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Original research

Effect of trout farm on the water quality of river using Iran water quality index (IRQWI): A case study on Deinachal River

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A B S T R A C T

Rivers can be contaminated with different pollutants such as trout farms. Evaluation of the effect of trout farm on water quality is important to give new permission for trout farm construction. In current work, the effect of constructed trout farms near the Deinachal River on some physicochemical properties namely chemical oxygen demand (COD), biological oxygen demand (BOD5), dissolved oxygen (DO), pH, temperature, turbidity, nitrate, nitrite, phosphate, heavy metals, total hardness, total alkalinity, calcium, magnesium, electrical conductivity, fecal coliform and ammonium were studied and the water quality was classified using Iran Water Quality Index (IRQWI). Results showed that except nitrite, ammonium, chromium, nickel, lead, cadmium and mercury, other parameters affected by both trout farms and domestic wastewater. However, assimilative capacity of Deinachal River due to entrance the branches into the river can improve the water quality.

Keywords: IRQWI, River, Trout farm, Water quality

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1. Introduction

Rivers are one of the most important potential sources of supplying the water all over the world. They can be contaminated by several pollutants such as human sewage, industrial wastewater and farm waste. Nowadays, trout farms are extensively expanded in Iran which can contaminate rivers due to add the remains of food and feces of fishes. On the other hand, dissolved solids which are released into the environment by fish and chemicals which are produced by the drug treatments are two other sources which may contaminate the river. So, evaluation of the effect of trout farm on quality of river is important for giving the new permission for trout farm construction. There are several case studies to evaluate the effect of trout farms on water quality of rivers. Bergheim & Selmer-Olsen (1978) studied the effect of trout farm on the water quality of river in Norway. They evaluated the values of nitrate, ammonium, phosphate and BOD before and after the trout farm and concluded that some parameters changed after trout farm. Kırkağaç et al. (2009) evaluated the effect of trout farm on the water quality of Sakarya River in central Antolia. Annually capacity of river was 30 ton and results showed that this trout farm changed ammonia-nitrogen, total phosphorus and orthophosphate up to the levels which were more than acceptable effluent limits. Živić et al. (2009) studied the effect of trout farm on the water quality of Trešnjica River in Serbia and evaluated the most proportional parameters to evaluate the water quality. Ardakani et al. (2014) evaluated the effect of trout farm on the water quality of Kabkian River. They evaluated the values of dissolved oxygen, pH, TDS, electrical conductivity (EC), temperature, NO3, NO2, PO4, NH4, biological oxygen demand (BOD5) and chemical oxygen demand (COD) in river before and after several trout farms. They concluded that different trout farms have different effects on water quality in Kabkian River. Also, authors resulted that parameters except phosphate reduced in downstream of river. Bagherian et al. (2014) studied the effect of trout farm on the water quality of Artkand River. They evaluated some quality factors of water namely EC, BOD, COD, acidity and dissolved oxygen and concluded that these parameters changed after trout farm.Gilan is a green province in Iran where the maintaining the water quality has an important role to preserve environment. Deinachal River is one of the most important water sources in Gilan province; so, maintaining its water quality is very important. Trout farms which are constructed near the river are one of the most important sources of water pollutant in Deinachal River. So, evaluation of the effect of these farms on the water quality is very important to maintain the water sources. In current work, the effect of constructed trout farms near the Deinachal River was studied and the water quality was classified using Iran Water Quality Index (IRQWI).

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Table 1. Locations of sampling in Deinachal river

Location number		Location place			Reason of selection
1	N E	35˚ 051˚	19' 3'	33.3"	It placed before the first trout farm
2	N E	37˚ 048˚	35' 55'	28.2" 25.2"	It placed after the second trout farm
3	N E	37˚ 048˚	35' 58'	25.4" 17.1"	It placed after a river branch
4	N E	37˚ 048˚	35' 59'	07.1" 45.1"	It placed after three branches
5	N E	37˚ 049˚	34' 02'	50.5" 01.2"	It placed after the third trout farm
6	N E	37˚ 049˚	37' 02'	32.2" 25.3"	It placed after a location where the sand was removed

2. Material and Methods

2.1. Selection of the location of sampling

Deinachal River placed near Parehsar in Gilan province. There are three trout farms in the Deinachal River, which have approximately same production capacity. Since, six locations were selected for sampling according to the reasons which were explained in Table 1.

2.2. Evaluation of the physicochemical properties of water

Both temperature and dissolved oxygen (DO) were determined on place with digital thermometer and portable DO meter, respectively. pH was measured with digital pH meter at 25°C (Metrohm, Herisau, Switzerland) and turbidity was measured using turbidmeter (TU-2016, Lutron Electronic, Taiwan) at 25°C and expressed as NTU. Electrical conductivity (EC) was evaluated using portable EC meter and expressed as mS/cm. Nitrate was measured with its absorbance at 410 nm after reaction with brucine in sulfuric acid solution. Biological oxygen demand (BOD5) was calculated with nitrification inhibition method and oxygen consumed in 5 days at 20°C was reported in a BOD incubator. Phosphate was measured with absorbance in spectrophotometer (CAMBDA 25 US/VIS, Perkin Elmer, USA) at 680 nm after sample preparation and expressed as mg/l. Fecal coliform was measured with MPN/100ml method using M-FC medium at 45°C. Chemical oxygen demand (COD) was evaluated with closed reflux method using oxidation with potassium dichromate.

Ammonium was measured with potentiometric method and expressed as mg/l. Nitrite was measured using UV-visible spectrophotometer (CAMBDA 25 US/VIS, Perkin Elmer, USA) and expressed as mg/l. Total hardness was measured using EDTA complexometric titration method. Heavy metals were detected by atomic absorption and total alkalinity was measured using titration with sulfuric acid (APHA, 1989).

2.3. Calculation of the Iran Water Quality Index (IRQWI)

Nine chemical parameters namely, BOD5, dissolved oxygen, total coliforms, nitrate, total hardness, phosphate, turbidity, pH and electrical conductivity, were used to calculate the Iran Water Quality Index (IRQWI) using Eq. 1.

$$IRWQI_{SC} = \left[\prod_{i=1}^{n} I_i^{W_i}\right]^{\frac{1}{\gamma}} \quad (1)$$

in which wi is the weight of parameter i which was shown in Table 2 and Ii is the sub-index of parameter i (between 0-100). γ was calculated according to Eq. 2.

$$\gamma = \sum_{i=1}^{n} W_i \quad (2)$$

Standard curves were used to calculate sub-index for selected chemical parameters according to Figs. 1-4. Water quality can be classified using Iran Water Quality Index (IRQWI) according to Table 3 (Instruction for calculation of Iran Water Quality Index).

Table 2. The weights of selected parameters to calculate IRWQI

Parameter	Weight
BOD	0.117
Dissolved oxygen	0.097
Total coliforms	0.140
Nitrate	0.108
Total hardness	0.059
Phosphate	0.087
Turbidity	0.062
pH	0.051
Electrical conductivity	0.096
COD	0.093
Ammonium	0.090

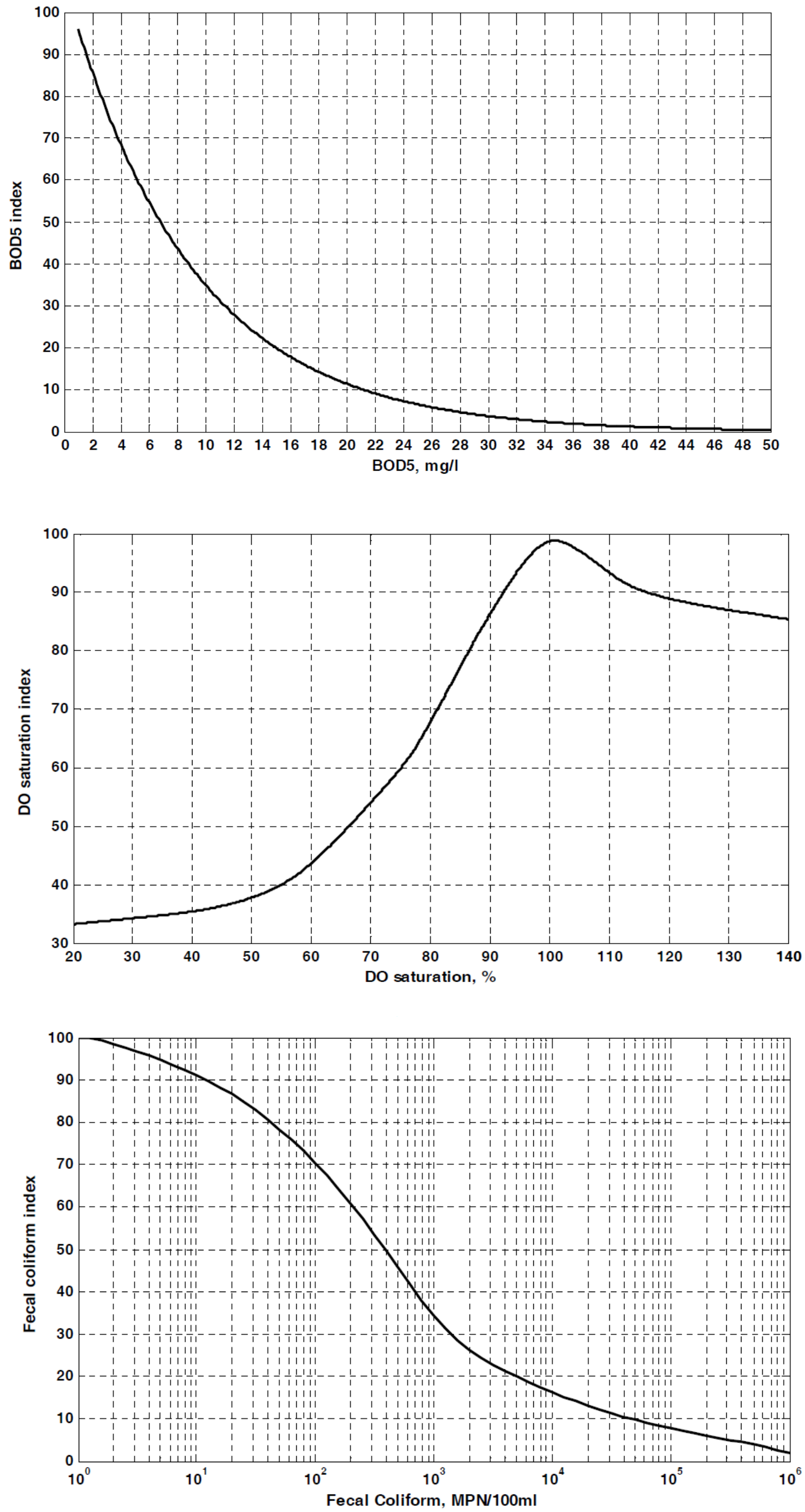

Fig. 1. Standard curves to calculate the sub-index of BOD5, dissolved oxygen and fecal coliform

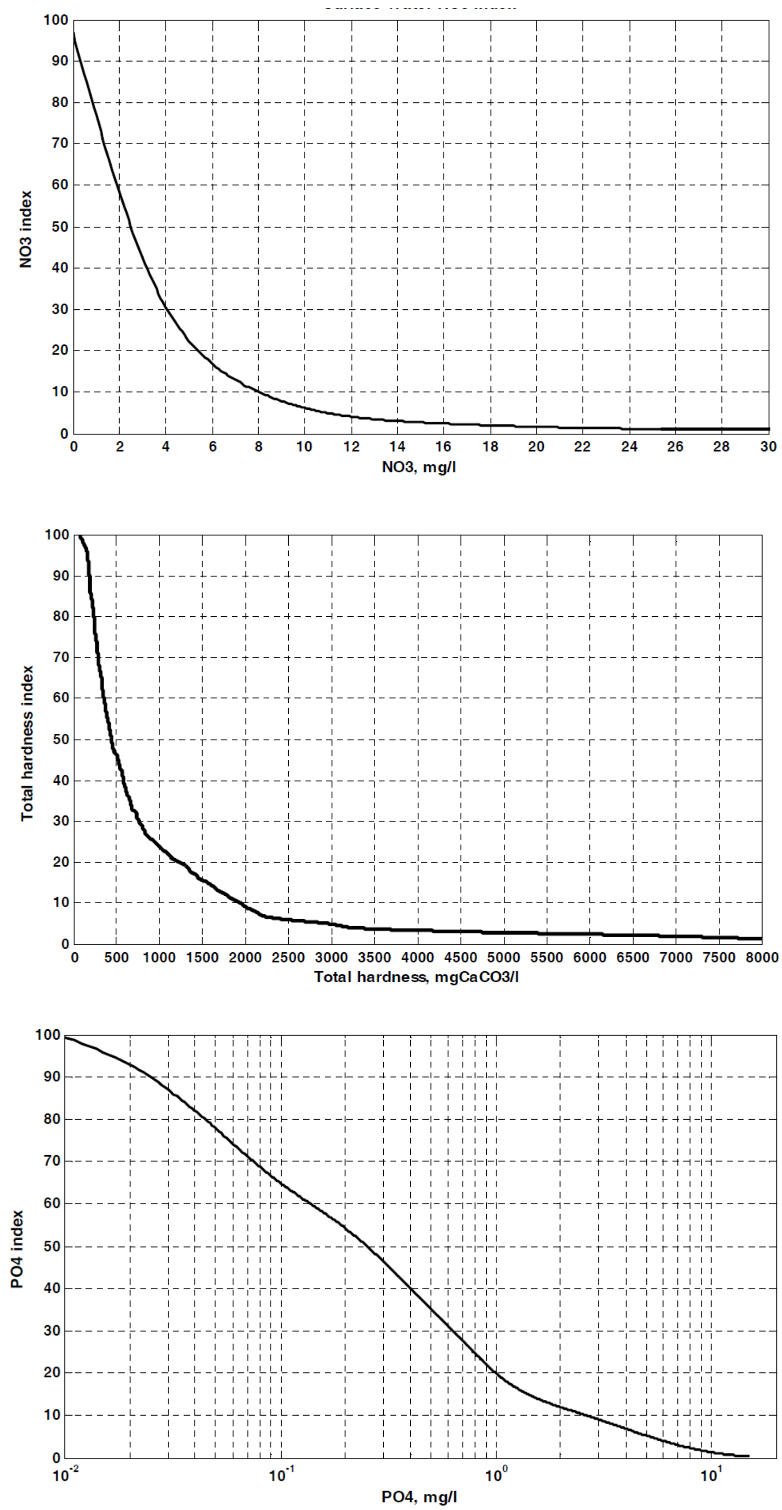

Fig. 2. Standard curves to calculate the sub-index of nitrate, total hardness and phosphate

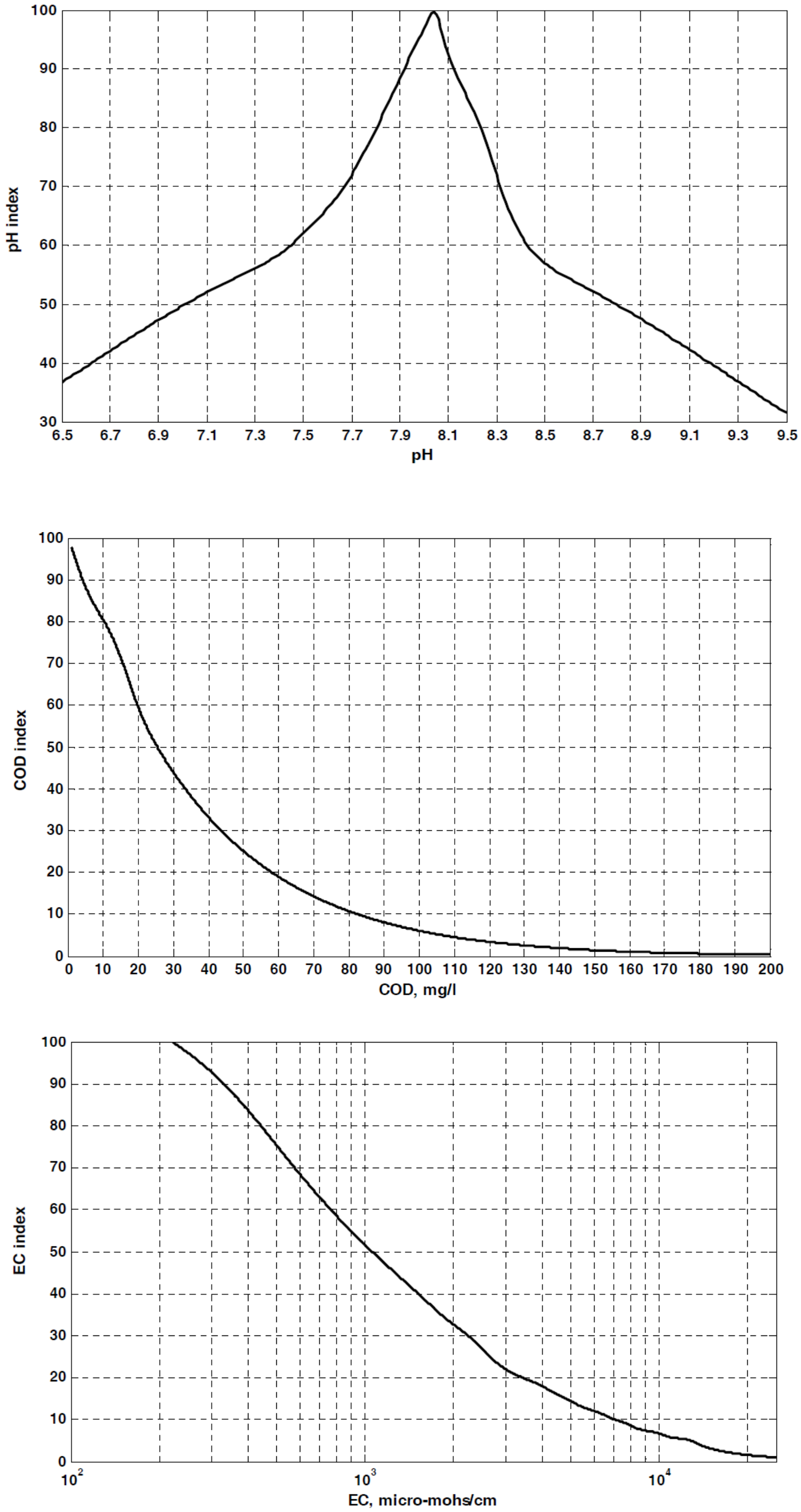

Fig. 3. Standard curves to calculate the sub-index of pH, COD and EC

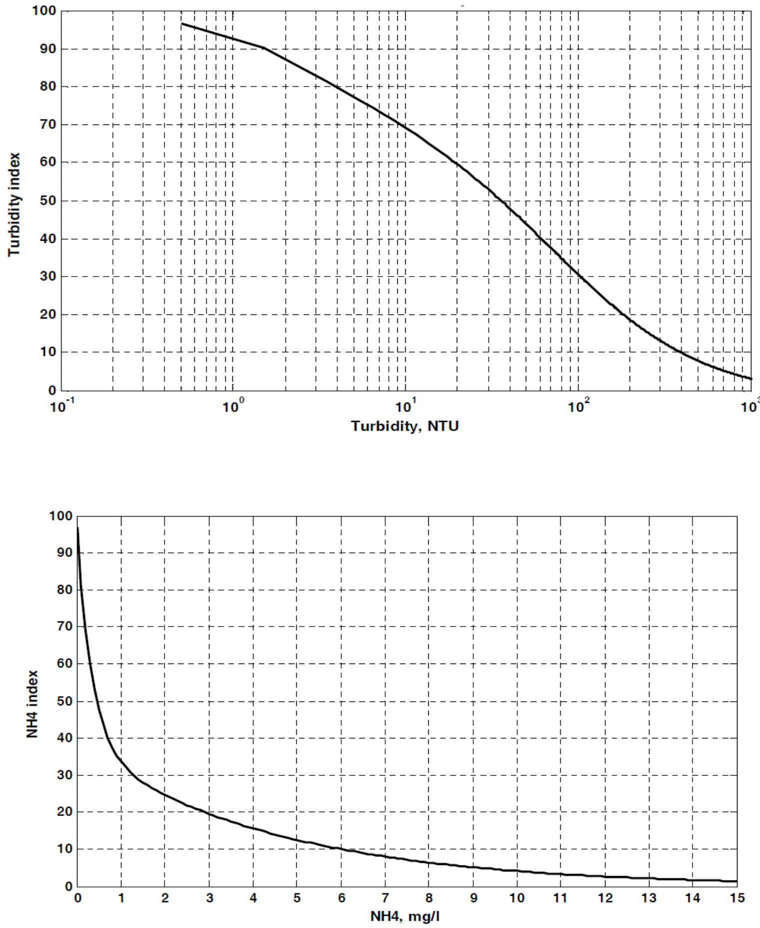

Fig. 4. Standard curves to calculate the sub-index of turbidity and ammonium

3. Results and discussion

3.1. Effect of trout farm on the physicochemical properties of water

Evaluation of total alkalinity showed that first and second trout farms had no effect on total alkalinity of river due to their low capacity; however, third farm increased it. On the other hand, entrance of water from the branch to river had the most important effect on reduction of total alkalinity. Also, domestic wastewater can extensively increase the total alkalinity in river (Table 4).

Evaluation of fecal coliforms showed that domestic wastewater and remove the sand from the river had the most important role on increase the fecal coliforms; however, trout farm did not increase the total fecal coliforms (Table 4). Determination of dissolved oxygen showed that the trout farms increased it and river branches can modify it (Table 4). Evaluation of COD and BOD showed that river branches decreased these parameters and trout farms had no effect on them; however, domestic wastewater and remove the sand can increase the COD (Table 4). Evaluation of calcium and total hardness showed that they gradually increased due to existence the domestic wastewater and remove the sand; however, trout farms did not change these parameters (Table 4). On the other hand, evaluation of magnesium showed that it increased in location number of 5 due to existence of third trout farm or entrance the domestic wastewater (Table 4).

Table 3. Classification of water quality using Iran Water Quality Index (IRQWI)

The value of IRQWI	Class of water quality
Lower than 15	Very poor
15-29.9	Poor
30-44.9	Semi poor
45-55	Average
55.1-70	Semi good
70.1-85	Good
More than 85	Very good

Table 4. The values of physicochemical properties of water in sampling locations

Parameter	Location number					
	1	2	3	4	5	6
Total alkalinity	130	125	120	135	140	155
Fecal coliform (MPN/100ml)	460	120	93	93	43	1100
Dissolved oxygen (mg/l)	5.53	5.76	5.47	5.43	6.28	6.55
COD (mg/l)	21	10>	10>	10>	10>	19
BOD_5	2	2	1	1	1	0
Calcium (ppm)	40	43.2	44.8	46.4	48	56
Magnesium (ppm)	7.73	5.15	5.15	5.15	7.7	5.15
Total hardness (ppm)	124	124	128	132	144	152
EC (µs/cm)	431.5	442.3	473.6	484	459.5	509.5
Turbidity (NTU)	33.47	32.68	24.49	24.11	10.75	31.30
Temperature (˚C)	9.5	9.5	10	10	10.1	10.1
pH	8.27	8.27	8.33	8.33	8.32	8.22
Nitrite (mg/l)	0.06>	0.06>	0.06>	0.06>	0.06>	0.06>
Ammonium (mg/l)	0.06>	0.06>	0.07	0.06>	0.06>	0.07
Nitrate (mg/l)	6.9	7	6.6	6.3	3	5.9
Phosphate (mg/l)	0.7	0.8	0.8	0.9	0.25>	0.8
Chromium (ppb)	100>	100>	100>	100>	100>	100>
Nickel (ppb)	100>	100>	100>	100>	100>	100>
Lead (ppb)	100>	100>	100>	100>	100>	100>
Cadmium (ppb)	100>	100>	100>	100>	100>	100>
Mercury (ppb)	0.05>	0.05>	0.05>	0.05>	0.05>	0.05>

Electrical conductivity had approximately same behavior as total hardness; however, turbidity had a dissimilar behavior before a location where sand was removed. High level of turbidity in first station can be attributed to raining (Table 4). Temperature increased with increase the distance from the mountainous area and pH increased near the residential area due to entry the detergents to river (Table 4). Evaluation of nitrate and phosphate that the sample which was prepared in location number of 5 had the lowest level of these parameters (Table 4). On the other hand, nitrite, ammonium, chromium, nickel, lead, cadmium and mercury had approximately constant level in river and trout farms and domestic wastewater did not affect these parameters (Table 4).

3.2. *Effect of trout farm on Iran Water Quality Index (IRWQI)*

Calculation of Iran Water Quality Index (IRWQI) showed that water quality was in average and semi good classes in different sampling stations of Deinachal River (Table 5). Results showed that trout farms which were in Deinachal River had no negative effect on the water quality. Table 5. Classes of water quality in different stations of sampling in Deinachal river.

In addition, the best water quality can be attributed to sampling location number of 5 where was after third trout farm (Fig.5). It can be attributed to assimilative capacity of river which was caused by different branches which were entered into Deinachal river.

Table 5. Classes of water quality in different stations of sampling in Deinachal River

Station of sampling	Class of water quality
1	Average
2	Average
3	Semi good
4	Semi good
5	Semi good
6	Average

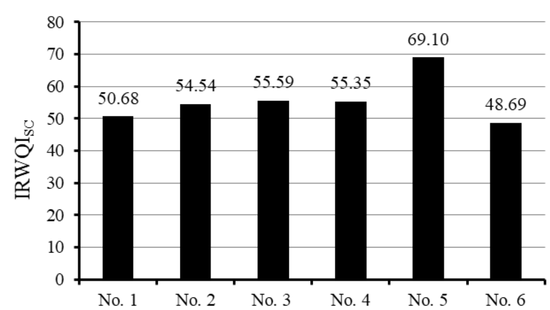

Fig. 3. Values of IRWQI in different sampling locations

4. Conclusion

Evaluation of the water quality in Deinachal River showed that trout farm and domestic wastewater are two main sources of water pollution; however, water quality can be improved after entrance the branches into river. So, increase the number of river branches can improve the water quality after the trout farms. On the other hand, raining can neutralize the negative effect of trout farms on the water quality of river. So, the rivers which are located in rainy region such as Gilan province are proportional area to construct the trout farms due to their assimilative capacity.

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