Growth performance of rainbow trout (*Oncorhynchus mykiss*) with respect to nutritional factors in north Iran (Haraz River)

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Abstract

Monthly samples of six fish farms from January 2010 to December 2010 in the northern Iran, Haraz River, were used to determine relationship between chemical parameters of main water, inlet and outlet and their effects on fish growth and production. Results revealed that concentration of nutrients in outlet was more than that of inlet of farms and statistical analysis showed that there were significant differences between stations (p<0.05). The amount of phosphate in upstream farms was lower than that of downstream. There was statistically significant difference between nitrite nitrates, concentrations in different months. Total sulphide, phosphate and ammonium in inlets were 0.002±0.009 (mg/l), 0.215±0.113 (mg/l) and 0.022±0.018 (mg/l) respectively. In outlets there was 0.003±0.009 mg/l sulphide, 0.302±0.193 mg/l phosphate and 0.037±0.026 mg/l ammonium. Ammonium concentration, showed no significant difference (p>0.05) in different months Correlation between daily growth, SGR, FCR, production and chemical parameters of water were analyzed by Pearson Correlation. The results revealed negative correlation (α= 0.01) between nitrite and daily growth (p=0.004, Pearson Correlation=-0.24), ammonium and SGR (p=0.0001, Pearson Correlation=-0.272), although there were no correlation for FCR, and nutritional parameters (p>0.05).

Keywords: Rainbow trout, Growth, Haraz, Production.

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Introduction

Since 2006, fifty six countries produced freshwater salmonids, which was concentrated in Europe (50%) and Asia (33%) (FAO, 2008). Freshwater salmonid production in Europe peaked in the 1990s, yet it showed increasing production trends in Asia, South America and North America for the period 1990–2006 ($p<0.05$) (FAO, 2008).

Iran was the largest producer in freshwater in 2008. Other major producing countries are including Italy, France, Norway, Spain, Germany, Denmark (FAO, 2008). As Rosenthal (1994) reported, the quantity and quality of effluents from freshwater land-based salmonid farms were different among production systems and is affected by treatment processes prior to discharge. Haraz River originates from Alborz mountains' ranges and flows into the Southern coasts of the Caspian Sea. Haraz River has over 137 kilometers length and the average bed slope is 2 percent (Army Geographical Organization of Iran, 2003). The outlet nutrients, biochemical oxygen demand (BOD) and suspended solids in effluents can thus vary as a function of feed quality, feeding strategy, time (e.g. daily and annual cycles) and location (e.g. latitude) (Tello *et al*., 2009).

Numerous studies attempted to explain concentration of ammonium, BOD, sulphides and content of output waters from trout farms in relation to stocking density and growth (e.g. Cripps, 1995; Hennessy *et al*., 1996; Viadero *et al*., 2005; Brinker and Rosch, 2005). The presence of pathogens and chemical residues was studied by Smith *et al*. (1994), Lalumera *et al*. (2004), Rose and Pedersen (2005). Cripps and Bergheim (2000) and Piedrahita (2003) stated that aquaculture wastes could be divided into solids and dissolved wastes, particularly carbon, nitrogen and phosphate.

Varedi *et al*. (2007) measured phosphate's extent of three rainbow trout farms on Haraz River. The results showed upstream farms have increasingly significant effect on downstream farms and these changes arised from farm's distance, production, quality and quantity of feeding. Also BOD_5 of inlet and outlet of rainbow trout farms on Haraz River was measured by Varedi and Nasrollahzadeh-(2009). Amounts of BOD_5 were 0.3mg/l and 7.81 mg/l for farm 1 inlet and outlet, 0.3 mg/l and 5 mg/l for farm 2 inlet and outlet, 1.8 mg/l and 6.4 mg/l for farm 3 inlet and outlet. Decreasing BOD_5 is related to wet food usage in some farms (Varedi *et al*., 2007).

Environmental impact of nutrients discharged by aquaculture wastes on Haraz River is studied. The results showed that the excreted wastes by fish did not increase nitrate and nitrite concentrations at the releasing point, but a remarkable reduction in phosphorous content was observed in the outlet water in comparison to upstream farms, also chemical oxygen demand (COD) and BOD were consistently higher for down steam farms (Amirkolaie, 2008).

Considering increasing demand for establishing rainbow trout farms along

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Haraz River in north Iran and existent farms and their relatively short distances from each other, quality and quantity of fish food and methods of feeding management, the present study was undertaken to examine impact of important nutritional parameters in inlet and outlet water on fish growth and production performance.

Materials and methods

Site map

The study was carried out in inlet and outlet of six farms for rainbow trout (*Oncorhynchus mykiss*) along Haraz River during 12 months, between January 2010 and December 2010 (Table 1). The location of stations is shown in Fig. 1.

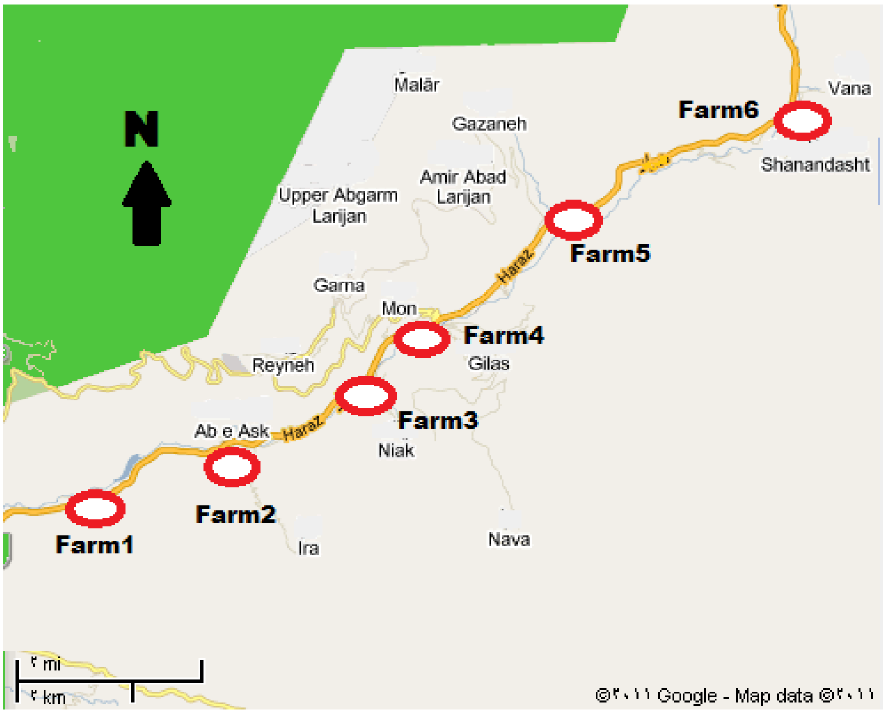

Figure 1: Map of sampling sites in Haraz River, IRAN (Google Earth, 2011).

The first farm out of 6 sampled farms was located at the highest altitude with 1860 m height at the inlet and the sixth farm with 1390 m was placed at the lowest altitude. The most distant were the farms 5 and 6, with 7.9km, and the least distant were the farms 3 and 4, with 1.06 km (Table 1).

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Table 1: UTM (Universal Transverse Mercator), Geographical information of stations.

Name of region	Station	X	Y	Height in inlet (m)	Distance with previous farm upstream*(km)
Abask	Farm 1	E52 07 47.5	N35 51 40.7	1860	-
Abask	Farm 2	E52 09 37.5	N35 52 11.4	1750	3.32
Nyak	Farm 3	E52 10 53.1	N35 52 39.7	1692	2.17
Gazanak	Farm 4	E52 11 26.9	N35 53 05.6	1667	1.06
Gazanak	Farm 5	E52 12 41.6	N35 53 39.4	1610	2.22
Vana	Farm 6	E52 15 59.5	N35 55 57.0	1390	7.9

*Distance was measured along river.

Sampling

Water quality parameters were measured monthly from inlet and outlet of the six farms. Concentration of nutrients (e.g. nitrite, nitrate, ammonium, sulphide and phosphate) were measured by a digital portable spectrophotometer (400-560 nm).

Farm productions were estimated using a questionnaire in each farm. fish growths were measured with a digital balance sheet. Weight Gain (WG), daily growth in each month, Specific Growth Rate (SGR) and Feed Conversion Rate (FCR) were calculated as below (Nafisi, 2010).

Weight Gain(g) = Initial average weight (g) - Final average weight (g)

Daily Growth in each month =Weight Gain (g) in each month ÷ 30day

SGR = (Ln Final average weight - Ln Initial average weight) ÷ 30day

Ln: Napierian logarithm

FCR= Total fish food consumption (Ton) ÷ Total fish production (Ton)

Statistical analyses were performed using SPSS 17. Analysis of variance was used to identify significant differences between nutritional parameters of waters of inlet and outlet in different farms. Correlation analysis was used to identify relationship between biological indices and concentration of nutrients.

Results

The average nutrients of each farm are shown in Table 2. Maximum concentration of nitrite was observed in farm 6 (inlet and outlet). Farm 1 had the lowest nitrite concentration (inlet and outlet). Comparison between Inlet and outlet showed that outlet waters had more nitrite than inlets (Fig. 2).

Table 2: Average nutrient concentrations measured at the 12 stations (Standard Deviations).

Farm	station	Nitrite (mg/l)	Nitrate (mg/l)	Ammonium (mg/l)	Sulphide (mg/l)	Phosphate (mg/l)
Farm 1	inlet	0.002 ±0.002	2.411 ±0.423	0.022 ±0.018	0.002 ±0.009	0.215 ±0.113
	outlet	0.006 ±0.005	2.405 ±0.620	0.037 ±0.026	0.003 ±0.009	0.302 ±0.193
Farm 2	inlet	0.036 ±0.022	2.799 ±0.367	0.030 ±0.019	0.002 ±0.006	0.200 ±0.079
	outlet	0.041 ±0.024	2.744 ±0.870	0.116 ±0.085	0.007 ±0.010	0.312 ±0.139
Farm 3	inlet	0.051 ±0.035	2.834 ±0.563	0.062 ±0.015	0.000 ±0.00	0.22 ±0.107
	outlet	0.059 ±0.036	2.912 ±0.622	0.164 ±0.064	0.001 ±0.003	0.226 ±0.110
Farm 4	inlet	0.056 ±0.022	2.812 ±0.172	0.102 ±0.045	0.001 ±0.003	0.137 ±0.062
	outlet	0.069 ±0.024	2.782 ±0.698	0.173 ±0.067	0.005 ±0.008	0.264 ±0.070
Farm 5	inlet	0.074 ±0.008	3.119 ±0.288	0.149 ±0.136	0.000 ±0.000	0.241 ±0.132
	outlet	0.078 ±0.023	3.141 ±0.368	0.314 ±0.183	0.000 ±0.000	0.220 ±0.049
Farm 6	inlet	0.104 ±0.070	3.160 ±0.254	0.196 ±0.067	0.005 ±0.008	0.248 ±0.064
	outlet	0.123 ±0.081	3.147 ±0.377	0.294 ±0.100	0.011 ±0.010	0.260±0.074
N		144	144	144	144	144

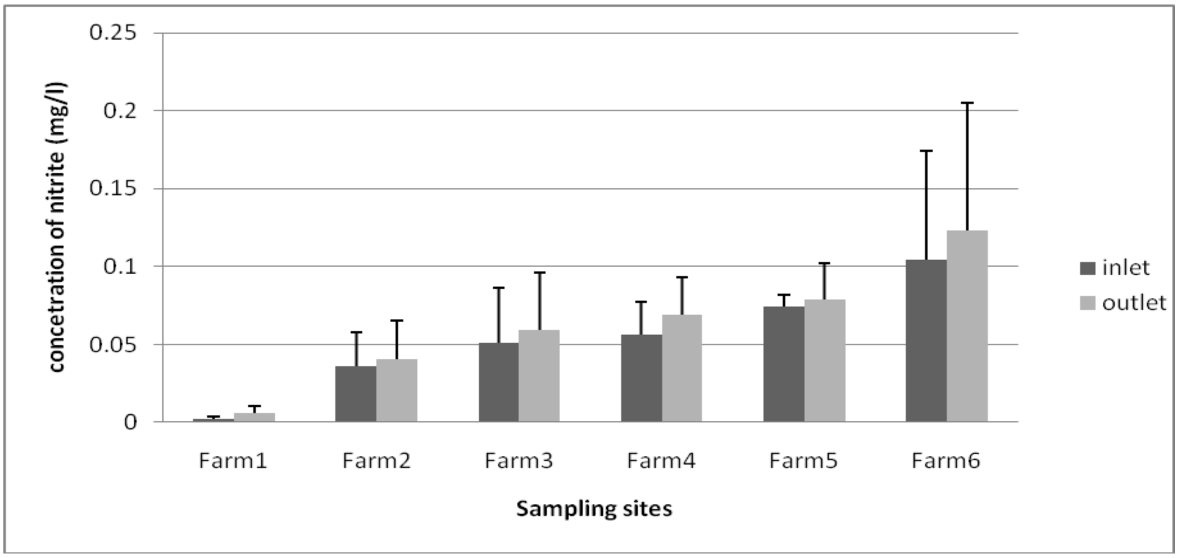

Figure 2: Mean nitrite concentrations in inlet and outlet of the six farms (±SE).

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Concentration of nitrate of downstream farms was more than that of upstream farms. In farms 1, 2, 4 and 6, concentration of nitrate was more in the inlet than the outlet, but they were close (Fig. 3).

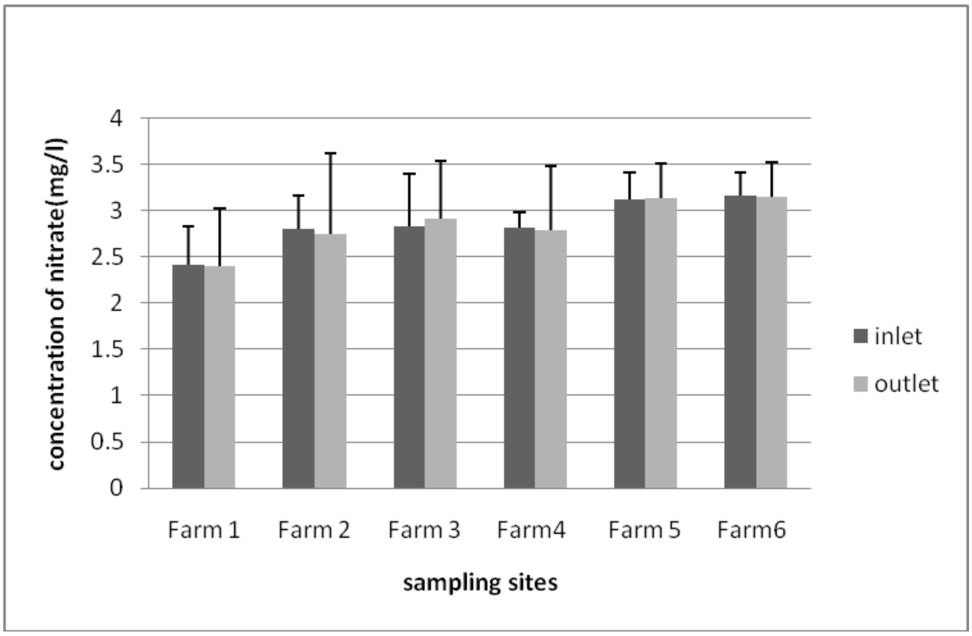

Figure 3: Mean nitrate concentrations in inlet and outlet of the six farms (error bars show standard deviations).

Farm 1 had the lowest ammonium concentration (inlet and outlet). Inlet and outlet mean comparisons showed that the outlets were higher in concentrations than the inlets (Fig. 4). The maximum concentration of ammonium was observed in outlet of farm 5.

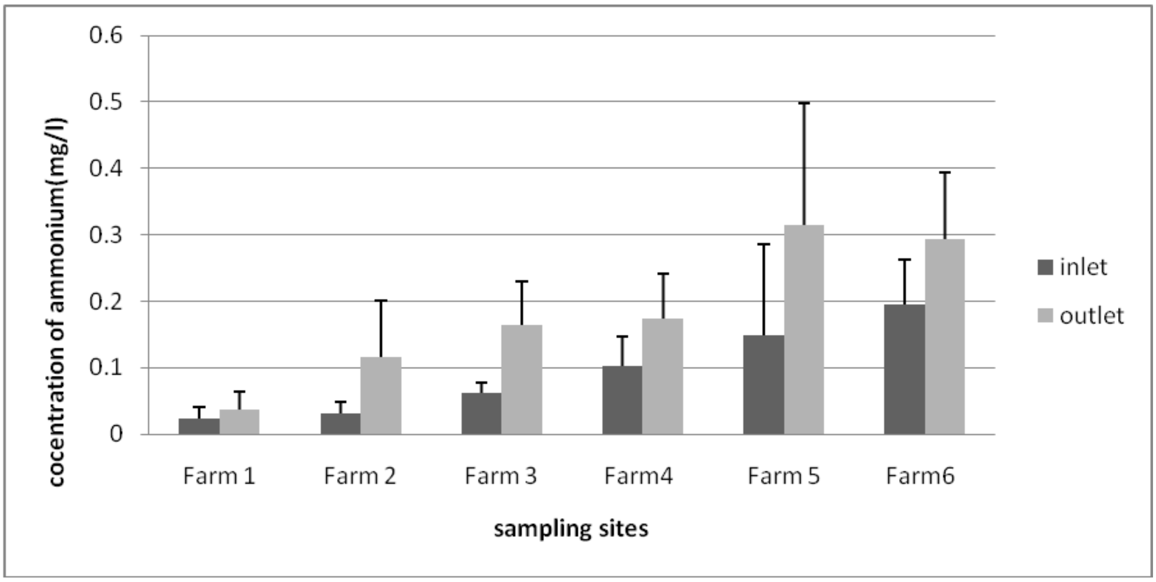

Figure 4: Mean ammonium concentrations in inlet and outlet of the six farms (±SE).

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Although sulphide concentration was zero in inlet and outlet of farm 5 and inlet of farm 3, but Fig. 5 shows an obvious increase in the outlets of farms 2 and 6.

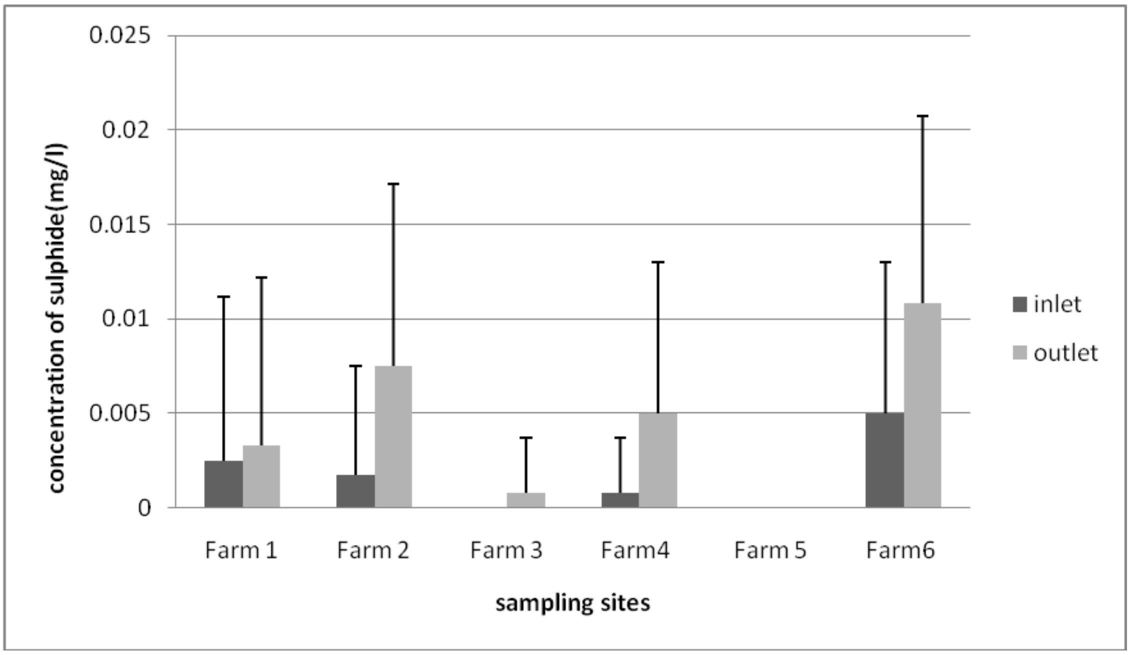

Figure 5: Mean sulphide concentrations in inlet and outlet of the six farms (±SE).

Surprisingly the maximum concentration of phosphate was observed in outlet of farms 1 and 2 (upstream farms). The minimum phosphate concentration was observed at inlet of farm 4. Comparison of mean phosphate concentrations in inlets and outlets showed that, inlet of farm 5 was more concentrated than the other inlets and the outlets (Fig. 6).

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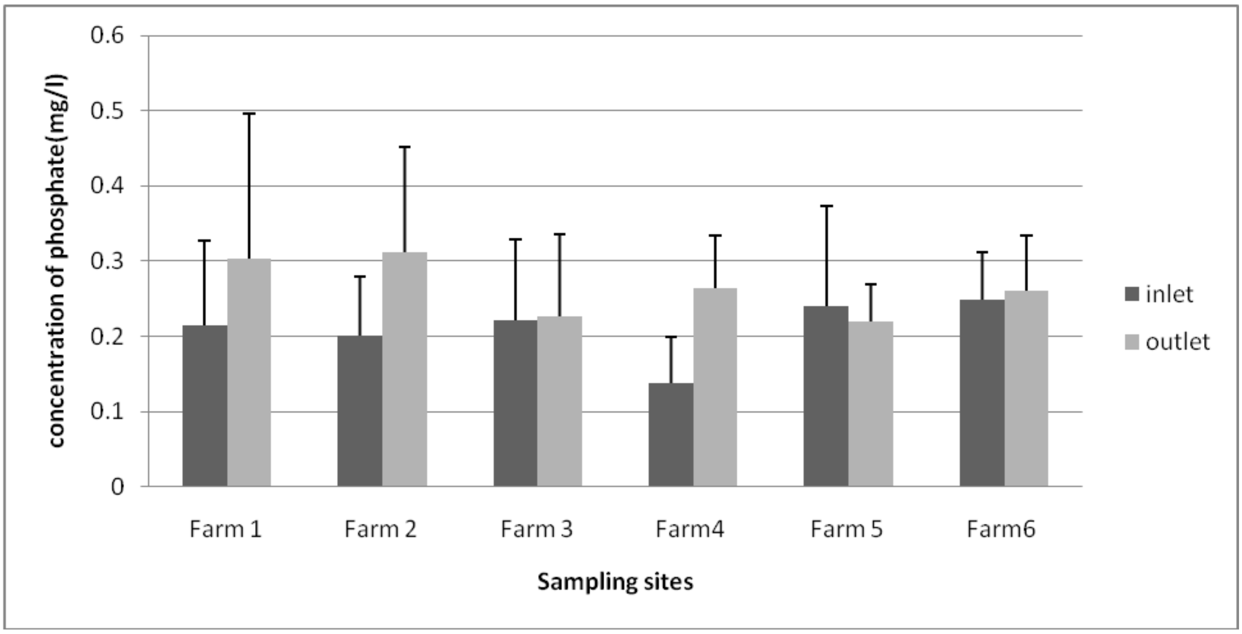

Figure 6: Mean phosphate concentrations in inlet and outlet of the six farms (±SE).

Although farm 2 had the most condensed sulphide and phosphate, but the maximum concentrations of nutrients were observed in the inlet and outlet of farm 6.

Also according to the changes in nutrient in different months, the result of averages are compared (Table 3). As for nitrite and sulphide results, the maximum concentration was observed in August. The concentration of nitrate increased in June. Ammonium and phosphate had similar results and they had the maximum concentration in July. As Table 3 shows, there was no sulphide in March and April. An overview on the concentrations of parameters from month 1 to 12 revealed that the maximums were observed in June, July, and August.

Table 3: Mean nutrients measured at the 12 stations in 12 months (Standard Deviations)

month	**Nitrite (mg/l)**	**Nitrate (mg/l)**	**Ammonium (mg/l)**	**Sulphide (mg/l)**	**Phosphate (mg/l)**
January	0.049 ±0.031	2.505 ±0.415	0.133 ±0.093	0.001 ±0.003	0.257 ±0.063
February	0.056 ±0.033	2.451 ±0.806	0.137 ±0.097	0.004 ±0.010	0.266 ±0.093
March	0.049 ±0.027	2.847±±0.319	0.132 ±0.090	0.000 ±0.000	0.254 ±0.076
April	0.033 ±0.020	2.977 ±0.288	0.140±0.150	0.000 ±0.000	0.197 ±0.076
May	0.029 ±0.019	3.064 ±0.380	0.138 ±0.148	0.002 ±0.006	0.222 ±0.126
June	0.039 ±0.024	3.178 ±0.329	0.136 ±0.127	0.002 ±0.006	0.219 ±0.125
July	0.041 ±0.036	2.953 ±0.366	0.202 ±0.190	0.002 ±0.006	0.340 ±0.218
August	0.092 ±0.108	2.617 ±0.751	0.166 ±0.138	0.009 ±0.012	0.269 ±0.135
September	0.081 ±0.048	3.062 ±0.515	0.137 ±0.099	0.005 ±0.008	0.195 ±0.056
October	0.080 ±0.048	2.917 ±0.488	0.127 ±0.132	0.006±0.008	0.187±0.046
November	0.076 ±0.046	3.197 ±0.557	0.127 ±0.103	0.006 ±0.009	0.212 ±0.076
December	0.076 ±0.051	2.497 ±0.524	0.082 ±0.104	0.002 ±0.004	0.231 ±0.092
Total mean	0.058 ±0.050	2.856 ±0.549	0.138 ±0.124	0.003 ±0.007	0.237 ±0.112

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There were statistically significant differences between nitrite ($p \leq 0.001$), nitrate ($p=0.001$), ammonium ($p \leq 0.001$), sulphide ($p \leq 0.001$), phosphate ($p=0.012$) concentrations in inlet and outlet of the 6 farms ($p<0.05$).

For ammonium there was no significant difference ($p=0.855$), but there were statistically significant difference between nitrite ($p=0.002$), nitrate ($p \leq 0.001$), sulphide ($p=0.048$), phosphate ($p=0.047$) concentrations in different months.

Comparison among the average values measured in the 12 stations and acceptance threshold for culturing rainbow trout (Table 4) was carried out by analysis of One-Sample T-test. There were significant differences between nitrite ($p \leq 0.001$), nitrate ($p=0.002$), ammonium ($p \leq 0.001$), sulphide ($p=0.002$), phosphate ($p \leq 0.001$) concentrations and acceptance threshold for culturing rainbow trout.

Table 4: Comparison among average nutrient concentrations and acceptance threshold for culturing rainbow trout (Standard Deviations).

Nutrients	Nitrite (mg/l)	Nitrate (mg/l)	Ammonium (mg/l)	Sulphide (mg/l)	Phosphate (mg/l)
Average at the inlet	0.054 (0.008)	2.856 (0.344)	0.094 (0.050)	0.002 (0.004)	0.237 (0.093)
Average at the outlet	0.063 (0.009)	2.855 (0.592)	0.183 (0.088)	0.005 (0.007)	0.264 (0.106)
acceptance threshold for culturing rainbow trout	<0.025 mg/l * 0.39**	<3 mg/l *	<1 mg/l *	<.0.002*** <0.003**	<0.1*

*(Gavine et al., 2006), **(Nafisi, 2010)

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Growth indices were measured for estimating correlation and linear relationship between concentration of nutrients and growth biological indices (Table 5).

Table 5: Results of growth and production of the 6 farms (Standard Deviations).

	Weight Gain in each month (g)	Daily growth (g)	SGR	FCR	Total production for 12 month (ton)
Farm 1	463.33±200.536	15.4250±6.68693	0.077333±.0159909	1.9158±.15427	279.30
Farm 2	308.75±94.481	10.2900±3.14971	0.107750±.0301853	1.3675±0.23130	155. 01
Farm 3	303.33±227.360	10.1050±7.57801	0.053675±.0241153	1.8350±.14923	169.16
Farm4	372.17±119.494	12.4008±3.98305	0.135417±.0517073	1.4125±.06595	384.00
Farm 5	397.33±122.853	13.2150±4.11551	0.197333±.0080793	1.1883±.07551	294.50
Farm6	372.50±65.955	12.4117±2.19578	0.102500±.0232659	2.0275±.02090	210.50
Total	369.57±156.864	12.3079±5.22926	0.112335±.0539782	1.6244±.34234	1492.47

Correlation between daily growth, SGR, FCR, production and chemical parameters of water were analyzed by SPSS and Pearson Correlation. The results revealed that there were negative correlation (at the 0.01 level) between nitrite and daily growth (p=0.004, Pearson Correlation=-0.24), ammonium and SGR (p=0.0001, Pearson Correlation=-0.272), but for FCR and production and chemical parameters there was no correlation (p>0.05).

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Table 6: Correlation between Biological indices and concentration of nutrients.

		Nitrite	nitrate	ammonium	sulphide	Phosphate
Daily Growth	Pearson Correlation	-0.240*	-0.130	-0.119	-0.082	0.075
	Sig. (2-tailed)	0.004	0.120	0.156	0.327	0.371
	N	144	144	144	144	144
SGR	Pearson Correlation	0.145	0.085	0.272*	-0.116	0.032
	Sig. (2-tailed)	0.082	.309	0.001	0.166	0.702
	N	144	144	144	144	144
FCR	Pearson Correlation	-0.036	-0.069	-0.031	0.117	0.058
	Sig. (2-tailed)	0.670	0.411	0.708	0.164	0.493
	N	144	144	144	144	144
Production	Pearson Correlation	0.063	-0.065	0.086	-0.129	0.045
	Sig. (2-tailed)	0.452	0440	0.307	0.123	0.590
	N	144	144	144	144	144

*Correlation is significant at the 0.01 level (2-tailed).

Results revealed that there was no significant linear relationship between daily growth, FCR and production and chemical parameters (p>0.05), but there was a significant linear relationship between SGR and chemical parameters (p=0.006). Correlation of coefficient of ammonium and sulphide were significant for SGR (p<0.05).

Discussion

Freshwater salmonid aquaculture can be a relevant source of anthropogenic pollutions (such as waste materials and drug residuals) to otherwise undisturbed stream ecosystems, particularly when aquaculture operations are located in the headwaters of river networks (Tello, 2009).

The main components of land-based salmonid farm effluents that can cause adverse effects on stream ecosystems are nutrients (mainly nitrogen and phosphorus), biochemical oxygen demand (BOD), suspended solids (SS), pathogens and chemical residues (Rose and Pedersen, 2005).

The results showed, concentrations of nutrients in outlet were more than those of inlet of farms and there were significant differences between concentrations of nutrients in twelve stations (p<0.05). Also results of one way ANOVA (LSD Test) revealed significant differences between farm 6 (downstream) and upstream farms (farms 1, 2, 3, 4 for nitrite and ammonium, farms 1, 2 for nitrate) (p<0.05), where there are the most number of rainbow trout farms (7 farms). Although the distance between farms 6 and 7 was 7.9 km, but excretion of farms affected the concentrations of nutrients.

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With the exception of phosphate, upstream farms had higher values than upstream farms. There are many restaurants and residential buildings before farm 1 in upstream, and the ratio of soluble to particulate phosphorus is also negatively correlated with temperature in the range 4–13 C.

There was no significant difference for ammonium (p>0.05) in different months. The results showed that the concentrations of nutrients were increased in June, July and August, where temperature was increased and decreased flow rate of water.

Farmers changed strategy for available biomass and production, so they release and harvest fish in different size. There was no correlation between FCR and production (p>0.05). Smolt farm effluents are extremely variable over daily and annual cycles, with much of the variation being related to the life-stage of the stocked fish (Hennessy *et al*., 1996).

Capacity of absorption of nutrients relate to depth, region topography, flow rate of water, whereas concentration of releasing nutrients relate to management performance (Carroll *et al*., 2003).

According to the results there were many nutritional factors that affected trout farms in Haraz River. Also there were significant differences between inlet and outlet water in all farms that may affect the growth performance and total production in that area, but still conclusive discussions may need supplementary studies.

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