Nutrient fluxes from rainbow trout (Oncorhynchus Mykiss) feces and uneaten feed in the black sea conditions

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NUTRIENT FLUXES FROM RAINBOW TROUT (*ONCORHYNCHUS MYKISS*) FECES AND UNEATEN FEED IN THE BLACK SEA CONDITIONS

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ABSTRACT

The phosphorus release from trout feces and feed at the low water temperatures (8 °C) occurred slowly, while at high water temperatures (20 °C) on the second day reached maximum levels (4.45 and 4.12 mg L^{-1} respectively), and then decreased to the lower level at the end of day 11 (1.43 and 0.96 mg L^{-1} respectively). The total released nitrogen concentration was increased gradually in both fish feces and feed day by day. Total nitrogen level was reached to the highest concentration at day 11. Additionally, there was an obvious nitrogen release detected by water temperature increments ($p<0.05$), i.e. higher water temperatures promoted and caused higher nitrogen emissions.

KEYWORDS:
Nutrient leaching, orthophosphate, total nitrogen, *Oncorhynchus mykiss*

INTRODUCTION

Cage farming in Black Sea coast of Turkey was began with the cultivation of Atlantic salmon (*Salmo salar*) in 1980s. However, due to the fact that Black Sea coastal water is warmer for its cultivation considering water temperature rises above 20 °C during the summer season; the rainbow trout aquaculture has been started in cages instead of salmon culture in the early 1990s [1]. Trout farming in net-cages on the Black Sea were started only with 3 company in the early nineties. But nowadays, dozens of cage farms were settled and farming is ongoing on the Black Sea coast of Ordu and Trabzon provinces and 6,872 tons of rainbow trout are produced [2-3].

In recent years, the environmental impact of aquaculture activities have been started to be one of the important issues. Cage farms which were settled in the marine environment affect marine ecosystems inversely. Primary reasons of environmental impacts of cage aquaculture activities consist the excretion of nutrients from fish, solid wastes, antibiotics, disinfectants and antifouling paints [4]. However, the most important reason is emissions result from fish feces and uneaten feed which is released directly to the marine environment [5]. Therefore, the cage farming leads to the enrichment of nutrients in the sea water column and affect the seabed negatively [6]. Organic matter also from fish farms is accumulated on the seabed. This organic enrichment causes bacterial growth which disrupts the composition and function of the benthos. Accordingly, because of the decrease in oxygen and increase in oxygen demand, biomass and biodiversity changes might occur [7].

The amount of waste released to the sea varies based on the feed ingredients and feeding methods used in the fish farming. Feed components are converted to the waste as metabolism products after digestion. These waste products are consisting of organic carbon, organic nitrogen, phosphate, ammonium, urea, bicarbonate, vitamin and pigment substances. The amount of feces and metabolic waste might be divergent depending on the stocking density, and the feed quality [8].

Phosphorus (P) and nitrogen (N) are one of the most crucial metabolic wastes and are produced by fish after digestion of feed. Nitrogen and phosphorus concentrations of feed varies depending on the nutrient content of fish feed. Feeds for carnivorous species are contained higher protein than omnivores one. However, raw materials such as fish meal and meat-bone meal used in fish feed; contain phosphorus at high rates [9]. Ammonium nitrogen is produced by the metabolism of fish feed protein. Therefore consumed or not consumed high rate protein containing feeds causes to high ammonia emissions [10]. Rainbow trout feed contains high levels of raw protein (45-55%) and raw fat (12-25%). Hence, trout feed consists of 7.2 to 8.8% nitrogen, 0.9 to 1.9% phosphorous and 30-40% carbon [9]. However, to ensure a sustainable increase in aquacultural production an adaption of eco-friendly production model is required. Using more digestible fish feed in the production and estimation of the level of nutrient release from fish feces besides uneaten feed to the water column will contribute to an eco-friendly production model. In this context, herein this study aimed to estimate nutrient release in cage trout aquaculture in the

TABLE 1
Nitrogen, phosphor and proximate content of trout feces and feed.

Samples	Variables			
	CP (%)*	**CL (%)***	**N (%)***	**P (%)***
Feces	13.46±0.42	3.12±0.07	2.15±0.17	2.13±0.12
Feed	41.78±1.05	16.95±0.71	6.68±0.56	1.95±0.06

*Rates were calculated as dry weight basis, CP: crude protein; CL: Crude lipid; N: Nitrogen; P: Phosphor

Black Sea. Thus, ammonia, nitrogen and orthophosphate leaching from rainbow trout feces and feed were determined at three different water temperatures; starts with min 8 °C, 15 °C and reaches up to the max. 20 °C, (during winter, spring-autumn and summer time, respectively) in the Black Sea.

MATERIALS AND METHOD

Rainbow trout, *O. mykiss* (300-350 g) stocked in a cylinder conic fiber glass tank (150 cm x 75 cm), which was supplied with a feces collector apparatus. Marine water was supplied into the fish tank at the flow rate of 0.3 L/s. After 10 days of acclimation stage, a widely known commercial trout feed was used to feed trout twice a day at 18ºC water temperature. After that feeding process the uneaten feed pellet was taken back from both the collector and the bottom of the tank. In addition to that muddy fish feces were removed from the collector at different time courses during the day. The removed trout feces were dried overnight at 105ºC. Dried trout feces were grinded and mixed. Same process was also performed for above mentioned collected pellets. Those mixed trout feces and feed were used for nutrient leaching experiments. In order to examining of nutrient leaching from the fish feces and trout feed, 150 mg feces or feed samples were put in a flask, and 100 ml of sea water from Black Sea was added into the feces and feed samples after filtered and autoclaved. Then, all the flasks were transferred gently into the incubators (Nüve ES250, ES500) and incubated for 11 days at three different temperatures (8, 15 and 20 °C). The contents of protein and total phosphorus in the feed and the feces were measured using AOAC [11] method. The initial (day 0) amount of orthophosphate (PO_4-P) and ammonium (NH_4^+) concentrations of the seawater used in each experiment were analyzed in advance spectrophotometrically (Shimadzu 1800, Kyoto, Japan) [12]. Besides that, the pH was recorded by a pH meter (Orion SA 520). The same analysis was repeated on the days of 1, 2, 3, 5, 7, 9, 11 for the experimental groups of the feces and feed which were incubated at different temperatures. All analysis either for nutrient release from the fish feed or feces were conducted as triplicates.

One-way analysis of variance (ANOVA) were used to determine if there were any significant differences in the nutrient concentrations leaching from the feces and diet groups under different temperature conditions on different days. Statistical analyses were made by the SPSS (ver. 23.0) statistical package programs at the 95% confidence interval.

RESULTS

The phosphorus and nitrogen values obtained in feces and fish feed are given in Table 1. The phosphorus and nitrogen ratio (P: N) in rainbow trout feed and feces was calculated as 1:3.42 and 1:1 respectively. These results indicate that main phosphorus emission comes from rainbow trout feces to the marine environment.

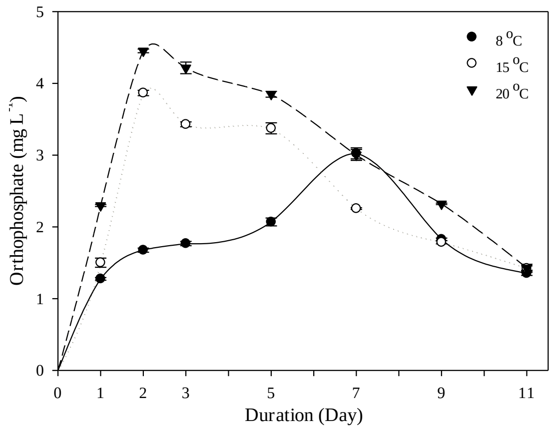

FIGURE 1
Orthophosphate releasing from trout feces at three different water temperatures.

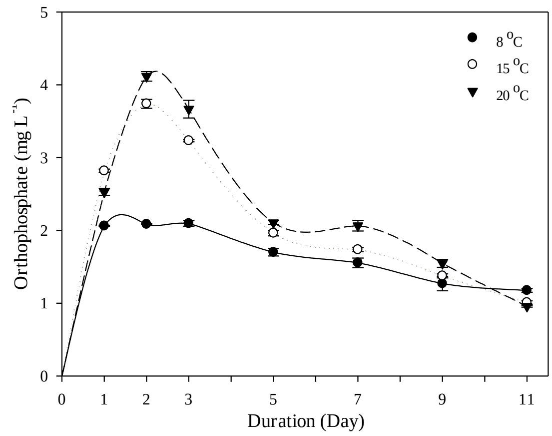

FIGURE 2
Orthophosphate releasing from trout feed at three different water temperatures.

The orthophosphate concentrations varied depending on the water temperature in both feces and feed. The highest orthophosphate concentration was detected at the highest water temperature (20 °C) on the second day (orthophosphate concentrations of fish feces and feed were measured as 4.45±0.01 and 3.74±0.04 mg L^{-1} respectively). At the end of 10 days, orthophosphate level was decreased to the value of 1.43±0.02 mg L^{-1} in the feces and 1.01±0.02 mg L^{-1} in the feed (Figure1, 2).

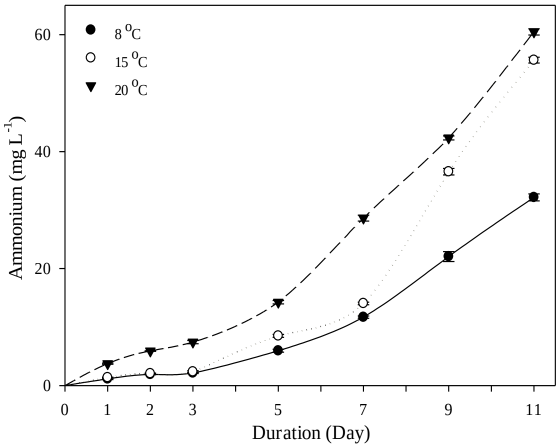

FIGURE 3
Ammonium releasing from trout feces at three different water temperatures

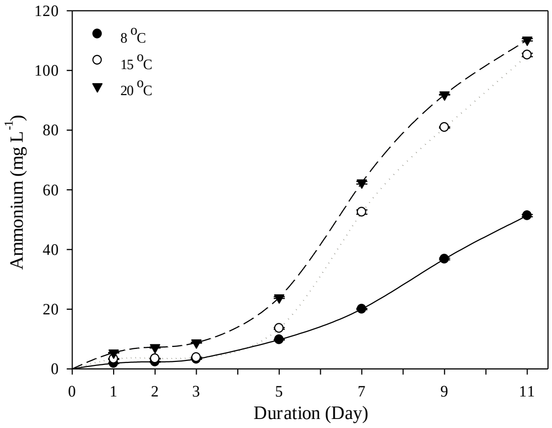

FIGURE 4
Ammonium releasing from trout feed at three different water temperatures.

Higher ammonia levels were measured at highest water temperature. The first three days, ammonium concentration remained as 2.37-3.8 mg L^{-1} in the feces and the feed. Ammonium level of water gradually increased in both feces and feed during the experimental period. Releases of the ammonium from the feces and feed were reached up to the highest concentration as 110±0.22 and 60.47 ± 0.31 mg L^{-1} respectively. When the feed and feces are compared, higher ammonium release from feed is detected instead of feces (Figure 3-4).

DISCUSSION

The amount of fecal waste produced by fish depends on the amount of feed consumed as feed digestibility. According to the Butz and Vens-Cappell [13], 26% of consumed feed is transformed into the fecal pellet on dry weight basis. Excreted phosphorus and nitrogen ratio in fish feces are depends on the fish species and feed content. For example: phosphorus and nitrogen has been reported as 1.9-3.08% 3.21-3.29% in silver perch [14], 4.0% and 2.3% in Atlantic salmon [15], 1:59% and 3.93% in rainbow trout [16], and 1.91% and 2.43% in sea bass (*D. labrax*) [17] respectively. In our study, phosphorus ratio was found as 2.13±0.12% and nitrogen ratio was found as 2.15±0.17 in rainbow trout feces similarly. These results indicate that phosphorus excretion occurs mainly through the fish feces.

According to the Rodehutscord et al. [18], excretion of phosphorus from the fish differs into three types: first one is inevitable phosphor loss (occurs even at zero intake phosphorus), second one is non-absorbable P loss (resulted from feed quality) and third one is P regulation loss in the fish body (If the certain phosphorus level of feed is too high than that of fish demand). The intake and bioavailability of phosphorus from the feed might be occurred at the best level when the phosphor level of feed is less than the required amounts which the fish need, and in this way regulatory loss would be reduced [18-19]. In the present study, the amount of phosphorus in the fish feed was found less than the feces. Therefore, we can conclude that phosphorus content of feed should be reduced to the optimum degrees.

Our study and previous studies showed that nitrogen and phosphate emission from fish feces and uneaten feed are occurred quite quickly at high water temperatures. Therefore, to prevent nutrient releases from fish feces and uneaten feed into the marine environment, they must be removed as soon as possible. Results showed that both ammonium and orthophosphate release are depending on the water temperature. The highest nutrient release occurred at 20 °C from the tested three different water temperatures (8, 15, 20 °C). Kibria et al. [14] reported that the release of the nutrient is altered with the changes in the pH, oxygen concentration and the microbial activity in addition to the temperature of the water

In sum, fish feed is the most important nutrient source in the aquatic environment for the living organisms. Hence, the fish feed industries and farmers should be careful pertaining to the phosphorus content of fish diet and overfeeding respectively.

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