The bird's population lacks a reproductive species
	The bird's population includes 1 reproductive species
	The bird's population includes 2 reproductive species
	The bird's population includes 3 reproductive species
	The bird's population includes 3-5 reproductive species
	The bird's population includes more than 5 reproductive species
Protection record	The area has national and international titles
	The area has one of the national protection titles
	The area has just an international title
	The area lacks protection titles
Human utilization	In the coastal district, more than 3 resources are utilized
	In the coastal district, 3 resources are utilized.
	In the coastal district, 2 resources are utilized.
	In the coastal district 1 resource is utilized.
Economic	More than 3 resources supply the livelihood of coastal dwellers

Importance	2-3 resources supply the livelihood of the coastal dwellers
	1 resource supplies the livelihood of the coastal dwellers
recreational importance	The coastal district includes more than 3 recreational spots
	The coastal district includes 2-3 recreational spots
	The coastal district includes 1 recreational spot
Tourism (facilities)	The coastal district includes 8-12 main tourism infrastructures and facilities
	The coastal district includes 4-8 main tourism infrastructures and facilities.
	The coastal district includes less than 4 main tourism infrastructures and facilities
Aesthetics	The area includes extremely valuable scenes and perspectives
	The area includes average scenes and perspectives
	The area includes low scenes and perspectives
Historic and cultural monuments	The area is lacks any historical/ cultural values
	The area includes one historical/ cultural monuments
	The area includes 1-3 historical/ cultural monuments
	The area includes more than 3 historical/ cultural monuments
Education value	The coastal district includes more than 5 elucidatory phenomena.
	The coastal district includes 3-5 elucidatory phenomena.
	The coastal district includes less than 3 elucidatory phenomena.
Research and monitoring value	The coastal area includes more than 5 districts (agricultural and virgin land)
	The coastal area includes 3- 5 districts (agricultural and virgin land)
	The coastal area includes 3 districts (agricultural and virgin land)
Threat factors (Part A)	The coastal area includes one of the threat factors
	The coastal area includes 2-3 threat factors
	The coastal area includes more than 3 threat factors
Threat factors (Part B)	The coastal area includes 1-5 the threat factors
	The coastal area includes 6-10 the threat factors
	The coastal area includes more than 10 threat factors

3. Results

According to the evaluated indicators, the environmental sensitivity of the study area can be shown in Table 2.

Table 2: Indicators for measuring and evaluating the environmental sensitivities of the study area

Indicators	Results
Bio geographical criterion	1. The mouth of Sefid Rood River as a unique hydrologic form 2. The existence of Ultra lutra in Boujagh 3. Spawning of Phasianus colchicus in Boujagh. 4. Gas and oil emission from Boujagh National Park and Zibakenar as a rare geological phenomenon
Virginity (naturalness) criterion	1. Boujagh 2. Two sides of Sefid Rood River and some Parts of Oushmak River
Uniqueness criterion	1. The estuary of Sefid Rood River as a unique delta system in the area 2. Boujagh for the considerable number of water fowls 3. The attendance of Manna trees in Boujagh (on the right side of Sefid Rood River) while Manna trees cannot survive in this condition. It looks that their seeds have been carried by Sefid Rood River
Bird criterion	The diversity of species and population is considerable in the area. The existence of the protected species is significant because of the suitable environmental condition in the mouth of Sefid Rood River and Oushmak River, Boujagh Weltland, and Kiashahr Puddle.
Dependence criterion	1. The existence of Barbus barbus in Sefid Rood River which is exposed to the extinction danger 2. Acipenser sp in Sefid Rood River 3. Rutilus Frisiikutum in Sefid Rood River 4. Phalacroccorax carbo and Haliaeetus albicilla in Boujagh 5. The procreation of Testudo Graeca in Boujagh
Habitant criterion	One important habitat is the narrow sandy band with the activity of mollusks. The other habitants include the delta system in Sefid Rood and the two-kilometer-long muddy area in the mouth of Sefid Rood. The mouth of Oushmak River also has ecological values. The land and areas of the dispersed wetlands and the meadows are the important habitats in the area. It should be noted, concerning the integrity of the habitant, that there is habitant

	integrity in 50% of Boujagh.
Marine mammal criterion	The accidental attendance of Phola caspius is reported in Kiashahr Pond and Boujagh Wetland.
Protection record criterion	1. forbidden hunting limits of Boujagh 2. Boujagh National Park
Human dependence criterion	3. The exploitation of the aquatics along coastline 4. The extensive bird hunting in Boujagh and around
Tourism criterion	1. formal and informal swimming resorts in Kiashahr, Zibakenar and Amirkiasar coasts 2. Hotels and camping areas in Zibakenar and Kiashahr 3. The local shopping centers near the coast including Miyaneh Mall before Sefid Kenar 4. Asgarabad around south of kiashahr for aesthetics (picture 3)
Education and Research criterion	Boujagh National Park has research and educational values from various ecological and environmental angles.
Threats criterion	1. Utilizing Sefid Rood and Oushmak Rivers has many aspects such as agriculture and irrigation, hunting, and tourism. 2. overexploitation like bird hunting in Boujagh coast, and overgrazing in Boujagh pastures and fields 3. A pier in Kiashahr which is a fish dock. 4. The fishing installations which are under construction, having an area about 100 hectares 5. The agricultural pollution is visible in the whole area. 6. Inappropriate ways of recreation across the whole areas allocated to healing plans of sea 7. A great deal of household waste from both the urban and the rural areas of Kiashahr and Zibakenar released around Kiashahr pond and near Oushmak River.
Aquatics criterion;	*Sefid Rood*: It has a significant role because of being the biggest river in the north of Iran, the most important phenomenon in the studied area, Acipenser immigration path, immigration path and spawning ground of 38 species of fish, and existing huge Acipenser and bony fish farms. *Boujagh Wetland in Kiashahr*: it is important because of the direct relationship with Sefid Rood River, having fresh water, being emigrant fish spawning ground, temporary habitat of the young fries in Sefid Rood River, and habitat for more than 40 species of fish during immigration season.

♦ The southern part of the studied region with the dominant agricultural, residential, and gardening use has slight sensitivity and is about 4572 hectares in area. It covers 39% of the whole region in terms of sensitivity.

♦ The central part of the area mainly with urban and rural use and human activity has average sensitivity and is 1913 hectares in area. It covers 17% of the whole region in terms of sensitivity.

♦ The northern part of the region above the city limits, with the most important natural and ecological values and 4575 hectares in area. It covers 40% of the whole region and has high sensitivity. This district, i.e. the mouth of Sefid Rood and Oushmak rivers and Boujagh Wetland, is the most valuable from selective criteria point of view.

♦ The northeast part of the region includes Kiashahr Pond and has an area of 408 hectares. It includes 4% of the whole region. It is extremely sensitive.

♦ The important point is that the studied area has been selected as the first marine coastal national park, i.e. Boujagh National Park. Unfortunately, the results of this survey show that the title and management degree by no means are appropriate for the ecological and environment values of the area. Furthermore, they don't have any required scientific and technical supports.

Figure 3 shows the zoning of habitat sensitivities in the study area based on the weighing of the desired indicators and criteria.

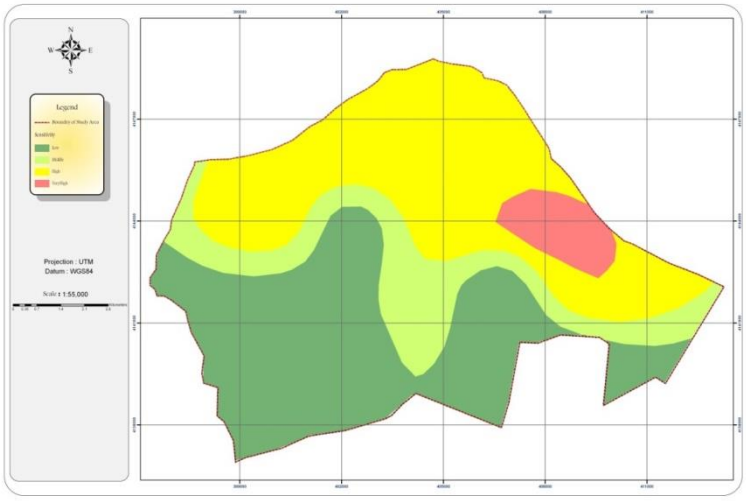

Fig. 3- Zoning of sensitive habitats based on the weighing of the desired indicators and criteria

In the following, the results related to the assessment and zoning of pollution in the sensitive coastal-marine habitat of Boujagh are presented.

Findings indicate that the central and southern parts of the study area have the highest level of pollution due to their agricultural, residential and industrial uses. Meanwhile, effluent pollution (urban, industrial and agricultural) is mostly observed in the southwestern and southeastern parts (Figures 4 and 5).

Fig. 4- View of bubbles created on the water surface due to the presence of excess fat in the effluent

Fig. 5- Release of urban and agricultural effluents in the southern part of the wetland

Field impressions showed that waste discharge in all parts of the wetland, especially in the south and southwest and center. The types of waste were mainly plastic containers, nylon, packaging containers and all kinds of glass, plastic and metal bottles, paper and household waste (Figures 6). Due to the fact that the groundwater level in this area is very high, it is possible for waste leachate to penetrate into the soil and access groundwater. This can cause more pollution. Based on the sampling results of waste in the area, and their physical separation, it was determined that 33% of waste is disposable containers and PET, 14% glass, 12% metals, 17% paper and the remaining 24% household waste., Food residues and wastes (Figures 7 & 8).

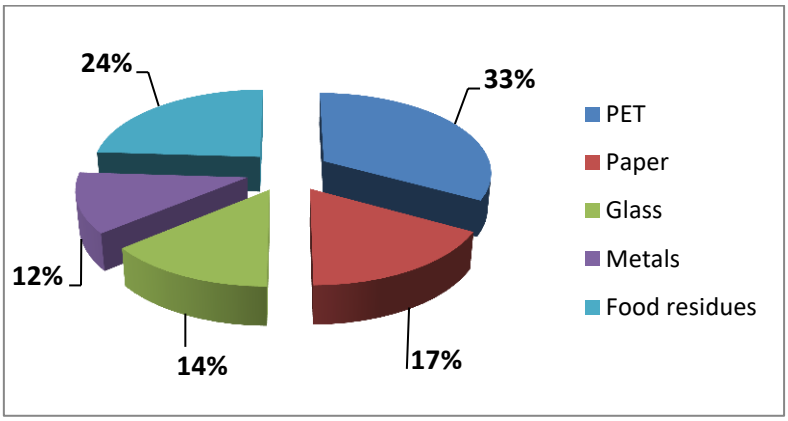

Fig. 6- Percentage of waste components in the study area

Fig. 7- Disposal of waste in the dry part of Boujagh wetland

Fig. 8- Garbage disposal on both sides of the Kiasar-Boujagh road

The results of the measurement of wastewater parameters are also shown in Table 3. The results presented in this table are the average of the measurements in 33 cells. Since urban, industrial and agricultural wastewater enters the wetland directly from 8 points, it was necessary to measure the parameters in all parts of the wetland separately. Accordingly, the table of maximum and minimum of each pollutant is also listed. Some cells were less infected than others. In others, however, the burden of pollution has been very high.

Table 3: Descriptive statistics of physicochemical parameters of 33 cells from the study area

Parameter	Unit	Minimum	Maximum (At the point of sewage discharge)	Average	SD
(NO_3)	mg/L	21	780	567	186.05
(NO_2)	mg/L	0.01	1.2	0.9	0.66
(EC)	ds/m	0.04	8	0.9	370.12
pH	-	5.66	10.44	9.88	0.23
(Na)	mg/L	33	150	122	17.6
(K)	mg/L	4.6	9	8.1	2.1
(Ca)	mg/L	32	101	88	24.05
(TDS)	mg/L	100	820	460	547.7
(Pb)	µg/L	0.03	1.1	0.9	29.8
(Cd)	µg/L	0.01	2.3	1.8	18.76
(Cu)	µg/L	0.3	35.6	21	7.77
(Mn)	µg/L	1.2	6	3.3	21.44
(Cr)	µg/L	1.7	4.5	3.2	10.11
(Co)	µg/L	0.003	0.8	0.06	38.87
(Fe)	µg/L	1.1	8.9	4.5	90.86
(Zn)	µg/L	1.6	8.07	4.8	15.66

Table 3 shows a comparison of the number of pollutants with the national standard. The results show that only 3 parameters of nitrite, potassium and cobalt are in the standard range and the rest of the measured parameters are higher than the allowable limit.

Table 4: Comparative comparison of pollutants with national wastewater standard

Parameter	Unit	(At the point of sewage discharge)	Sewage standard for entering surface water	Result
(NO_3)	mg/L	780	50	×
(NO_2)	mg/L	1.2	10	✓
(EC)	ds/m	8	3	×
pH	-	10.44	6.5 – 8.5	×
(Ca)	mg/L	101	75	×
(TDS)	mg/L	820	150	×
(Pb)	µg/L	1.1	1	×
(Cd)	µg/L	2.3	0.1	×
(Cu)	µg/L	35.6	1	×
(Mn)	µg/L	6	1	×
(Cr)	µg/L	4.5	0.5	×
(Co)	µg/L	0.8	1	✓
(Fe)	µg/L	8.9	3	×
(Zn)	µg/L	8.07	2	×

As indicated, figures 9 - 11 shows the zoning map of pollutants from wastewater discharge in the study area. Due to the large number of maps obtained, in this section only 3 examples of maps that show the number of pollutants measured are shown. Figure 9 shows the nitrate contamination rate from the lowest (21 mg/l) to the highest (780 mg/l) in the study area. Also, figure 10 shows the zoning of pollution in terms of TDS. Figure 11 shows the zoning of pollution in terms of iron. Figure 12 shows the pollution zoning in terms of pH.

The obtained correlation matrix is shown in Table 5. According to this table, there is a significant correlation between EC, TDS and heavy metals parameters at the level of 0.01. On the other hand, there is a correlation between the parameter of iron (Fe) and electrical conductivity (EC) at the level of 0.01. There is also a correlation between Ca and K parameters at the level of 0.01. On the other hand, there is a correlation between nitrates, sodium, calcium, potassium, total solids. However, the pH parameter had no correlation with other parameters.

Table 5- Results of Pearson correlation analysis of measured parameters in the study area

Elements	NO_3	NO_2	EC	pH	Na	K	Ca	TDS	Pb	Cd	Cu	Mn	Cr	Co	Fe	Zn
NO_3	1															
NO_2	0.76*	1														
EC	0.33	0.1	1													
pH	0.00	0.0	0.48	1												
Na	0.42	0.51	0.75*	-0.31	1											
K	0.21	0.32	0.08	0.0	0.68*	1										
Ca	0.38	0.21	0.02	0.5	0.3	0.9◆	1									
TDS	0.67	0.66	1◆	-0.3	0.81*	0.22	0.2	1								
Pb	0.49	0.36	0.00	-0.6	0.43	0.2	0.31	0.82◆	1							
Cd	0.05	0.08	0.00	-0.4	0.28	0.6	0.4	0.83◆	0.5	1						
Cu	0.06	0.06	0.00	-0.3	0.11	0.21	0.33	0.88◆	0.56	0.31	1					
Mn	0.2	0.17	0.00	-0.3	0.21	0.7*	-0.2	0.84◆	0.61*	0.56	0.34	1				
Cr	0.34	0.09	0.001	-0.3	0.5	0.18	-0.5	0.85◆	0.54	0.71*	0.36	0.33	1			
Co	0.9	0.25	0.003	-0.2	0.6	0.43	0.22	0.89◆	0.77*	0.55	0.4	0.22	0.31	1		
Fe	0.5	0.7	0.9◆	0.3	0.4	0.7	0.3	0.87◆	0.78*	0.1	0.3	0.06	0.2	0.4	1	
Zn	0.3	0.08	0.05	-0.4	0.6	0.8	0.3	0.89◆	0.44	0.2	0.6	0.77	0.3	0.2	0.1	1

Legend: ◆ significant correlation at the level of 0.01 / * significant correlation at the level of 0.05

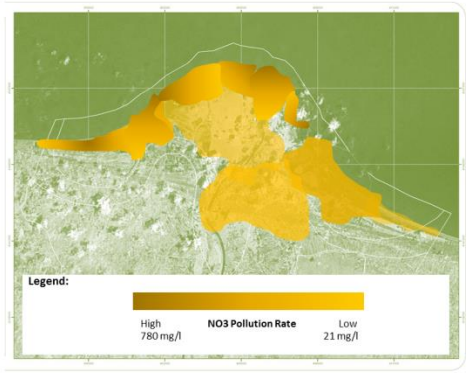

Fig. 9- Zoning of NO3 pollution rate in the study area

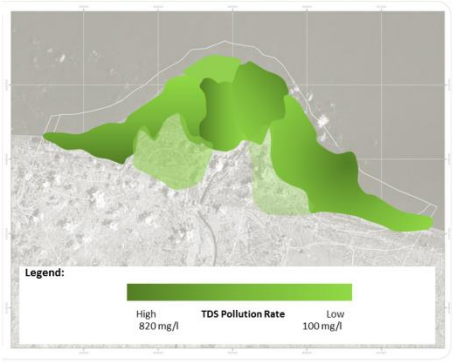

Fig. 10- Zoning of TDS pollution rate in the study area

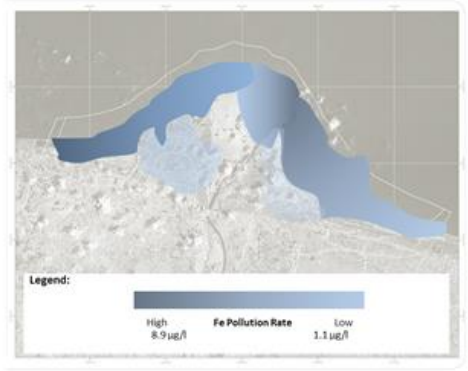

Fig. 11- Zoning of Fe pollution rate in the study area

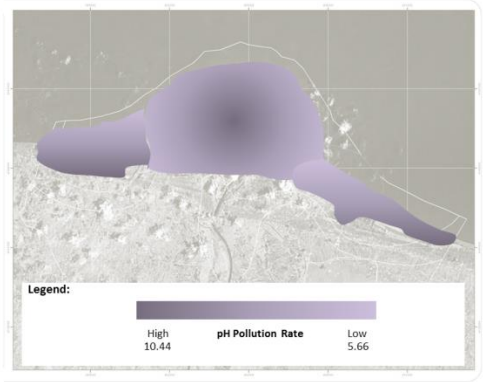

Fig. 12- Zoning of pH pollution rate in the study area

4. Discussion

The research findings indicate that the study area is ecologically sensitive. Of course, the degree of ecological sensitivities varies in different places. So that the southern parts are less important and the northern parts of the study area have the highest degree of ecological sensitivity, especially the northeastern part of the lagoon. The results of this section are completely consistent with the studies of Yousefi et al (2013).

On the other hand, the study and measurement of wastewater entering the wetland as well as sampling done at the wetland level shows that the pollution rate of the wetland is very high. In order to analyze the results, two standards have been used. One is related to the World Health Organization and the other is the national standard of Iran on wastewater discharge to surface waters.

Given that water salinity is a function of two parameters of electrical conductivity and total solids, electrical conductivity less than 0.7 ds/m does not limit plant growth and the range between 0.7 – 3 ds/m indicates average limit and rate higher than 3 ds/m indicates a high limit, by comparing the research results, it is determined that the lowest electrical conductivity in the measured samples is 0.9 and the maximum is 8 ds/m, which in principle indicates a relatively high limit of soil and water for plants.

On the other hand, total solids are also considered as the second parameter affecting water salinity. Accordingly, if the measured rate is less than 450 mg/l, it indicates no limit and the range between 450-2000 mg/l indicates a moderate limit and above 2000 mg/l indicates a severe limit. The results show that the average measured for this parameter in the study area is 460 mg/l, which indicates the average limit. Also; regarding pH, the average recorded for the study area is 9.88, which is in the national unauthorized range and the standard of the World Health Organization (WHO). In the case of nitrate, the permissible limit of the World Health Organization and the national standard is 50 mg/l, the average study range was 567 mg/l, which is slightly higher than the allowable limit, and in the case of nitrite, the permissible limit of the World Health Organization and the national standard is 10 mg/l, Given that the average nitrate measured was 0.9 mg/l, the result is within the allowable range.

Regarding potassium, it can be said that the standard of the World Health Organization and the national limit for this parameter is 12 mg/l and the optimum national limit is 14 mg/l. According to the mean obtained in the study area (9.1 mg/l), it can be said that this parameter is within the allowable and standard range. Regarding calcium, it can be said that the standard of the World Health Organization for this parameter is 75 mg/l, according to the mean obtained in the study area (88 mg/l) it can be said that the value of this parameter is higher than the allowable limit.

In the case of heavy metals; specially Pb, the WHO standard and the national permissible limit for this parameter are 1µg/l. According to the mean obtained in the study area (0.9 µg/l), it can be said that this parameter is within the allowable and standard range. In the case of cadmium, the WHO standard for this parameter is 0.1µg/l. According to the mean obtained in the study area (1.8 µg/l), it can be said that this parameter is higher than standard range. Regarding Mn, it can be said that the standard of the World Health Organization and the national limit for this parameter is 1 µg/l. According to the average obtained in the study area (3.3 µg/l), it can be said that this parameter is higher than standard range.

As Farhadi et al. (2020) have noted in their research, increase in agricultural activities along with increasing the use of pesticides and chemical fertilizers has effects on the quality of groundwater. In order to manage pollution, first of all, the type of pollution must be known and then the origin and method of their production must be examined (Fataei et al. 2005). Today, having a healthy environment and protecting it is one of the most important human concerns, and ways to preserve this environment by considering the resources available in it as a major challenge has been considered by the international community (Rabani et al. 2020).

From a legal point of view, the fight against water pollution consists of three stages:

A) The principle of prevention

Along with the principle of precaution, a concept has been created that has not yet become a principle, and that concept is prevention. The difference with the precautionary principle is the existence of certainty, which, despite scientific certainty, makes it necessary to prevent damage and pollution (Virginie, 2016).

Prevention: It is a set of actions that we imagine in our minds to prevent accidents or damage by implementing them. Environmental rules and regulations must anticipate and prevent the causes of environmental degradation. Almost all international environmental law instruments have made the principle of preventing environmental degradation a reality, most of which are about pollution of the seas, inland waters, air or the protection of living resources. The principle of prevention requires the use of special techniques such as risk analysis and subsequent evaluation of the consequences of the activities performed. Environmental Impact Assessment Before initiating an activity or project that may cause significant environmental impacts, the environmental impact of the project should be assessed to ensure that the development has the least adverse effects and guarantees sustainability. Therefore, environmental assessment helps to carry out the plans and formulate the necessary strategies to reduce the side losses resulting from the implementation of the plans and, in general, increase the implementation score of the project (Forsythe, 2012).

B) prosecution and investigation; That is, in the event of a breach of the rules, domestic and international courts must impose more or less severe penalties on the offending ships and the government concerned.

C) Monetary compensation for damages; That is, the offender and his government must compensate for the

damage to beaches, fish, crabs, and infected birds or their extinction.

4. Conclusions

Due to the ecological values and high environmental sensitivities of this region, it is necessary to eliminate the source of effluent and waste pollution as soon as possible. Leakage of waste leachate as well as the infiltration of wastewater into soil and groundwater, in addition to disrupting the life cycle, cause damage to biodiversity and even endanger human health. In order to control the entry of sewage pollution into the wetland and its surrounding votes, it is necessary to take legal and administrative measures immediately. Bojagh International Wetland is one of the most valuable wetlands in the country, which unfortunately is exposed to various types of urban, industrial and agricultural wastewater, which has reduced the quality of habitat and endangers the growth of native plant species in the region.

5. Conflict of interest

The authors declare that they have no conflict of interest.

6. Additional Information And Declarations

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Author Contributions

Atefeh Mahdi: Proposed the plan, conceived the experiments, analyzed the data,

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Parvin Farshchi: Article review

Mostafa Panahi: Article review

Ethics Statement

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