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International Journal of Oceanography & Aquaculture

Investigation of Rainbow Trout Farm Effluents on Water Quality of Humestan River (Isfahan, Iran)

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Research Article

Volume 1 Issue 3

Received Date: July 3, 2017

Published Date: July 07, 2017

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Abstract

In the present study, the impact of effluents exiting from four rainbow trout farms on the water quality of Humestan River (Isfahan, Iran) across 11 stations was investigated. Water samples were collected in the spring, summer, fall and winter and such factors as dissolved oxygen, pH, BOD_5, COD, ammonia, nitrite, nitrate and phosphorus were measured. The results showed that the amounts of phosphorus entering the River during spring, summer, fall and winter were 311.8 kg, 408.1 kg, 408 kg and 683.1 kg, respectively. Furthermore, the amounts of nitrogen entering the River during spring, summer, fall and winter were 1653.75 kg, 2164.05 kg, 2164 kg and 3622.5 kg, respectively. The amount of BOD and COD in all sampling stations and in all four seasons was less than 5 and 10 mg/lit, respectively. Due to the very low concentration of ammonia in water samples, no number was reported on the part of laboratories in this case. The amount of nitrite in all four seasons significantly exceeded the recommended level (0.02 mg/lit) (P <0.05). Given the whole year, it was indicated that the amounts of nitrate and total nitrogen were significantly less than the conventional level (2 mg/lit) (P <0.05). Moreover, the minimum and maximum amounts of phosphate were reported in the spring and winter, respectively, and this amount did not significantly exceed the critical level in any of the seasons (0.5 mg/lit) (P >0.05). In general, fish farming and effluents imported into Humestan River affected the water quality thereof.

Keywords: Humestan River; Water samples; Nitrate concentration; Water Quality

Introduction

Given the past 50 years, it is clear that human beings have changed the Earth's ecosystems with an increasing and uncontrollably speed and range compared to similar periods in Earth's history so that they may provide and secure food [1]. At present, rivers and streams in mountainous areas are commonly used in order to produce rainbow trout. However, the expansion of these activities will be followed by large environmental consequences. The construction of fish farming and breeding centers has generated large amounts of effluents and their subsequent importation into the rivers [2]. Interestingly, the effluents caused by rainbow trout farms can contain such useful substances as pathogens, drugs, disinfectants, feed residuals and fish feces [3]. In fact, production of 1000 kg of fish leads to generation of 500 kg of solid waste (including feed residuals and feces). Usually, these effluents and other chemical changes caused by the metabolism of fish are added into river without any purification and, consequently, the quality of water is deteriorated [2]. Generally speaking, since such fish-related activities increase in summer, there are more nutrients in the effluents. Due to the decreased water flow and temperature rise in this season, it is believed that the impact of effluents of fish farms, which are located in the riversides, on the ecosystem and water quality of these rivers will be more severe [3]. Accordingly, several studies have been conducted on the ecological response of natural ecosystems (such as rivers) as well as assessment of threats and risks imposed on these ecosystems. Bayati, et al. reported that effluents flowing from rainbow trout farms into Marbor River could negatively affect the quality of water. Similarly, Naderi-Jelodar, et al. reported that effluents flowing from rainbow trout farms into the river could reduce the number of large benthic invertebrates in the river. In the same vein, Salimi-Bani, et al. and Azimi, et al. [4,5] achieved similar results.

Amankwaah, et al. [6] investigated the impact of effluents flowing from concrete fish ponds into Sophia River in Ghana on the physical and chemical properties of river water. Besides, Pulatsu, et al. [7] examined the impact of effluents flowing from rainbow trout farms into Karasu River in Turkey. Similarly, Bonisławska, et al. investigated the causes of deteriorated water quality of Gunika River in Poland. In addition, Mirrasooli, et al. reported that effluents flowing from rainbow trout farms into Zarrin Gol River negatively affected the quality of water [8,9]. Furthermore, Mazaheri, et al. and Rahimibashar, et al. [10,11] achieved similar results. Given the present study, it was attempted to gauge the impact of effluents of four riverside rainbow trout farms on the water quality of Humestan River (Isfahan, Iran).

Materials and Methods

Fish Farms and Stations

There were four rainbow trout farms in the vicinity of Humestan River (Isfahan, Iran). As such, it was attempted to gauge the impact of effluents of four rainbow trout farms on the water quality of Humestan River across 11 stations. The stations were selected on the basis of flowing the river water into the farms and exiting from them, and, then the mixing with effluents at a distance of 50 to 100 meters. Also, two water sampling stations (located at distances of 500 and 1000 meters) were selected in the riverside in which the outlet water of the last farm was mingled with effluents. It should be noted that the latter stations were selected in order to gauge the self-purification of Humestan River. In addition, sampling process was carried out during one year and in different seasons.

Measured Water Quality Parameters

First, it was attempted to make use of portable devices (EUTECH, Cyberscan 600, Singapor) in order to gauge the level of dissolved oxygen and pH at each station. Then, one bottle of water was extracted from each station with two repetitions. Then, it was numbered and was sent to the laboratory to measure ammonia, nitrogen, nitrite, nitrate, phosphate, COD and BOD.

Statistical Analysis

The obtained data were edited in the Excel Software (2010). Next, the data were compared with each other using SAS Software and T-test [12].

Results and Discussion

Estimation of Entered Phosphorous and Nitrogen to the River

According to Table 1, the sum of the minimum and maximum food intakes in the concerned four farms were equal to 47250 kg and 103500 kg in the spring and winter, respectively. Since fish usually was released in farms during the spring, the minimum consumption of food was observed in this season.

According to the food intakes in four farms (Table 1), it could be said that the amounts of phosphorus entered into the river in the spring, summer, fall and winter were 311.8 kg, 408.1 kg, 408 kg and 683.1 kg, respectively. However, the amounts of nitrogen entered into the river in these seasons were 1653.75 kg, 2164.05 kg, 2164 kg and 3622.5 kg, respectively. Thus, on average, the daily amounts of 4.96 kg of phosphorus and 33.71 kg of nitrogen were entered into the Humestan River as a result of effluents flowing from rainbow trout farms. Pulatsu et al. estimated that up to 12205 kg of phosphorus (resulting from five rainbow trout farms) entered into the river [7]. Besides, they reported that, on average, the production of 1000 kg of trout fish led to discharge of 9.38 kg of phosphorus into the river. Furthermore, they argued that, due to the consumption of 1000 kg of fish food, a total amount of 8.09 kg of phosphorus was discharged into the river. Given the present study, it was concluded that the consumption of 1000 kg of fish food led to discharge of

6.7 kg of phosphorus and 35.2 kg of nitrogen into the Humestan River.

Farm No.	Spring	Summer	Fall	Winter
1	13500	31500	18000	18000
2	15750	10350	13500	40500
3	18000	18000	27900	18000
4	No stock	1980	2430	27000

Table 1: Mean feed intake (kg) in four rainbow trout farms.

Dissolved Oxygen Changes

The results showed that although the concentration of dissolved oxygen in the spring was significantly higher than normal (8 mg/lit), this amount was significantly lower than the concerned level in the other three seasons ($P<0.05$). Since the Humestan River (after the last farm) had a wide width, low depth and gravel bedding, it succeeded to absorb the oxygen through the air and provided the necessary concentration for trout fish. Vafai and Abbasi argue that contamination of shallow rivers embedded with a fast water flow and gravel bedding shall be refined faster because these kinds of rivers are characterized with a more oxygen absorption [13]. Salimi-Bani, et al. and Azimi, et al. [4,5] have examined the status of self-purification and the role of river gauging in promoting water quality in terms of ecological conditions. The investigation of physical and chemical properties of river water in Sophia River in Ghana indicated that the amount of oxygen in the upstream stations were significantly higher than the amount of oxygen in the downstream stations. The same vein, Pulatsu et al. reached similar results in case of Karasu River in Turkey.

Season	Mean	SD	SE	*P* value
Spring	9.71	0.36	0.11	0.0001
Summer	6.91	0.35	0.1	0.0001
Fall	6.91	0.54	0.16	0.0001
Winter	7.31	0.49	0.15	0.001

SD: standard Deviation, SE: Standard Error.
Table 2: Comparison of mean dissolved oxygen in each season compared to 8 mg/lit as conventional value.

pH Changes

In all seasons, pH changes were not significant across the stations. On average, the lowest and highest levels of pH were observed in the spring (7.5) and winter (8.58), respectively.

The optimal pH range for cold water fish has been reported to be 6.5 to 8 (Institute of Standard and Industrial Research of Iran, 2006) [14]. The mean seasons and the upper critical level (i.e., 8) have been statistically compared. Table 4 shows that the pH level has not exceeded the critical level only in the spring and that it has been located in the desirable range. However, this level is significantly over-critical in the next three seasons ($P<0.05$). Thus, fish breeders should take steps to reduce pH levels in the summer, fall and winter seasons. Amankwaah, et al. [6] investigated the physical and chemical properties of Sophia River in Ghana and concluded that the pH levels of fish ponds and downstream stations must be located in 7.6-7.9 and 7.48-7.73 ranges, respectively. Furthermore, they argued that the pH levels of upstream stations should be located between 7.25 and 7.5. Besides, Pulatsu, et al. [7] investigated the changes in pH levels in different stations in Karasu River in Turkey and concluded that these changes were not significant at all. Rahimibashar, et al. [11] reported the changes in pH levels in Shenrood River (Guilan, Iran) during the spring and summer as 7.5 to 8.7, respectively. In the present study, there have been almost similar changes as depicted in aforementioned reports.

Season	Mean	SD	SE	*P* value
Spring	7.91	0.16	0.05	0.1223
Summer	8.16	0.2	0.06	0.0236
Fall	8.42	0.27	0.08	0.0005
Winter	8.38	0.15	0.05	0.0001

SD: standard Deviation, SE: Standard Error.
Table 3: Mean pH values in each season compared to 8 as a critical point.

Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)

The results showed that the levels of BOD and COD were less than 5 and 10 mg/lit in all sampling stations and in all four seasons. Actually, if BOD_5 is greater than 5 and COD is greater than 60 mg/lit, there is a potential for contamination and the risk of lack of oxygen [15]. Therefore, the quality of water at the upstream and downstream stations of the farms has been relatively desirable. This finding is consistent with environmental standards (1993). Rahimibashar, et al. examined the levels of BOD_5 and COD in the Shenrood River (Iran) and reported that these levels were 1.3 ± 2.2 and 4.7 ± 3.4 mg/lit, respectively. Similarly, some significant changes were also reported for BOD_5 and COD by Pulatsu, et al. in case of Karasu River in Turkey [7].

Ammonia Changes

Regarding the very low concentration of ammonia in water samples, it was concluded that there was no significant number in any of the stations. However, it was argued that the low concentration of ammonia in the river water was related to vibrant activities of microorganisms, the speed of water and the gravels resided in the river bed. This possibility was previously acknowledged by Vafai and Abbasi [13]. In this line, Rahimibashar, et al. reported the level of ammonia, caused by effluents of rainbow trout farms in the Shenrood River (Guilan) during the spring and summer as 6.9 ± 4.8 mg/lit [11].

Nitrite Changes

In general, the minimum and maximum amounts of nitrite concentration were observed in the spring and winter, respectively (Table 4). In all seasons, the concentration of nitrite in the outlet of the fish ponds and the place of mixing the effluents with the river was slightly higher than the rest of the stations. Actually, nitrite levels in all four seasons were significantly higher than the recommended level (0.20 mg/lit) (P <0.05). Therefore, fish breeders are recommended to pay due attention to this factor and think about ways to reduce nitrite levels for downstream farms. Given the results of research conducted by Pulatsu, et al. and Mirrasooli, et al. [7,9], it was indicated that they reported a significant impact of fish breeding activities on the nitrate concentration in the river water. Amankwaah, et al. reported that the average concentrations of nitrite in the upstream and downstream stations of the Sophia River (Ghana) were 7.57 and 5.05 mg/lit, respectively. Furthermore, they reported that the average concentration of nitrate inside the fish ponds was 5 mg/lit. In this line, Rahimibashar, et al. reported that there was 0.18 ± 0.9 mg of nitrite per liter in the Shenrood River (Iran). Given the fact that the measured levels were much lower than those aforementioned reports, it was expected that downstream farms might not face a particular problem.

Season	Mean	SD	SE	*P* value
Spring	0.03	0.01	0.0043	0.0067
Summer	0.06	0.03	0.0109	0.0032
Fall	0.05	0.02	0.0079	0.0008
Winter	0.25	0.25	0.0779	0.0144

SD: standard Deviation, SE: Standard Error.
Table 4: Mean nitrite values in each season compared to 0.02 mg/lit as a conventional level.

Nitrate Changes

Table 5 shows that the amount of nitrate in all four seasons was significantly lower than the conventional level (2 mg/lit) (P <0.05). Thus, it was expected that downstream farms might not face a particular problem. Besides, the concentration levels of nitrate were higher in winter than other seasons. Similarly, reported the maximum nitrate concentration in the winter [16]. Amankwaah, et al. asserted that the amounts of nitrate in the upstream stations were significantly higher than those in downstream stations and inside fish ponds. Pulatsu, et al. reached similar results in case of Karasu River in Turkey. Also, Mirrasooli, et al. reported a significant impact of fish farms' effluents on the concentration of nitrate in the river water. In this line, Rahimibashar, et al. reported that there was 6.2 ± 2.7 mg of nitrite per liter in the Shenrood River (Iran).

Season	Mean	SD	SE	*P* value
Spring	0.67	0.46	0.14	0.0001
Summer	1.07	0.23	0.07	0.0001
Fall	1.03	0.24	0.07	0.0001
Winter	1.66	0.48	0.15	0.0453

SD: Standard Deviation, SE: Standard Error.
Table 5: Mean nitrate values in each season compared to 2 mg/lit as allowance level.

Phosphate Changes

The minimum and maximum amounts of phosphate were reported in the spring and winter, respectively (Table 6). The amounts of phosphate in the spring and fall were significantly less than 0.5 mg/lit but these amounts were insignificant in the summer and winter. In fact, the concentration of phosphate did not exceed the critical level in any of the seasons. Pulatsu, et al. and Mirrasooli, et al. confirmed the impact of fish farms' effluents on the amounts of phosphate in the river water. Rahimibashar, et al. reported that there was 0.13 ± 0.9 mg of phosphate per liter in the Shenrood River (Iran).

Season	Mean	SD	SE	*P* value
Spring	0.16	0.04	0.01	0.0001
Summer	0.42	0.16	0.05	0.1656
Fall	0.2	0.03	0.01	0.0001
Winter	0.44	0.32	0.09	0.5822

SD: standard Deviation, SE: Standard Error.
Table 6: Mean phosphate values in each season compared to 0.5 mg/lit as conventional level.

Conclusion

In sum, the results showed that since the effluents of rainbow trout farms entered into the Humestan River, the quality of water was negatively affected. This led to an increase in nitrogen and phosphorus in water. Besides, this significantly changed the pH, nitrite and phosphate levels in the river water. However, these changes were not uniform in different seasons. Interestingly, such factors as dissolved oxygen, ammonia, BOD, COD and nitrate did not undergo significant changes.

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