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The Impact of Rainbow Trout Farm Effluents on Water Physicochemical Properties of Daryasar Stream

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Abstract: In order to study the effect of aquaculture activities in a rainbow trout breeding and cultivation farm on water physicochemical properties of Daryasar Stream (North of Iran), 5 sampling sites were selected inside the stream. The first station located at 35 m before the outlet was selected as the reference station and others were at the distance of 35, 125, 400 and 750 m after the outlet (50 m before the adjacent farm). A 15-day sampling intervals was selected and sampling survey was conducted in summer 2011. Physicochemical parameters including temperature, pH, EC, TDS, turbidity, DO, NO_3, NO_2, TAN and PO_4 were measured. The results showed that farm activities caused no significant changes in physical parameters of the water (P>0.05) while the difference of nitrogen and phosphorous compounds between before and after the outlet was significant (P<0.05). The latter compounds showed increasing trend at stations located near the outlet while indicated a downward trend at other stations implicating self-purification capacity of the stream for the pollutants.

Key words: Aquaculture Effects · Water Pollution · Water Physicochemical Properties · Rainbow Trout · Daryasar

INTRODUCTION

Rainbow trout (*Oncorhynchus mykiss)* is considered as the most important coldwater fish in Iran. The country is regarded as the first and the fifth producer of rainbow fish in Asia and throughout the world, respectively [1]. The production tonnage of this species can fulfill the demand of consumers for white meat and enhance the economic situation of the government. Beyond this development, several detrimental effects on the environment have being left. Most of fish breeding and cultivation systems are relayed on sources to supply nutrients and energy required, thus producing inconsumable energy and waste nutrients. These waste materials as potential contaminants, not only are resulted from human inefficiency in the exploitation of natural resources, but also produced by inevitable processes which are necessary for life maintenance.

In aquaculture systems such as raceway and tank, sewages are discharged into the environment by which a great amount of nutrients and solid matters are accumulated in a receptive area [2]. The deposited food materials and fecal matters removing from fish farming have a key role in water physicochemical and biological changes; particularly when artificial pelted diets are used. The average amount of fecal materials produced is estimated 510 kg solid matter, 108 kg nitrogen and 19 kg phosphorous per each fish production tonnage [3]. The most significant effects of fish farming activities on the receptive stream include increased concentration of dissolved and suspended phosphate, increased content of nitrogenous compounds, reduced dissolved oxygen and accumulation of unsteady matters in the sediment [3-8].

Fish farms are considered as a constant threat for streams in highland areas; in particular at waterless period [9]. During summer season, as fish farming activity, nutrient releasing and temperature are increased, the effect of waste water from farms on stream and its water quality is intensified [3]. As global demand intends to steadily exploit the environment, the governments emphasize on the continuous regulating, control and

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monitoring of the producers to minimize the adverse effects of aquaculture activities [8]. The application of water quality control (physicochemical) as a quick and reliable method is widely used in order to evaluate the aquaculture effects.

MATERIALS AND METHODS

This investigation was performed in Daryasar Stream, one of the head branches of Cheshme-Kile Stream. This stream flows downstream to the west part of Mazandaran Province located in North of Iran. The stream length is approximately 15 km with average substrate slope of 19%. The stream bottom was mainly mountainous and covered with trees [10, 11]. There is no other aquaculture activity in the uppermost study reach. In the present farm, activities like propagation of the fish and broodstock maintenance are often done while rearing of the fish is sometimes performed. During the first and second sampling period of water physicochemical parameters, the production tonnage was 20 (ton) and at subsequent sampling occasion, the production tonnage was reduced to the less than 4 (ton) due to a severe fish mortality by a sudden water flooding. The location of sampling stations at Daryasar Stream is presented in Figure 1.

Station 1 was regarded as the control station. To ensure a complete mixing between stream water and sewage water resulted from the farm, station 2 was considered at distance of 35 m to the last outlet. Station 3, 4 and 5 was at distances of 125m, 400m and 760m to the outlet. Station 5 located in residential area with a few population, was less affected by human impacts. A 15-day sampling intervals was selected and sampling survey was conducted in summer 2011. Water samples were transported in standard condition using plastic containers. Physicochemical parameters including temperature (°C), pH, EC (µS cm^{-1}), Total Dissolved Solids (TDS: mg L^{-1}), turbidity (NTU), DO (ppt), Nitrite (mg L^{-1}), Nitrate (mg L^{-1}), Total Ammonia Nitrogen (TAN: mg L^{-1}) and phosphate (mg l^{-1}) was measured using a Wagtech with digital kits and a photometer (Model: Photometer 7100). For comparison means of water physicochemical properties of Daryasar stream in different stations, we used One-Way ANOVA (*Post Hoc* Duncan) in significant level of $P<0.05$. Analyses did by SPSS 18 software.

RESULTS AND DISCUSSION

Results of physicochemical parameters measurements in Daryasar Stream are presented (Table 1). As indicated,

Fig. 1: Study reach in Daryasar Stream. Stream location of the trout farm and sampling stations (s1, s2, s3, s4 and s5)

Table 1: Physicochemical Properties of different sites in Daryasar Stream water (Mean ± Standard Deviation)

Parameters	S-1	S-2	S-3	S-4	S-5
Temperature (°C)	13.5±2.6	13.4±2.5	13.5±2.5	14.0±2.4	14.3±1.7
EC (µs.cm)	316±6	322±6	323±5	321±6	320±7
TDS (mg/l)	158±2	161±3	160±2	160±3	160±4
Turbidity (NTU)	12.08±3.35	12.33±2.04	13.25±2.52	14.67±2.12	16.85±3.49
Ph (ppt)	8.53±0.24	8.46±0.09	8.47±0.09	8.52±0.10	8.55±0.10
DO (ppt)	9.84±0.05	9.79±0.14	9.75±0.13	9.74±0.07	9.77±0.09
NO_3 (mg/l)	0.569±0.126	0.83±0.131	0.917±0.085*	0.962±0.201*	0.954±0.335*
NO_2 (mg/l)	0.009±0.001	0.019±0.002*	0.022±0.004*	0.016±0.007*	0.019±0.005*
TAN (mg/l)	0.05±0.01	0.45±0.3*	0.44±0.16*	0.28±0.13*	0.22±0.08*
PO_4 (mg/l)	0.04±0.01	0.29±0.05*	0.28±0.05*	0.22±0.04*	0.20±0.02*

*indicates significant difference with the reference station (P<0.05)

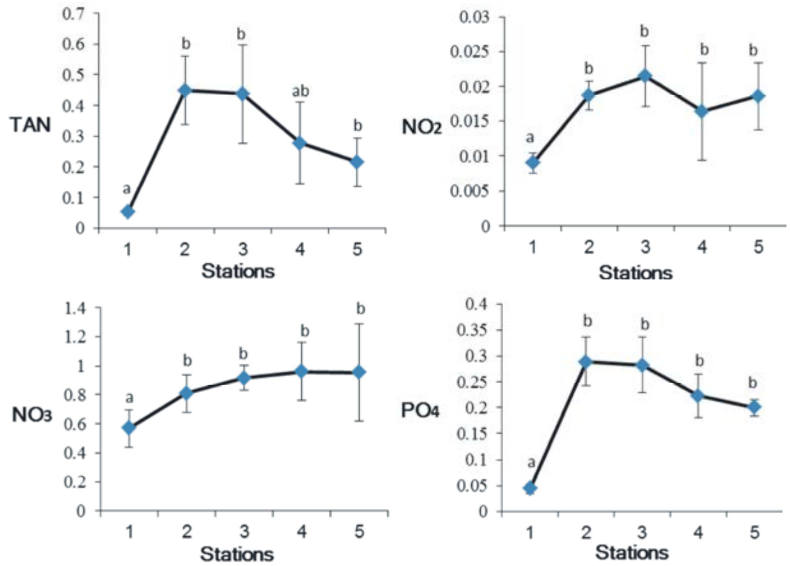

Fig. 2: Changes in nitrogenous and phosphorous compounds in sampling stations of Daryasar stream

parameters including temperature, EC, TDS and pH had no significant changes during the whole sampling occasions. Total amount of dissolved solids differs from a place to place because of natural differences and anthropogenic sources [12]. As the studied stream length is less than 1 km, different sampling stations had similar amounts of TDS content. Thus, aquaculture activity of the aforesaid farm had no effect on this parameter.

pH content did not change among sampling stations due to low production tonnage and agricultural land use ($P>0.05$). Unlike previous researches [3, 5, 6], as the distance to the outlet of the farm got further turbidity showed an increasing trend but no significant changes were observed between most stations with the control station ($P>0.05$). This suggests that farm activities had no impact on increasing turbidity level. Therefore other factors should be investigated to reveal the cause of increased turbidity. Road preparation near the study reach might make the stream walls unsteady which would increase the turbidity level in stations located downstream. Considering the unchanged DO content amongst different stations, it should be noted that DO level in fish farms is correlated with fish biomass, feeding frequency and amount of feeding diets [8, 13].

No sign of decreasing DO level was observed because of low production tonnage, agricultural land use (broodstock preservation in low density) and passing farm effluent through stairs (about 50 m length), thus there were no significant changes in DO contents at various stations (Table 1). pH content detected no significant differences amongst stations due to the above mentioned factors. pH is of great importance in water quality of the fish farms. Decreased pH might cause a reduction in species diversity and richness [12, 14, 15]. Furthermore, pH level may affect water quality changes like conversion of ammonium to ammonia [3, 12]. Ionized form of ammonia, ammonium, is less toxic than un-ionized form (NH_3).

At first stage, dominant form of ammonia nitrogen either in ionized or un-ionized form is dependent on pH. Each one-unit change in the pH scale corresponds to a ten-fold change in this ratio [13]. In our survey, total ammonia nitrogen contents at stations 2-5 were higher than station 1 (reference station) and indicated a significant change. The highest level of ammonia nitrogen was found at stations 2 and 3 (Fig. 2) while it showed a decreasing trend at subsequent stations, implicating self-purification and the role of nitrification process to convert ammonia nitrogen into nitrite (NO_2) and nitrate (NO_3). Ammoniac, as the final product of protein catabolism, results from decomposition of fecal matters, urine and unconsumed food materials as well as excretion from the fish gills [13].

Acceptable limit of un-ionized ammonia in trout farming is 1.1-1.16 mg/l. according to the standard reference data for ammonium to un-ionized ammoniac ratio at different temperatures and pH and with regard to mean temperature and pH in the present study reach (T: 14°C and pH: 8.5), un-ionized ammonia comprises about 7% of total ammonia nitrogen reported here [14] which is at safe limit. Likewise, phosphate compounds indicated first an increasing trend and then decreased.

Decreased ammonia and phosphorous concentrations far from the farm outlet (Fig. 2) might be attributed to their absorption by littoral plants and mosses and biological conversion of ammonia to nitrite and nitrate by nitrification process as well. Dissolved orthophosphate is considered as an available nutrient for plants [13, 14]. Nitrite and nitrate contents increased as distance to the farm outlet got further which might be due to nitrification process. Increased level of nitrite and nitrate as the intermediate and final product of nitrification process, respectively, as well as increased concentrations of phosphate and ammonia nitrogen, altogether resulting from aquaculture activities have been previously proved by many researchers [3-8, 16].

Nitrite, an intermediate compund in nitrification process, is un-ionized form of nitrose acid (HNO_2) and highlighted as a dangerous and fetal compound as much as ammoniac [15]. This can cause undesirable effects on aquatic organisms. Fortunately, the concentration of this unstable compound increases rarely in fish farms. Due to low production tonnage, desirable management and regarding to the standards for effluent discharge, this parameter showed an idealistic level. However, aquaculture activities of the studied farm had a positive and significant effect on nitrite changes in Daryasar Stream.

Lawson (1995) estimated the acceptable limits of nitrite, nitrate and ammonia in trout farm to 0.19-0.39 (mg/l), 1.36 (mg/l) and 0.5-0.7 (mg/l), respectively. Owing to the low production tonnage, situation of the discharging the effluents and standard management level, the aforsaid measurements were at desirable level. According to the rules established by the government (environmental organization), the allowable limits of discharging ammonia, nitrate, nitrite and phosphate to the surface waters were 2.5, 50, 10 and 6 (mg/l) [17]. In the present farm, these elements were discharged at less than the mentiond limits from the trout farm into the stream.

CONCLUSION

Farm activities caused no significant differences in water physical parameters while nitrogenous and phosphorous compounds detected significant differences between before and after the outlet of the farm. These compounds showed an increasing trend at stations located near the outlet while indicated a decreasing trend afterwards implicating the capability of the stream in self-purification of the pollutants.

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