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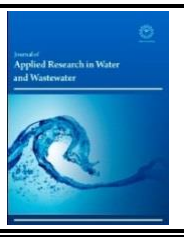

Original paper

The study and zoning of dissolved oxygen (DO) and biochemical oxygen demand (BOD) of Dez river by GIS software

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ABSTRACT

Pollution sources into the water, the necessity of qualitative studies of water resources is one of the most important new challenges for mankind in almost every parts of the world. Dissolved oxygen (DO) and Biochemical Oxygen Demand (BOD) are among parameters of water quality indexes which are considered as water pollution indexes. In the present research, DO and BOD of Dez River basin water (in Dezful City) were studied and zoned by applying the Geographic Information System (GIS). Nine stations were considered for sampling during six months in 2013. The results indicate that the average maximum amount of DO at an average of six months is 8.47 mg/l in S1 station and the minimum amount is 1.71 mg/l in S8 station. The average maximum and minimum amounts for BOD during an average of six months are orderly 150.83 mg/l in S8 and 3.16 mg/l in S1. By a qualitative zoning, places that are prone to pollution can be recognized and measures can be taken for monitoring and preserving such areas. Decreasing the amount of water pollution and controlling the pollution sources are possible by adoption appropriate measures.

1. Introduction

Today, by the expansion of social, economical, and developmental contexts and promotion of education level, there is a dire need to a clean and green environment (Thanh Binh et al. 2012). Continual monitoring of water quality is essential for efficient management of city rivers in order to control the pollution sources quickly (Hur & Cho 2012). As city rivers are prone to different pollution sources, they can be easily contaminated and as a result, the water quality will degrade. Instantly, the phenomenon is directly and indirectly a danger which threats the humans' health and aquatic ecosystems (Henderson et al. 2009; Su et al. 2011; Mouri et al. 2011). Generally, the density of DO is a key parameter for describing the nature and wastewaters of the environment (Keeling et al. 2002). A decrease in the level of DO in the world's oceans is increasingly on the rise which will affect the total earth ecosystem such as Carbon cycle (Joos et al. 2003), weather (Keeling et al. 2002; Keeling et al. 2010, Keeling et al. 2002; Shaffer et al. 2009; Gilbert et al. 2009). The amount of existing DO in natural waters is so essential that for doing researches related to nature, data will be gathered by considering the environment protection, hydro biological points of view and/or ecology (Nagy et al. 2008). Enough amount of DO is needed for the survival of water plants, animals and also wastewater treatment plant (Hobbs & McDonald 2010). Measuring and monitoring the density of DO is required to promote the quality of the environment (Naykki et al. 2013).

In aquatic environment, oxygen is produced by photosynthesis in plants and algae, and then plants, animals and bacteria breathe it in. The oxygen is also needed in the increase of the organic loading, in the formation of sediment which are formed by oxygen and oxidation, and aeration by exchange with the atmosphere (Radwan et al. 2003). Generally, oxygen may be added to water or be removed from it through different physical, chemical and biological actions (Fortes Lopes 2008). According to Europe standard, DO limit in a river is at least equal to 5 mg/l, for a suitable qualitative rate (Krenkel & Novotny 1980). A high amount of BOD is produced by the fast decomposition of biodegradable organic materials after which the decrease in the oxygen level will lower the water quality of the river (Jin & Cho 2012). GIS can geo reference, organize, process, and analyze the complicated information (Pedrero et al. 2011).

Pollution zoning and providing a valid image of the quality of the surface water by GIS, can help a better management decision-making which directly and indirectly, will promote the quality of surface waters (Hooshmand et al. 2008; Dunnette 1989; Curtis 2001). In a research done by Martin et al (2013) the density level of some of the effective parameters on DO, such as BOD, are surveyed for providing a model for predicting and decreasing the amount of DO in Athabasca river in Canada. BOD was considered as an index in the mentioned research. In another research conducted by Abdolhamid et al (2010) water quality index of Dokan river in Kurdistan-Iraq was determined by 10 parameters of water quality. The results of the mentioned research indicate that different human activities have affected some parameters like BOD. Kevin et al. (2000) have used GIS to study Zardchin river in order to estimate the level of relationship between pollution and hydrological and ground operation. Also, Akkoyunla & Akiner (2012) and Rosoli et al. (2012) have measured the water qualitative parameters such as BOD and DO to indicate the relationship between the level of pollution and the water quality.

The present research has focused on Dez river in Dezful city which is an important agricultural and industrial zone in Khoozestan Province to study and zone the trend of changes in the level of BOD and DO and their relation with each other.

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2. Materials and methods

Since it is not possible to monitor the whole parts of the river, 9 stations along Dez river are considered which are placed before the City, in Dezful and after the City. The stations are called Gellal Dez, Ziba Shahr, Parke Dowlat, Artesh, Nabavi, Pole Panjom, Khoroojiy-e-tasfiyekhane, Koshtargah-e-Dami, and Gavmish Abad. Sampling from the determined stations was done monthly, during 6 months, from March to September in 2013. Polyethylene containers were used for estimation BOD and transferred to laboratory. Also, Horiba U-10 was used to estimate DO. Data obtained in laboratory were entered into Excel. Also, ArcGIS software was used to provide zoning map. It should be noted that since the river is not wide, borders are considered around it to have a clear zoning image and easier analyzing process. The positions of the sampling stations are shown in Figure 1.

3. Results and discussion

The present research has attempted to determine the status of DO and BOD indexes in all of the stations by doing a comparison between spring data and summer data. The six-month averages are indicated in Table 1.

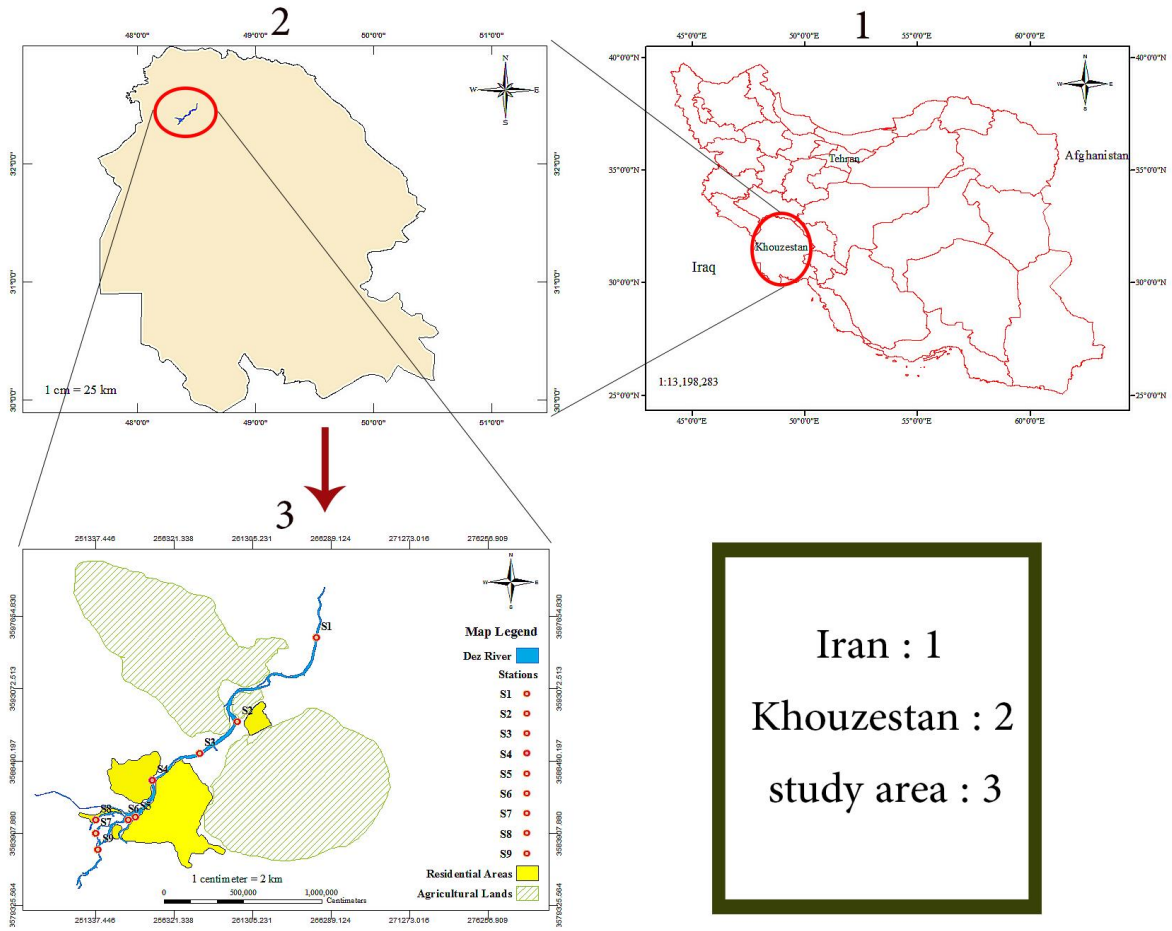

Fig. 1. The position of sampling stations in the map of administrative divisions.

Table 1. The level of DO and BOD in spring and summer.

Six-month average		Summer average		Spring average		
BOD	DO	BOD	DO	BOD	DO	Stations
3.16	8.47	3.76	8.31	2.56	8.36	S_1
43.38	7.28	7.76	7.2	79	7.36	S_2
20.05	7.06	6.86	5.43	33.23	8.7	S_3
26.13	5.45	7.93	4.23	44.33	6.66	S_4
7.83	7.65	7.33	6.83	8.33	8.46	S_5
17.55	4.95	19.1	3.63	16	6.26	S_6
27.83	4.28	24.3	3.76	31.33	4.8	S_7
150.83	1.71	93	0.57	208.66	2.86	S_8
10.93	5.56	9.86	4.96	12	6.16	S_9

The maximum amount of DO in spring was for S3 (central station) because of favorable temperature, flow, and wind turbulence. The maximum amount of DO in summer was for S1 (the first station located at upstream) because of low input organic loading and microbial population of the river. The minimum amounts of DO in both spring and summer were for S8 (located at the downstream) because of an increase in the volume of raw animal waste entered into the river which itself, increases the level of river pollution. So, the maximum amount of BOD in spring and summer is for S8 and the minimum amount of BOD is spring and summer is for S1.

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Figures 2 and 3 have indicated the changes in the level of DO in a 6-month average. The maximum amount of DO was for S1 (8.47 mg/l) and the minimum amount of it was for S8 (1/71 mg/l). The maximum amount of BOD was for S8 (150.33 PPM) and the minimum amount it was for S1 (3.16 mg/l). So, it can be said that because of an increase in the volume of raw and untreated animal waste, existence of organic materials, and microbial agents, DO has decreased and BOD has increased. Since S1 is located at an upper level from industrial, agricultural and residential areas, it enjoys a high level of DO.

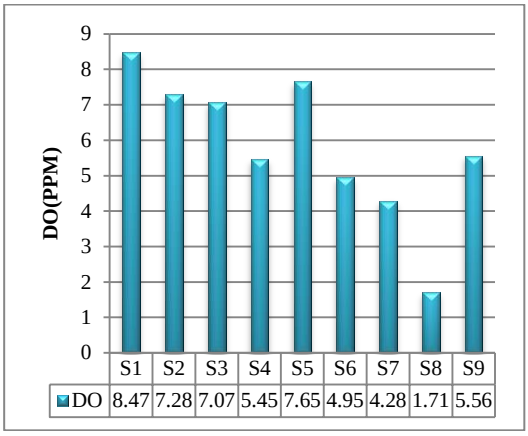

Fig. 2. Position-dependant changes in DO density (mg/l) in determined stations (an average of 6 months)

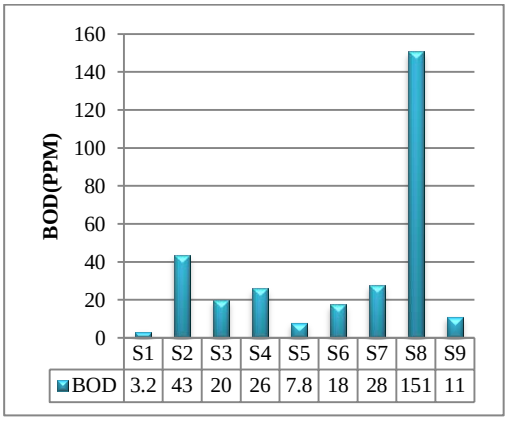

Fig. 3. Position-dependant changes in BOD density (mg/l) in determined stations (an average of six months).

In Figure 4, monthly DO changes are shown. S1, as it is located at a higher place, has the maximum level of DO, and S9 which is located in the lowest part has the minimum level of DO. S5 is a central station (between S1 and S9). With an overview to the DO changes during spring and summer, it can be concluded that DO level in spring is higher than the summer. The findings are similar to what Lehman (2002) and Fortes Lopes (2006) indicate in their studies regarding rivers' sediments.

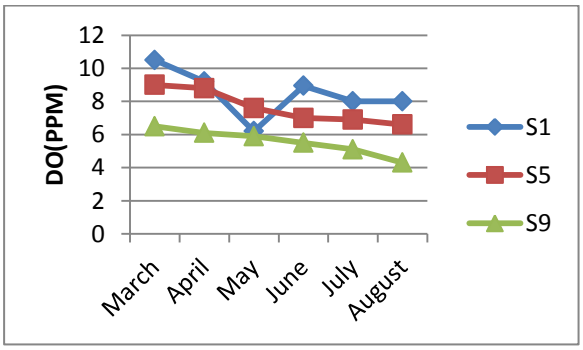

Fig. 4. Monthly changes at the level of DO in S1, S5, and S9.

The low level of DO in S1 during May can be the result of increased level of rainfall and erosion, the area around the river being washed and entering the microbial agents and organic materials into the river.

Figure 5 has indicated the monthly changes of BOD in determined stations. According to the diagram, it can be said that S9 has the maximum amount of BOD, S1 has the minimum amount of BOD, and S5's BOD is in between. With an overview to the diagram, it is clear that in comparison with summer, BOD in spring has increased because of increased level of rainfall and organic material. Aerobic biodegradation includes biologic oxidation of organic materials. During the process, microorganisms change the organic materials into microbial biomass (Jouanneau et al. 2013). So, in spring, microbial population, especially Fecal Coliform, will be increased due to the increased level of rainfall and as a result, BOD will increase too. Romas et al. (2006) and Moungi et al. (2003) indicate a strong relationship between the level of rainfall and its runoff and the level of microbial pollution loading of surface waters. Kim et al. (2005), has also claim that E. coli has increased 7 times in rainfall months more than that of in dryer months. Therefore, in summer, due to the decreased level of rainfall, its runoff, and suspended particular matters, E. coli will be lessening in the rivers' waters. According to the provided zoning in figures 6 and 7, dark blue indicates the maximum amount of DO which is for S1, while red indicates the minimum amount of DO which is related S8. In S1 discharge of wastewater into the river has not been observed and the pollution loading is lesser in comparison with the other stations which is a reason of high level of DO. Also, BOD level for the average of 6 months in S8 is higher in comparison with the other stations and is shown in blue. Usually, surface flow of the residential areas will be increased intensely in spring. Consequently, microbial loading in surface waters will be increased too (Jaglass 1997; Venter et al. 1997).

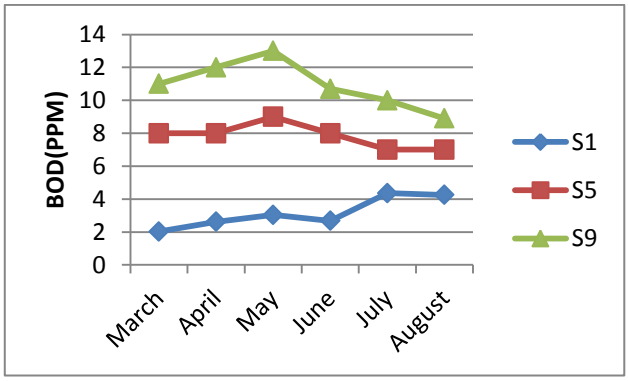

Fig. 5. Monthly BOD changes in S1, S5 and S9.

4. Conclusion

Monitoring of DO and BOD provides us with enough information about a river conditions (Tyagi et al. 1999). If BOD is low, the water is clear and without organism. In the case of existence of any organism they do not use Oxygen (Tchobanoglous et al. 2003).

So, in the stations with low amount of BOD, we observe a smaller microbial population. Where there is a low level of DO and naturally, a high level of BOD, this is the place of entrance of wastewaters, and raw and untreated wastewaters.

An increased level of rainfall in spring will cause the entrance of organic materials and expands the microbial population which all of these factors affect the level of BOD.

The present research states that the reason for the low density of DO in some stations is due to the entrance of wastewaters, having stagnant water in some places, and existence of microorganisms or algae. Using a shared database for boosting the relationship between monitoring and reconstruction of environmental projects is essential in the promotion of technology transferring (Quinn et al. 2005). By the help of GIS, critical points of pollution in the rivers can be recognized. So, online monitoring of rivers for promotion of water quality is possible. Therefore, GIS software, and controlling and monitoring the pollution sources entered into the aquatic ecosystems of the rivers are suggested for having precise information about the rivers' qualitative status and studying the effective and important estimation parameters in the rivers' waters quality, as it is used of Dez river.

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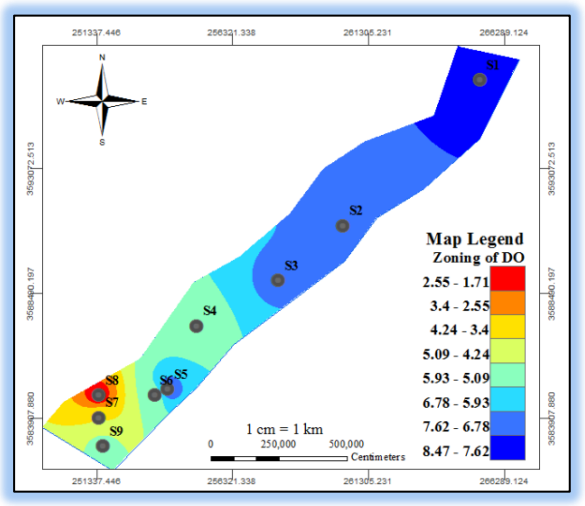

Fig. 6. Zoning the average DO in six months.

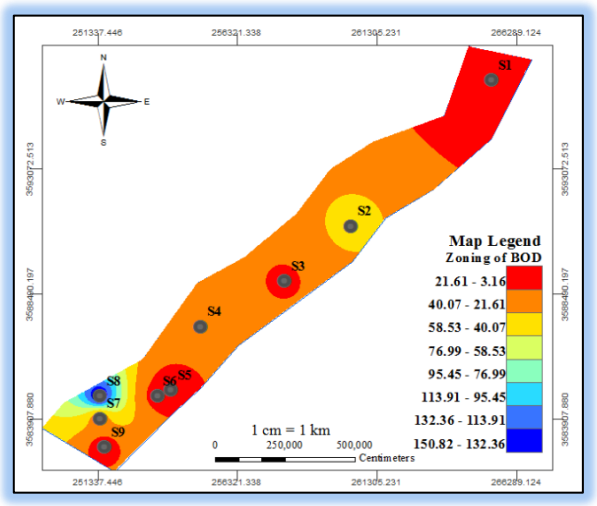

Fig. 7. Zoning the average BOD in six months.

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