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Water Quality Evaluation of Bamdezh Wetland Using Combination of NSFWQI and Geographic Information System

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Abstract

Bamdezh wetland with the geographical coordinates of north longitude, east latitude and an area of 44 square Kilometers, is located in about 40 km northwest of Ahvaz and Shavur River is the main source of its supply. This wetland is not only a habitat and suitable food source for aquatic and migratory birds, but as well a significant resource of income for the locals. Today, with the arrival of various pollutants, construction of dam, water depth and wetland life has been threatened. In this study, in 29 sampling stations, the physical, chemical and biological water quality parameters of Bamdezh wetland, monthly for 6 months was collected. These parameters included temperature, fecal coliform, turbidity, NO3, PO4, pH, BOD, DO, TSS. Then, by determining the boundary of study area, using specialized software of Geographic Information System (ArcGIS9.3), database and processing of them, zoning maps and spatial distribution of pollutants using NSFWQI were prepared and analyzed. Among the notable results, the highest and lowest values of Water Quality Index were in June and medium water quality in all months (with some negligible part as exception in June) can be mentioned.

Key Word:
Bamdezh Wetland, Spatial Distribution, NSFWQI, GIS, Water Quality

1. Introduction

Wetlands are incredibly diverse, but any form that they have, such as ponds, marshes, coral reefs, lakes or mangrove, have a similar structural aspect. All wetlands are similar in the interaction between their fundamental components, namely, soil, water, animals and plants that make several operations and also

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provide numerous products (The Ramsar Convention Manual: a guide to the Convention on Wetlands, 1971). Today, wetlands known as landscapes that have a natural view and uniquely identified that provides countless services to humans, fish and wildlife. Among the services and functions we can mentioned the improvement of water quality, provide habitat for fish and wildlife, flood control and maintenance and storage of surface water during dry seasons. Such functions can highlight the inherent and unique characteristics of wetlands. Despite the fragility of these ecosystems, wildlife and the livelihoods of millions of people still directly depend on the existence of wetlands, products and their services (Newcome et al. 2005). This dependence is mainly visible in Asia. In this context, sustainable management of wetlands can reduce the damage that they have.

Khuzestan has five major wetland named Myangran, Shadegan, Bandoon, Hawr Al Azim and Bamdezh. This province which is encompass 50% of Iran’s wetlands, have suitable habitat for a variety of seabirds, and these wetlands are rich economic resource for natives along the wetland (Cultural Heritage News, 2013).

An overview of the current status of Iran's wetlands show that most of them due to lack of management indices, inefficient management, land use changes and conversion of wetland, construction of dams, more hunting than it can bear, dehydration and drought, implementation of development projects, importing non-native species caused loss of wetlands (Pure Human & Clean Earth Association, 2013). Six international wetlands that are recorded in the Ramsar Convention, are in the List of Montero[1] (http://isna.ir/fa/news).

Each hectare of wetland has more than 20 thousand dollars economic value that destruction of the bird habitats, particularly in wetlands due to domestic and industrial wastes, disrupts the ecological balance, population of birds and fishes caused reducing this economic value (Cultural Heritage News, 2013).

This is while, assessing, identifying and predicting environmental impacts is one of the plausible way to achieve sustainable development goals and could be used as a planning tool that is available for planners, managers and decision makers to identify potential environmental impacts that appeared by implementation of development projects and choose reasonable alternatives to the solve their problems (Cultural Heritage News, 2013).

The purpose of this study is using GIS and preparing water quality zoning maps (Spatial distribution of water quality) in order to evaluate the water quality of wetlands, according to the physical, chemical and biological parameters, withdrawal and polluting agents in Bamdezh wetlands.

Gupta and Roy (2012) in the study with the aim of assessing the groundwater quality and its suitability for drinking purpose used Water quality index (WQI) to know the overall quality of groundwater. Zare et al (2012) used GIS features to determine spatial changes of heavy metals in different parts of the Anzali wetland and their sources. In Geostatistical studies, they used ordinary Kriging method for interpolation and spatial changes of data. L. Bruland et al (2006) used a stratified random sampling design to collect

1- Severe Ecological Changes

soil cores from 388 sites to quantify the spatial distribution of soil properties in a 233000 ha subtropical wetland. The aim of the study was using geostatistics to examine spatial patterns and then assessing the relationships of these patterns to known ecosystem drivers. Hettiarchchi et al (2011) do historical analysis of trends in surface water quality parameters and situation analysis of short term spatial and temporal water quality variation in the wetlands around the city of Colombo. Karami et al (2009) evaluated and optimized the relationship between NSFWQI and physical, chemical and biological parameters of Bamdezh Wetland. Karami et al (2010) in an another project introduced a conceptual model for determination of environmental water requirement for Bamdezh Wetland.

2. Materials and Methods

2.1. Study Area

Bamdezh wetland with the geographical coordinates of $31^{o}38'54''$ North Latitude and $48^{o}48'56''$ East longitude and an area of 44 square kilometers, is located about 40 kilometers North West of the city of Ahwaz, which is bounded on the north by Mazrae village and Shavur dam, to the south by the Tavana Channel, at the east by Bamdezh village along Ahwaz-Andimeshk Railway and at the west by Sadat Tavaher and Seyed Jasem Villages. Bamdezh wetland is mainly influenced by Shavur River (Jamee, M. 2002).

Shavur River from about 15 km north of Susa originated from Dezful and Susa groundwater, after receiving the return water of west Dez area and feeding ramified rivers finally entering the Bamdezh Wetland. Output branch of the wetland named Khavar, after crossing the Tavana Channel finally entering Dez River. Accumulation of freshwater in Bamdezh wetlands is mainly due to water of Shavur River that under topographic characteristics of the area has been considerably extended into the area and creates wetland. In the image that produced by GIS software, the view of Bamdezh wetland is presented. In this image Dez River is situated in East of the wetlands and Karkheh River is located in the West (Jamee, 2002). In the past Bamdezh wetland had a large area of approximately 10,000 hectare and covered a large area. Unfortunately, for various reasons that gripped all natural areas of Iran, it’s area is greatly reduced. At present, the maximum range of the wetland area is about 3,500 acres that approximately less than 50 percent of all wetlands area in the past (Pourmansory et al. 2009).

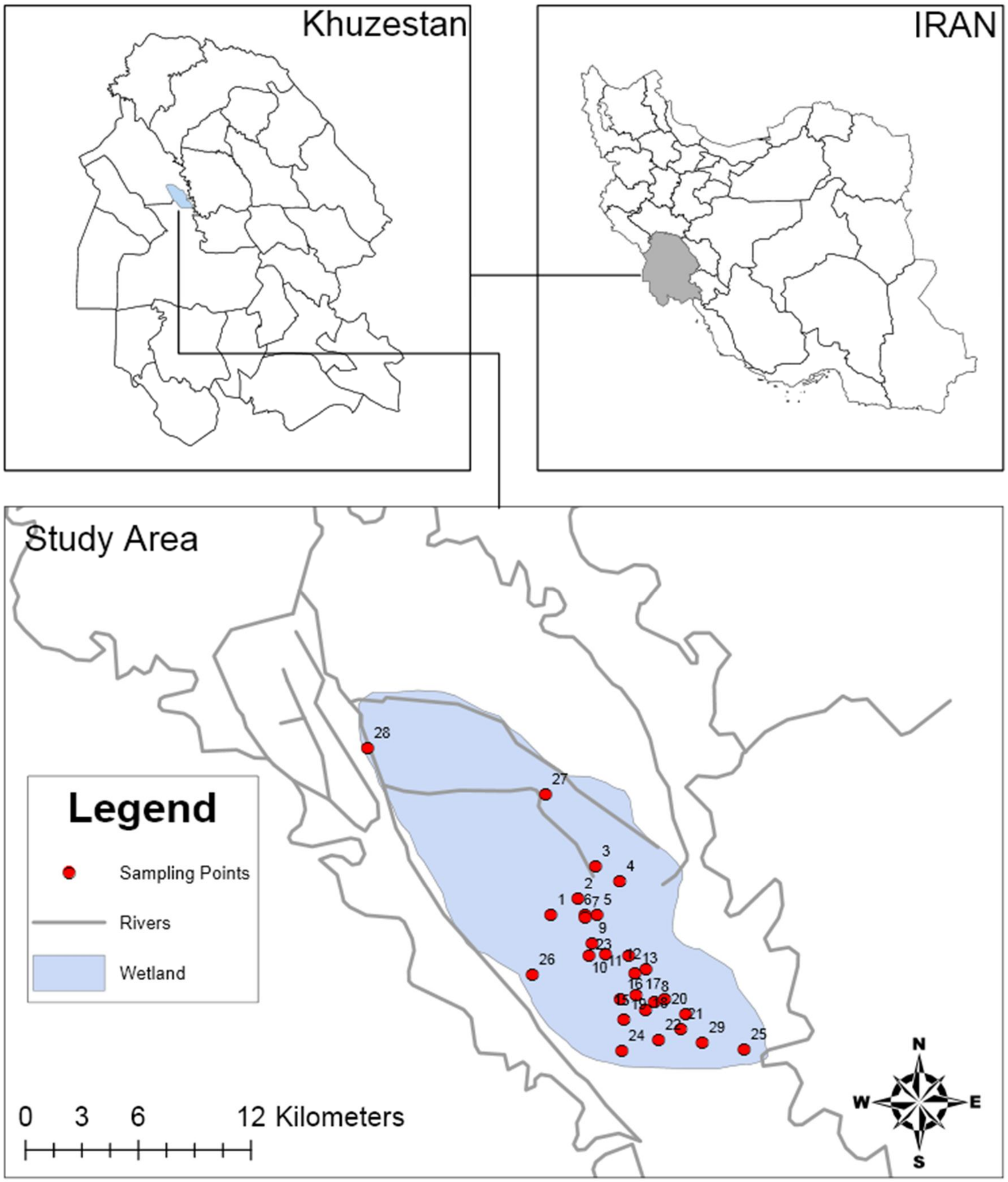

Fig.1 Study Area and sampling points

Regardless of the waste that enters in the wetland in recent years, generally part of the wetland in all year which had constant depth of 1 to 2 meters that extended to a certain margins of wetland. Scope and depth of the water in the wetlands margin is not stable and permanent and gradually its area is reduced by negative water balance. As a result, in every year, seasonally part of the land is out of the water and again in the season of high water is covered by a layer of water. In previous years, before the construction of the Karkheh Dam, the overflowed of the river causing flow of water into the area and entering into the wetland that extended the wetland areas. But by construction of the Karkheh Dam, there was no flood zone witnessed, therefore wetland has no progress in area (Nabavi, M. 2002). The lands in the study area are generally divided to agricultural affairs, fish ponds and residential sectors. Anyway, major land use and significant area is not witnessed in the region. Agriculture is the major land uses in the study area. The significant portions of the land surrounding the wetland are barren lands (Bostanzadeh, 2003). This wetlands that is the source of more than 200 plant species, over 140 species of birds, and 40 other animal species and types of fishes, could be considered as recharge groundwater, regulation of water flow, flood control, weather modification, sources of natural products, creations of tourism zones, gene bank, conducting research and educational visits and etc. (http://www.farsnews.com/newstext.php?nn=13920805000148). From total of 447 species of birds that known in Iran, more than 260 species live in the Khuzestan province, especially in wetlands (http://www.chn.ir/NSite/FullStory/News/?Id=62236&Serv=0&SGr=0). Viewed objectively of the Bamdezh wetland indicated the massive death of small and big fish in the wetland that is the origin of the economic prosperity of the region (http://www.magiran.com/npview.asp?ID=1541014).

2.2. Data Collection and sampling station

The needed data from29 sampling station (Fig. 1) include of the water quality parameters ,was given from Bamdezh wetland Project, Khuzestan Water and Power Authority by Supervision of Southeast Water Exploitation, Production and Transfer Company for 6 months. The sampling depth mentioned 15 cm with longitude and latitude coordinate.

2.3. Water Quality Index

Protection of drinking water resources, Development of Activities, recreational uses and Create a suitable environment for fish and wildlife, required equivalent water quality of rivers and wetlands. In this regard, determining the most important factor in water quality is important. According to number and range of water quality parameters, which makes them difficult to interpret, water quality indicators were codified to obtain technical information that is used by experts and managers to assess river water quality and provide relevant decisions (Guideline Manual for Assimilative Capacity Studies in Rivers, 2009). A water quality index provides a single number (like a grade) that expresses overall water quality at a certain location and time based on several water quality parameters (http://bcn.boulder.co.us/basin/watershed/wqi_info.html). Water quality indices are an effort to provide answer to general questions about water quality management. Water quality index is for initial assessment and it is useful for comparative purposes and general questions (Guideline Manual for Assimilative Capacity Studies in Rivers, 2009).

Some chemical and physical indices in the studies and researches have been represented that can be divided to general index, special purpose index, design index, statistical index and biological index. These main groups have some sub index such as, Horton quality index, USA national Sanitation Foundation index, Prati index, Mc Duffie index, Dinius index, Dojlido index, Walski and Parker index, Nemerow and Sumitomo index, Oregon index, National Canada index, Harkins index, Beta index and etc. (ott, 1978).

By evaluation of the indices, some advantages and limitation are determined. Statistical indices can't compare some data to another. Design indices used for management and are not used for classification surface water. Some parameter that requirement for general indices are not measured in Iran so, can't be used. Some indices such as, Oregon index is local index. Between indices that have introduced, NSFWQI is the most applicable and easiest index which is well known for environmental experts and it is adequate for modest evaluation objectives (Karami et al. 2009).

To this end, an attempt has been made for the first time in order to determine spatial distribution of Bamdezh wetland water quality within the study area based on: (1) Use of Geographical Information System and (2) Water Quality Index calculation (Ketata-Rokbani et al. 2011).

2.3.1. Classification of wetland quality by using of WQI

This index is a decreasing index (i.e. the index decreases with increasing pollution). This index is between zero and 100. WQI index is calculated as follows:

$$\sum W_i Q_i$$

W_i : Weight of parameter i

Q_i : Quality factor from 0 to 100

Several charts is used for define Q value for every parameters. So from these charts, Q value is determined. The qualitative range of this index is specified in table 1.

Table 1 Water Quality Index Legend

Quality	Very Bad	Bad	Medium	Good	Excellent
Range	0-25	25-50	50-70	70-90	90-100

According to environmental conditions and limitations of the study area, 29 sampling points were selected. Sampling was done monthly for 6 months, and in each month one sample of each station was given.

ArcGIS9.3 software was used to this study in order to processing spatial distribution of water quality to enable comprehensive analysis on the results that are presented as maps. Significant environmental benefit of GIS is the simultaneously access of descriptive and geometric information and the interaction between the two sets of information. In this study, in order to the spatial distribution of Bamdezh water quality with WQI, this software package has been used. To facilitate the interpretation of results which obtained in this section, another functionality of the software is considered. In this context, we can use the software capabilities to display colors using a gradual process of qualitative change. Monthly values of the WQI were classified so that each class has specific color. The output of this section is the zoning maps that show's spatial distributions of the water quality index.

2.4. Application of GIS and Geostatistics analyses

Geo-statistics is a part of statistics which are able to uncertain temporal and spatial modeling of phenomenon. The basis of geo-statistical models is estimation of uncertain amount as a random number with a clear possible distribution in a favorable point of the space under consideration (Goovaerts, 1998). In order to change the dotting information into a map with regional information, one of the common method that is used in Geo-statistics, called Kriging. Kriging is widely used in geology, hydrology, environmental monitoring and other fields to interpolate spatial data (Nas et al. 2008). Kriging is used for interpolation, area-making and predicting the possibility of occurrence of data which have correlation (Zare Khosh Eghbal et al. 2012). Among the various forms of Kriging, Ordinary Kriging has been widely used as reliable estimation method (Nas et al. 2008). So in this study, Ordinary Kriging method was used for interpolation and spatial changes of data.

The public formula for estimation of unknown amounts at the all Geo-statistical interpolation methods like Kriging is calculated from the following relation (Zare Khosh Eghbal et al. 2012):

$$Z^*(x) = \sum_{i=1}^{n} \lambda_i . Z(x_i)$$

$Z^*(x)$: the observed amount of variable Z in the point of xi,

λ_i : weight of importance given to the variable Z in the point of xi,

$Z(x_i)$: number of observation

3. Results and discussions

By producing the spatial distribution maps in this software, it could be possible to by clicking on each data layer, the information of the layer can be observed. Water quality state of Stations is presented in table 2 by NSFWQI. The cells which left blank presented dry situation that occurred on related month. Figure 2 shows wetland water quality zoning by NSFWQI, from April to September 2009.

Table 2 Stations water quality presented by NSFWQI

Station	WQI (April)	Status	WQI (May)	Status	WQI (June)	Status	WQI (July)	Status	WQI (August)	Status
1	65	Medium	61	Medium	63	Medium	68	Medium	56	Medium
2	71	Good	65	Medium	59	Medium	61	Medium	59	Medium
3	60	Medium	72	Good	-		-		64	Medium
4	60	Medium	61	Medium	51	Medium	-		56	Medium
5	61	Medium	64	Medium	65	Medium	63	Medium	55	Medium
6	68	Medium	-		61	Medium	60	Medium	65	Medium
7	-		-		-		66	Medium	55	Medium
8	-		-		-		-		59	Medium
9	64	Medium	-		-		-		-	
10	65	Medium	67	Medium	-		61	Medium	60	Medium
11	64	Medium	75	Good	-		58	Medium	58	Medium
12	65	Medium	63	Medium	65	Medium	-		64	Medium
13	64	Medium	73	Good	65	Medium	64	Medium	62	Medium
14	57	Medium	70	Medium	63	Medium	-		-	
15	73	Medium	67	Medium	64	Medium	-		-	
16	70	Medium	69	Medium	66	Medium	-		-	
17	70	Medium	69	Medium	66	Medium	48	Bad	58	Medium
18	67	Medium	68	Medium	65	Medium	65	Medium	59	Medium
19	69	Medium	69	Medium	60	Medium	56	Medium	-	
20	73	Good	70	Medium	63	Medium	63	Medium	60	Medium
21	64	Medium	65	Medium	59	Medium	-		64	Medium
22	68	Medium	68	Medium	56	Medium	-		-	
23	68	Medium	61	Medium	64	Medium	63	Medium	64	Medium
24	68	Medium	45	Bad	60	Medium	60	Medium	56	Medium
25	62	Medium	67	Medium	41	Bad	46	Bad	51	Medium
26	73	Good	63	Medium	79	Good	57	Medium	60	Medium
27	60	Medium	55	Medium	63	Medium	54	Medium	55	Medium
28	65	Medium	57	Medium	90	Good	61	Medium	62	Medium
29	67	Medium	56	Medium	87	Good	57	Medium	50	Medium

In April, water quality heals from north to south and from east to west of Bamdezh wetland. This caused by wetland assimilative effect for pollutants, while the water enter the pond from the north and exit from the south. In this month WQI index is between 62 to 69 which represent the medium quality of water that trend’s to good.

Also this index improves from west to east that the lower water quality in the west is because of effluent from aquaculture ponds that is located in the east of the wetland. Zoning map in May is similar to April with this difference that in the eastern part of wetland which shows better water quality but the improvement in quality is not very sensible. The water quality deference between the eastern and western parts of wetland is approximately 4 units. This can be attributed to deeper water, better vegetation and finally better assimilative performance of wetland. It should be noted that the depth of the wetland grows up to 2 meters from west to east.

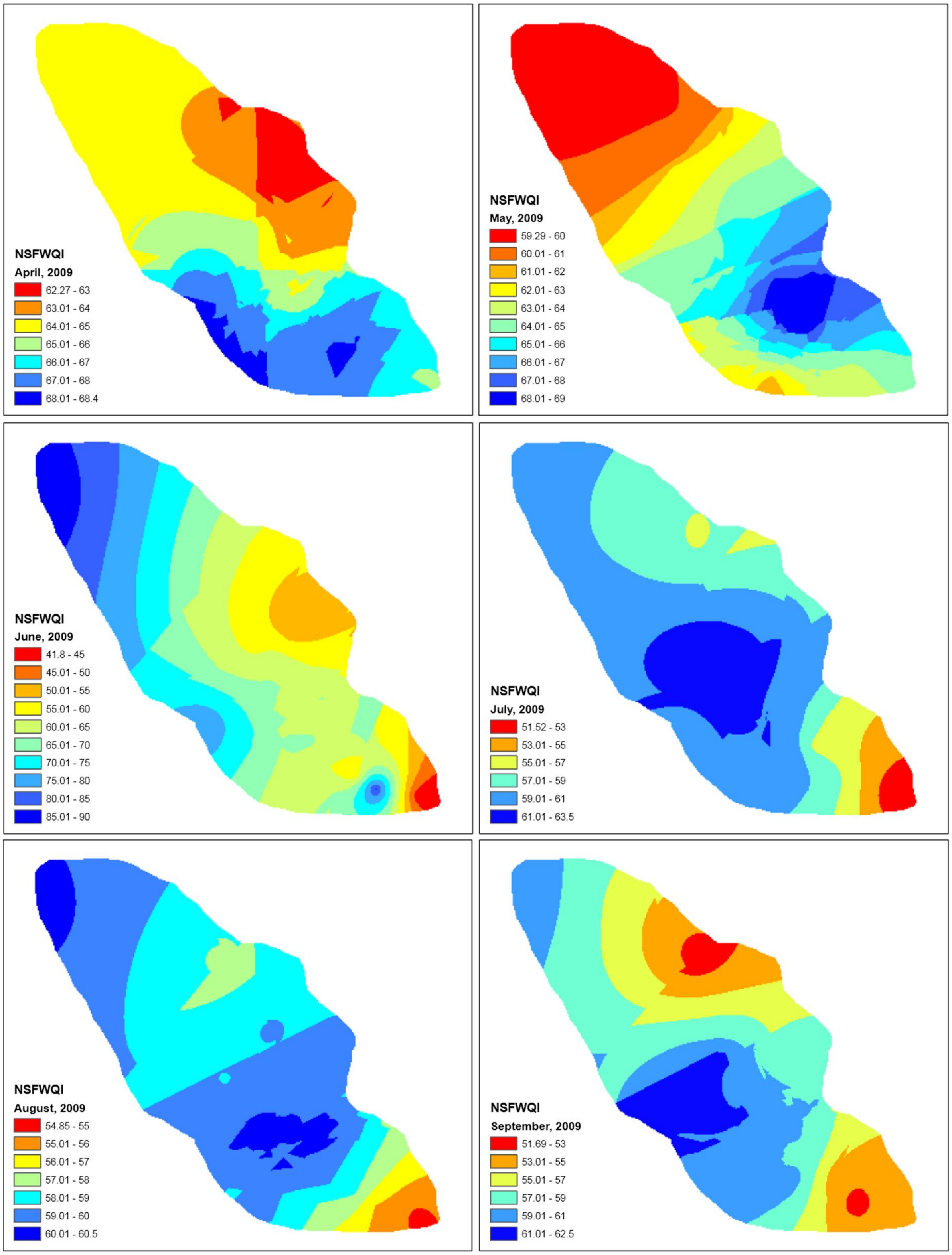

Fig.2 Spatial distribution of WQI in Bamdezh Wetland from April to September, 2009.

But in June, as can be seen, the process is in the opposite way that is occurred in May and April. So in this case the northern part of the wetland exits from flooding due to valves closure of Shavur dam and the loading of pollutants is from the southeast and fish pond. Since the output of the wetlands is located in the southern, so in those points of water that remain stagnant in the northern, wetland has better assimilative function. Northern part of the wetland had good water quality. In the Southeast parts, the water quality is bad, so that is alarming and needs to give more concern.

The range of water quality index in this month varied between 41 to 90. But if pollutant loading was done from northern part of wetland, the range of water quality index compacted and improvement in performance of wetland assimilative capacity was witnessed. In July we see the same trend as in June, with this difference that water quality range compacted and water qualitative index are placed in the medium range. Quality range is between 51 to 64 differs. Peak reduction of the wetland water quality from 90 to 64 in these two months (25 unit difference in June and July) in the northern part can be attributed to the lower water depth.

In August and September saw the same process as we saw in July and have more pollutants in the eastern part of the wetland. Also in these months the water quality is almost uniform, especially in August, qualitative difference is less than 6 units. So that is because of reducing the depth of the water on the north side than the previous month.

Reduced water quality in the eastern part of the wetland can also attributed to the agricultural drainage that is entered to this section (Bianchi, 2003). Because the major farm lands are located in the eastern part and wetland is located in the lowlands, drainage water from the lands easily entered into the wetland.

4. Conclusions

Bamdezh wetlands from early May to late June spent it's dehydration period, because the closure of the valves and inundation of the shavur dam, the flow that enters the wetland dropped, agricultural effluent entering the wetland was also exited by Khavar drainage and marginal areas of wetland would dry (Afkhami, 2004). These are serious threats to the region's ecosystem and animal life that is dependent's on wetlands.

Water Quality Index, except in June that the quality of southeastern part of the wetland is bad, in the rest of the months has medium quality. Wetland zoning maps show that if the wetland in some months of the year impounding out, the concentration of the pollutant in some area, increased.

Cause this focus of infection, will put aquatic and wetland-dependent species at risk (Bostanzadeh, 2003). To prevent high contamination concentration, the water balance always should be regular. It is recommended that the discharge points of pollutants perched at north of the wetland to use assimilative capacity of wetlands in order to improve the quality of organic wastewater and agricultural drainage water. Also with this accumulation of pollutant concentrations in specific areas will be reduced. Various wastewater could also enter in the areas where the water flows in the wetland to use dispersion capacity of wetlands flow to reduce contaminant concentration, balanced spatial distribution and better digestion of pollution is occurred (Guideline Manual for Assimilative Capacity Studies in Rivers, 2009).

Creating a fish pond in the east of wetland, influx of pesticides from northeast, fishing with poison, and create drainage, threatening plants, fishes and birds life more than ever (Bostanzadeh, 2003).

The zoning map, concentrated pollutants in the eastern part, and their impacts and responses of wetland to them in all months is clearly visible. Therefore, the concentrations should be reduced as much as possible or the point that pollutants discharged, should be changed. This study demonstrated that use the combinations of GIS and WQI could provide useful information for water quality assessment.

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