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Environmental Impact of Nutrient Discharged by Aquaculture Waste Water on the Haraz River

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Abstract: The aim of this study is to assess the effect of aquaculture waste water on water quality of the receiving ecosystem. Vana rainbow trout farm was selected as a site of the study. There were four sampling stations around the fish farm along the Haraze river (200 m before and 200 m after farm, inlet and outlet of the farm) for water quality measurements. Waste excreted by fish did not increase nitrate and nitrite concentration at the releasing point but surprisingly a reduced phosphorous content was observed for the outlet water in comparison to station 1. Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD) were consistently higher for station 3 where waste water was released. However, the organic matter discharged was reduced in fall compared to winter. In conclusion fish farm effluent contains pollutant that can affect river water quality. However the pollutants magnitudes are too low to put a significant impact on the river ecosystem.

Key words: Aquaculture, water quality, nutrients, river, waste water, environment

INTRODUCTION

Aquaculture has been showing a tremendous growth during past decades (FAO, 2004). Fish produced by farming activities currently accounts for over one third of all fish directly consumed by human (FAO, 2004). This huge growth resulted in competition for natural resources (i.e., land and water; Piedrahita, 2003) and consequently intensification of aquaculture system and environmental problems (Pillay, 2004). Since inland aquaculture contributes to 70% of total global fish production (FAO, 2004; Santos Simoes *et al*., 2008), the environmental problem related to the increased production in land-based aquaculture system is going to be more serious.

Aquaculture similar to other animal production system generates waste. The amount and quantity of waste depends on production system and feed quality (Cho and Bureau, 1997). Aquaculture waste can be divided into solid and dissolved waste, particularly carbon, nitrogen and phosphorous (Cripps and Bergheim, 2000; Piedrahita, 2003). Solid waste mainly originates from uneaten and/or spilled feed by the fish and from the feces. Dissolved waste is coming mostly from metabolites excreted by fish (through gill and urine). Accumulation of these pollutants deteriorates water quality in the system (Amirkolaie *et al*., 2005) and can increase the incidence of disease in fish (Liltved and Cripps, 1999). In order to maintain a better water quality in aquaculture system, waste has to be discharged with effluent water.

Discharge of aquaculture waste forms a major environmental concern because they can cause eutrophication of receiving water such as lakes and rivers (Cripps and Bergheim, 2000). Solid waste by settling to the sediment has a negative impact on the benthic ecosystem of river and lake (Gowen *et al*., 1991). As the production of fresh water aquaculture particularly flow through system continue to rise, the effluent control discharged from these farm going to be a challenge facing further aquaculture development (Bergheim and Brinker, 2003). This condition led to the regulation of strict measures by some European country such as Denmark, Germany and Netherlands in order to limit pollutants discharge into the river (Pillay, 2004).

Moreover, public concern about the environmental pollution are putting increasing pressure on fish farm to threat their waste water before release. However there is still a debate over the magnitude of aquaculture waste and its role in aquatic ecosystems destruction. Therefore the main objective of the study is to determine the impact of waste water released by aquaculture farm on water quality of receiving ecosystem.

MATERIALS AND METHODS

Site Introduction

Hraze river originates from Alborz mountain ranges and flows into the Southern coast of the Caspian sea. Due to appropriate water, there are an increasing number of rainbow trout (*Oncorhynchus mykiss*) farm throughout the bank of the river. Vana farm (one of few big fish farms available at the region) selected as a sampling site and sampling stations were placed on the bank of the river. This farm receives water flow of surface water from the Haraze river and is a flow through rainbow aquaculture system with production of about 100 ton per year. The study lasted for six months between September 2006 and February 2007.

Sampling Procedure

There were totally four sampling stations; 200 m before the farm (station 1), inlet water into the farm (station 2), out let waste water before release to the river (station 3), 200 m after releasing point (station 4). At two stations (station 2 and 3) two samples were collected as replicates, whereas at station 1 and 4 four samples were collected in the form of a cross-section from the right to left bank. Vana fish farm is located in a remote area far enough to be influenced by urban or industrial waste water.

Because of finical problem, water quality parameters were measured only two times (fall and winter) during the experiment. Dissolved Oxygen (DO), pH and turbidity were measured directly by using a digital detector. For the rest, the equal water samples from different sides and depth of each station were collected in a bucket. The sample buckets are transported on ice to the laboratory in Sari.

Laboratory Analysis

The bucket content was stirred gently by a pump to attain maximum homogeneity. Sub-samples per each station were obtained using 1 L plastic bucket. The measured water quality parameters were; Total Suspended Solids (TSS), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Nitrate, Nitrite, phosphate and also total coliform. Nitrite and Nitrate were determined by UV spectrophotometer. Phosphorous was determined by a vando-molybdate method after sample combustion at 550°C and digestion with acid. For measuring the TSS, a 300 mL sample was filtered onto a pre-weighed and pre-dried Whatman GF/A glass micro-fiber filter. The filter was then oven dried at 70°C for 24 h. COD was determined using method described by Floqi *et al*. (2007). BOD was determined as the difference between initial and 5 day oxygen concentrations in bottles assayed by the Winkler method, after incubation at 20°C (Floqi *et al*., 2007). Total coliform was grown in E M B Agar (36 g in 1000 mL distilled water; central drug house (p) Ltd., Post Box No. 7138, New Delhi, India) and then enumerated by counting the bacteria colony.

All data are presented as means of each treatment with standard deviation.

RESULTS AND DISCUSSION

Data on nutrients content showing that waste water did not result in a higher concentration of nitrate and nitrite at the releasing point and surprisingly reduced the phosphorous content in the station 3 and 4 (Table 1).

Table 1: Nutrients content measured at different distance of the river affected by aquaculture waste water. For each measurement, water quality data for each sampling station were averaged

Parameters	Station 1	Station 2	Station 3	Station 4
Nitrate (mg L^{-1})	1.400±0.550	2.100±0.700	2.100±0.650	1.900±0.450
Nitrite (mg L^{-1})	0.031±0.007	0.021±0.005	0.017±0.006	0.028±0.008
Phosphorous (mg L^{-1})	0.404±0.090	0.207±0.050	0.147±0.050	0.237±0.060

Table 2: Water quality parameters measured at different distance of the river affected by aquaculture waste water. For each measurement, water quality data for each sampling station were averaged

	Station 1		Station 2		Station 3		Station 4	
Parameters	Fall	Winter	Fall	Winter	Fall	Winter	Fall	Winter
DO (mg L^{-1})	5.2±0.4	3.8±0.3	5.2±0.5	3.10±0.4	4.6±0.1	3.00±0.1	5.00±0.4	3.00±0.4
BOD (mg L^{-1})	6.0±0.5	6.0±0.4	4.0±0.5	5.00±0.8	30.0±3.2	12.00±1.3	10.00±0.8	8.00±1.0
COD (mg L^{-1})	15.5±2.0	16.0±1.8	12.4±1.2	13.50±1.0	75.0±5.1	30.00±2.6	26.00±2.8	18.50±1.9
TSS (mg L^{-1})	15.0±3.0	28.0±2.9	14.0±1.9	16.00±1.7	6.0±0.9	20.00±2.3	16.00±1.8	13.50±1.5
pH	8.6±0.3	8.2±0.2	8.6±0.2	8.16±0.1	8.5±0.2	8.16±0.3	8.56±0.4	8.22±0.1
Turbidity	9.0±0.4	13.0±1.1	16.0±1.6	10.00±0.8	9.0±0.8	15.00±1.0	18.00±1.3	9.00±0.7

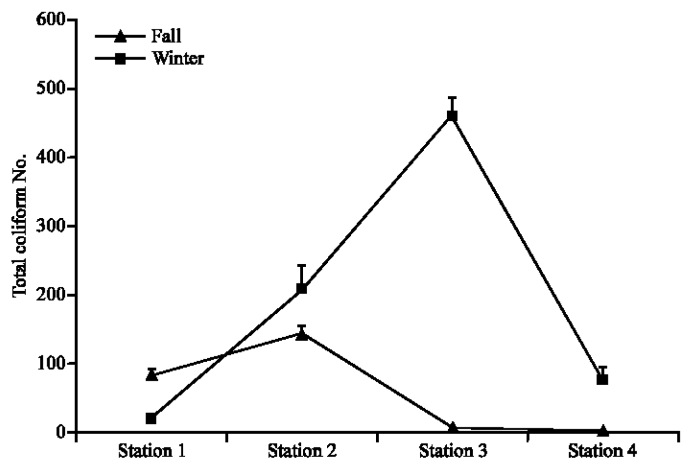

Fig. 1: Total coliform number measured at different distance of the river affected by aquaculture waste water. For each measurement, total coliform number for each sampling station were averaged

Dissolved oxygen was lower in the station 3 where waste water discharging into the river (Table 2). COD and BOD were also affected by waste water released from the fish farm. There were a consistence higher BOD and COD for the station 3, these figures however recovered by some extent for station 4. TSS figures also show an obvious increase for station 3 and 4 related to fish excretion.

In fall organic matter index (BOD and COD) were lower compared to winter at releasing point showing less organic matter discharge from this station into the river. We however measured a smaller figure for TSS and turbidity at releasing point in fall than those of winter.

Total coliform number as a bio-indicator for water quality is shown in Fig. 1. It has been measured a large number of coliform bacteria at the releasing point (station 3) in winter. However coliform bacteria for this station in fall were almost close to zero.

The results suggest that the waste flow generated by fish farm enters the Haraze river. The waste content however is not too much to put a significant effect on water quality of the river. COD and BOD measurements showed that organic matter is flowing into the river. The similar data also observed by Pillay (2004) who concluded that the organic matter content of aquaculture waste increase COD of receiving water. A slightly lower oxygen concentration in station 3 and 4 also support this idea.

Organic matter load to the river is generated by uneaten food and/or feces excreted by fish (Cho and Bureau, 2001). A quick solid removal in the aquaculture system lessens the amount of organic matter undergoing bacterial decomposition, thus reducing the organic loading discharge into the surrounding water (Amirkolaie *et al*., 2005). Degradation of organic waste in the river by micro organisms may cause eutrification and dissolved oxygen shortage. In addition, the enrichment of benthic ecosystem by organic matter settlement has a negative impact on benthic organisms. Pillay (2004) reported that increased levels of dissolved organic matter cause an increase in the number of bacteria and a change in the nature of benthic fauna in down stream. There is evidence in the Haraze river suggesting that settling of aquaculture organic matter damage benthic biota or causes a change in benthic organisms communities (personal communication).

An overview on water quality parameters from station 1 to 4 revealed that the aquaculture waste contains a low concentration of dissolved pollutants (N and P). A study in the UK also showed that farms were generally sited on river containing high water quality caused very little change in water quality of down stream (Solbe, 1982). Similar results also was observed by Teodorowicz *et al*. (2006) on the water quality in downstream of Marozka river, except a little drop in oxygen saturation in summer. Aquaculture generally discharges diluted waste water into the environment (Kelly *et al*., 1998) and pollutants are dispersed fast in the river. A comparison between various waste water composition estimates showing that effluent water from fish farm contribute to less than 1% of total SS, BOD and Phosphorous discharged into the environment (Enell, 1995; Kelly *et al*., 1998). All of the previous evidence suggest that impact of aquaculture effluent on water quality of the river is too slight and localized to put a huge effect on the river water quality.

A calculation on total daily nutrients load in the river indicates that phosphorus concentration in the inlet water is surprisingly larger than that of in the outlet water. One possibility is that fish rearing pond act such as settling basin and phosphorus particles settle to the bottom of the pond. The average phosphorus concentration in the river water was relatively high (between 2 and 4 mg L^{-1}), larger than euthriphication threshold. Potential euthriphication problem occurs in aquatic ecosystem where total nitrogen exceeds 0.92 mg-N L^{-1} and total phosphorous exceeds 0.13 mg-P L^{-1} (Mills *et al*., 1985). However, there were no visible sign of algae bloom or periphyton growth in the river. This may be caused by high water velocity at sampling site or cold temperature during sampling period (fall and winter).

In conclusion, particulate fractions (uneaten feed and feces) are known as the major environmental problem associated with flow through land-based aquaculture facility. The impact of particles produced by fish farm on water quality is localized (few ten meters after releasing point). Means to minimize the environmental impact of flow through systems include minimizing feed wastage through a proper feeding strategy, building settling basin to retain most particulate before release and improving feed composition to increase digestibility and/or removal ability of feces excreted by fish.

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