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Growth of *Pangasius hypophthalmus* in Sewage Treated Water

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Abstract: Treated sewage water constitutes a sustainable water resource that has been used for aquaculture. The suitability of sewage treated water for *Pangasius hypophthalmus* (Sauvage, 1878) was estimated during the present study in terms of growth parameters. *P. hypophthalmus* was cultured under three treatment groups: freshwater, sewage treated water without feed and with feed. The growth parameters of *P. hypophthalmus* in cultured in freshwater, sewage treated water with feed and without feed revealed higher weight (40.86 g), length (16.88 cm), weight gain (724.07 g), average daily weight gain (0.66 g/ day), biomass (817.20 g), percent increment in weight (1021.29%), percent increment in length (106.55%), specific growth rate (1.17%) and survival (100%) for fishes in sewage treated water with feed as compared to the other two treatments. Despite the absence of any external feeding, the fishes were able to survive in sewage treated water without feed as it is rich in nutrients, organic matter, micro-organism etc. The growth (weight, length) of *P. hypophthalmus* showed significant positive correlation with temperature (26.39^{0}C), conductivity (2.45 ms/cm), total dissolved solids (618.95 ppm), dissolved oxygen (6.10 mg/l), pH (7.86), hardness (283.30 mg/l) and salinity (1.36 ppt) of sewage treated water, however, ammonia (0.58 mg/l), nitrite (0.09 mg/l) and alkalinity (198.80 mg/l) had no correlation.

Keywords: Growth, *Pangasius hypophthalmus*, Treated sewage water, Water quality

During last six decades, Indian fisheries have grown more than seventeen folds with an increase in fish production from 0.752 million tons in 1950-51 to 14.16 million metric tons in 2019-20 (Anonymous 2020). In inland fisheries, Haryana stands second in the average annual fish production per unit area in the country. The average annual fish production in the state is 7000 Kg per hectare against a national average of 2900 Kg. There is a growing realization that freshwater will become a scarce resource in the foreseeable future with increasing population as well as with improvement in agricultural and industrial growth in India (Mukhopadhyay and Sarangi 2006). In addition, according to the Food and Agriculture Organization (FAO 2018) prediction for the early 2020s, aquaculture will only be able to cover 40 percent of global fish demand. In order to fill this fish demand-supply gap, aquaculture would need to grow globally in 9.9 percent every year. Hence, reuse of sewage effluent for aquaculture has been advocated due to scarcity of water resources. Treated wastewater constitutes a sustainable water resource that has been used for aquaculture in many countries including Germany (Prein et al 1990), Hungary (Etnier and Guterstam 1996), China (Phong Lan et al 2007), India (Roy et al 2011), and USA (Cuevas-Uribe and Mims 2014). Treated waste water use can reduce both the demand for freshwater and water costs in existing aquacultural operations, thus rendering the fish production more profitable. Few fishes like *Clarias batrachus*, *Heteropneustes fossalis*, *Channa* spp., *Tilapia mossambicus* and *Ctenopharyngodon idella* are cultured in sewage treated ponds as they can survive in water with lesser dissolved oxygen content (Samiksha 2019). Zaibel et al (2019) suggested that the yield of fish (*Poecilia reticulata*) grown in treated wastewater is potentially similar to that in freshwater, and the produced fish comply with the standards of consumer safety. Keeping these points in view, the effect of sewage treated water on *Pangasius hypophthalmus* growth parameters was evaluated in the present study.

MATERIAL AND METHODS

For present study, sewage treated water was collected from sewage treated ponds of the university and brought to the water quality laboratory of the College of Fisheries Science, CCSHAU, Hisar. The water was filtered to remove the twigs and debris before pouring into the glass aquariums. The aquariums were supplied with aerators to ensure the proper availability of oxygen. Before setting up the experiment, water quality parameters were estimated following standard methodology. The fishes were acclimatized for ten days at room temperature before the experimental setup. For *P. hypophthalamus*, three treatment groups *viz*, freshwater, sewage treated water without feed and sewage treated water with feed were designed under triplicate conditions to see the effect on weight, length and other growth parameters. Each replicate (aquarium of size 60 x 18 inches base, 24 inch height, 12 mm thick glass) contained 20 fishes and two aerators. The fishes of second treatment were fed commercial feed at the rate of 8 percent of their body weight twice a day. Observations on weight and length of *P. hypophthalmus* were measured at an interval of 10 days. Additionally, the temperature, pH, dissolved oxygen, alkalinity, total hardness, total dissolved solids, conductivity, salinity, ammonia nitrogen and nitrite nitrogen of the water were also estimated during each observation period. Sewage treated water was added regularly to maintain the water level. At the end of study period i.e. 90th day, growth parameters such as weight gain (g), percent increment in weight, percent increment in length, average daily weight gain (g/day), biomass (g), feeding rate (g/day), feed conversion ratio, specific growth rate (%) and survivability (%) was calculated by standard methodology(APHA, 2012). Weight (g) and length (cm) of the experimental fish was measured for the assessment of growth parameters by using electric weighing balance and scale, respectively.

Statistical analysis: For the statistical evaluation of the study, OPSTAT was used.

RESULTS AND DISCUSSION

Fish growth parameters in freshwater: There was significant increase in the weight and length of fish species from 0 to 90 day duration (Table 1). The fish weight was 3.68 g at 0 day which significantly increased to 28.71g at the end of study period. However, the fish weight during 0-10th day, 10th-20th day and 40th- 50thday was statistically comparable with each other. Fish length showed significant difference with each other during the whole experimental period with a 100% survivability. The weight gain, average daily weight gain and percent increment in weight ranged between 30.45 to 498.29 g, 0.12 to 0.48 g/day and 41.43 to 677.00 percent during 90 day study period. Likewise, percent increment in length was calculated as 13.72 percent at 10th day which increased to 91.16 cm at 90th day. There was a continuous increase in biomass (73.55 to 574.10 g) and feeding rate (58.70 to 287.05 g/ day). Feed conversion ratio (FCR) fluctuated between 1.70 and 3.56. At 50th- 60th day duration was minimum. Similarly, specific growth rate ranged between 0.99 and 2.00 percent in fresh water cultured *P. hypopthalamus*.

Fish growth parameters in sewage treated water without feed: Growth parameters of *P. hypophthalmus* in sewage treated water without feed assessed at different observation days in triplicate condition showed that there was an irregular trend in the weight and length of the fishes during 0 to 90 days duration (Table 2). Fish weight during 0th and 70th day did not show significant difference with each other. 50th day is marked by significant decrease in the average weight of the fishes. At an interval between 50th-60th day, the weight was stagnant. A significant increase in weight was observed after 60th day till the end of experiment. There was significant increase in length of *P. hypophthalmus* from 8.42 cm at 0 day to 14.73 cm at 90th day. The increase in length was not significant. Other growth parameters also followed the similar trend. Thereafter, continuous increase in growth parameters was recorded due to addition of fresh sewage treated water. The irregular trend followed by *P. hypophthalmus* in sewage treated water without feed can be explained as sewage treated water is a rich source of planktons on which the fishes feed. As there was no artificial feeding, the fishes were completely dependent on the presence of planktons and the growth of planktons was directly related to the availability of organic matter, nutrients, micro-organisms etc. in the sewage treated water. The sudden decline at 50th day can be represented as decline in the number of planktons. On 60th day, 50 percent of fresh sewage treated water was added which resulted in the sudden increase in weight, length and other growth parameters of the fish at 60th-70th day duration. Weight gain, average daily weight gain, percent increment in weight, percent increment in length, biomass and specific growth rate ranged between 16.72 to 165.09 g, 0 to 0.27 g, 22.18 to 254.57 percent, 9.50 to 74.94 percent, 75.35 to 240.42 g and 0.43 to 0.93 percent respectively. The survivability of the fishes was 100 percent till 50th day and declined to 90 percent at 60thday due to the decline of planktons in sewage treated water without feed. Datta (2006) also reported that there is direct relationship between inflow of sewage and productivity of the ponds. Mandal et al (2021) observed ≥75% fish survival in sewage concentrations up to 50 percent after 30 days rearing of three fish species namely Labeo rohita, Cirrhinus mrigala and *Labeo bata* whereas less than 50 percent fish survived in 75 percent sewage concentration.

Fish growth parameters in sewage treated water with feed: In treatment where feed was given to *P. hypophthalmus* in sewage treated water, results showed significant increase in all the growth parameters (Table 3). The fish survival was 100 percent under this treatment. With increase in observation days from 0 to 90 days, a significant increase in fish weight from 3.61 to 40.86 g was recorded. The fish weight at 10th (5.82 g) and 20th (6.91 g) day were statistically at par with each other. Fish length at different duration showed a significant increase till the end of study period (Table 2) from 8.17 to 16.88 cm at 90 days. Likewise, a continuous increase was recorded in weight gain, average daily weight gain, percent increment in weight, percent increment in length, biomass and specific growth rate. These

Table 1. Growth parameters of *Pangasius hypophthalmus*in fresh water at different durations

Observation days	Weight (g)	Length (cm)	Weight gain (g)	Average daily weight gain (g/day)	Percent increment in Weight	Percent increment in Length	Biomass (g)	Feeding rate (g/day)	Feed conversion ratio	Specific growth rate (%)
0	3.68[a]	8.38					73.55	58.70		
10	5.20[a,b]	9.53	30.45	0.16	41.43	13.72	104.02	83.20	1.92	2.00
20	6.38[b]	10.16	54.07	0.12	73.53	21.30	127.62	102.00	3.52	1.20
30	8.87	11.43	103.88	0.24	141.25	36.45	177.43	141.90	2.04	1.28
40	10.86[c]	12.07	143.66	0.19	195.35	44.03	217.22	108.60	3.56	1.16
50	12.42[c]	12.82	174.90	0.15	237.82	52.98	248.46	124.20	3.47	1.06
60	16.07	13.82	247.68	0.36	336.87	64.97	321.30	160.60	1.70	1.07
70	19.17	14.64	309.88	0.31	421.40	74.76	383.44	191.70	2.58	1.02
80	23.86	15.34	403.59	0.46	548.80	83.05	477.14	238.50	2.04	1.15
90	28.71	16.02	498.29	0.48	677.00	91.16	574.10	287.05	2.40	0.99

Values denoted by similar letter do not differ significantly with each other
The survivability for the experimental fish was 100% during the study

Table 2. Growth parameters of *Pangasius hypophthalmus* in sewage treated water without feed at different durations

Observation days	Weight (g)	Length (cm)	Weight gain (g)	Average daily weight gain (g)	Percent increment in weight	Percent increment in length	Biomass (g)	Specific growth rate (%)	Survivability (%)
0	3.77[a]	8.42[a]					75.35		100.00
10	4.60[a],[b]	9.22[a],[b]	16.72	0.08	22.18	9.50	92.07	0.87	100.00
20	5.77[b],[c]	10.22[b].[c]	39.65	0.12	53.22	21.30	115.45	0.93	100.00
30	6.25[d]	10.92[c]	49.65	0.04	65.99	29.69	125.07	0.73	100.00
40	7.78[d]	11.43[c],[d]	80.14	0.15	106.34	35.74	155.50	0.78	100.00
50	6.80[c]	10.43[b],[c]	60.71	0.00	80.59	23.87	136.07	0.51	100.00
60	6.80[c]	10.80e	60.71	0.00	80.59	28.26	136.07	0.43	90.00
70	8.06[d]	12.31[d]	69.68	0.12	113.88	46.15	145.03	0.47	90.00
80	11.09	13.87[e]	119.65	0.27	187.65	64.75	195.07	0.57	90.00
90	13.36	14.73[e]	165.09	0.25	254.57	74.94	240.42	0.61	90.00

Values denoted by similar letter do not differ significantly with each other

Table 3. Growth parameters of *Pangasius hypophthalmus* in sewage treated water with feed at different durations

Observation days	Weight (g)	Length (cm)	Weight gain (g)	Average daily weight gain (g)	Percent increment in weight	Percent increment in length	Biomass (g)	Feeding rate (g/day)	Feed conversion ratio	Specific growth rate (%)
0	3.61	8.17					72.88	58.20		
10	5.82[a]	9.68	44.32	0.21	59.77	18.45	116.45	93.10	1.31	2.04
20	6.91[a]	10.58	66.04	0.10	89.57	29.46	138.17	110.40	4.28	1.39
30	9.71	11.85	122.06	0.28	166.43	44.94	194.20	155.20	1.97	1.42
40	13.32	12.66	194.25	0.36	265.50	54.85	266.38	133.10	2.14	1.41
50	17.07	13.29	269.24	0.37	368.38	62.56	341.38	170.60	1.77	1.34
60	22.58	14.02	379.41	0.55	519.56	71.50	451.54	225.70	1.54	1.32
70	27.48	15.04	477.53	0.49	654.20	84.04	549.66	274.80	2.30	1.25
80	34.27	16.06	613.16	0.67	840.29	96.40	685.30	342.60	2.02	1.21
90	40.86	16.88	724.07	0.66	1021.29	106.55	817.20	408.60	2.50	1.17

Values denoted by similar letter do not differ significantly with each other
The survivability for the experimental fish was 100% during the study

ranged between 44.32 to 724.07 g, 0.10 to 0.67 g/day, 59.77 to 1021.29 percent, 18.45 to 106.55 percent, 72.88 to 817.20 g and 1.21 to 2.04 percent, respectively. The average daily weight gain was maximum at 80^{th} day followed by 90^{th} day. The maximum recorded feed conversion ratio was at 10^{th}-20^{th} day duration whereas the minimum feed conversion ratio was estimated at 40^{th}-50^{th} day duration.

Liney et al (2006) observed that *Rutilus rutilus* reared in ~80 percent secondary treated waste water for 300 days showed significantly larger post-hatch than fish reared in the tap water and the ~40% treated waste water. Dasgupta et al (2008) assessed_ water productivity in a controlled carp culture system (silver carp, *catla, rohu* and *mrigal*) in comparison to those involved in a fertilized based one and concluded that the sewage incorporation at 79.3 × 10^5 ha^{-1} yielded similar gross fish production as recorded from fertilizer based system, whereas net water productivity using sewage as nutrient source was found 64 percent higher than that of fertilizer based system. They observed better growth of fish in diluted sewage water than raw sewage water. The growth performance was significantly higher for fishes cultured in sewage treated water as represented in the present study on *P. hypophthalmus*.

Correlation between *Pangasius hypophthalmus* growth parameters and water quality: The sharp drop or an increase in the physico-chemical parameters of water causes stress to the fish which adversely affect its physiology. The weight of *P. hypophthalmus* showed significant positive correlation with temperature (0.96, 0.96), conductivity (0.91, 0.99) and salinity (0.92, 0.95) sewage treated water without feed (Table 4) and sewage treated water with feed, respectively (Table 5). Temperature of the sewage treated water in the aquariums during present study ranged between 23° C to 33.5 °C. In different concentrations (25, 50, 75 and 100%) of sewage water, water temperature ranged from 27.53 to 30.47°C which was considered ideal for carp culture (Jana et al 2016). In the present study, the electrical conductivity of sewage treated water ranged from 2.02 mS/cm to 3.11mS/cm which is higher than reported for freshwater (0.61 to 0.78 mS/cm) (Reecha 2021). In the present investigation, the concentration of total dissolved solid (504 to 776 ppm) in sewage treated water was significantly higher than reported in the freshwater (155 to 248 ppm) (Reecha 2021). Khan et al (2017) recorded in ponds around Gurgaon canal, total dissolved solids was between 653 and740 mg/l. The salinity in the present study ranged from 0.3 to 1.74 ppt which is within permissible levels.

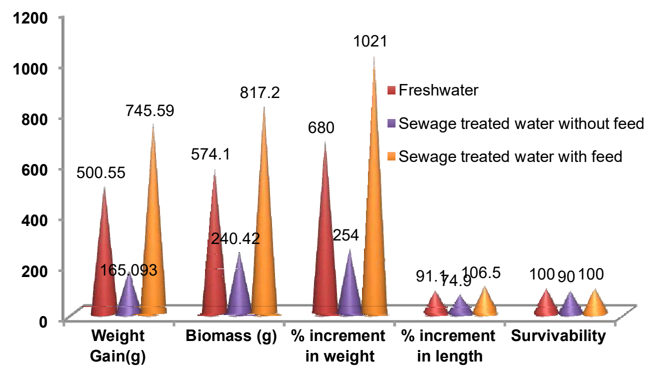

Fig. 1. Comparison of growth parameters of *Pangasius hypophthalmus* in fresh and sewage treated water

Table 4. Correlation between weight of *Pangasius hypophthalmus* (without feed) and sewage treated water quality parameters

Days	Fish weight (g)	Fish length (cm)	Temperature (°C)	Conductivity (ms/cm)	Total dissolved solids (ppm)	Salinity (ppt)	Dissolved oxygen (mg/l)	pH	Ammonia (mg/l)	Nitrite (mg/l)	Hardness (mg/l)	Alkalinity (mg/l)
0	3.77	8.42	23.10	2.02	565.00	0.99	6.00	7.70	0.00	0.00	260.00	180.00
10	4.60	9.22	24.80	2.03	504.00	1.14	3.50	7.80	2.30	0.01	200.00	220.00
20	5.77	10.22	24.80	2.11	528.00	1.19	3.50	7.80	1.50	0.25	174.00	200.00
30	6.25	10.92	24.20	2.19	547.50	1.23	6.50	7.60	0.70	0.21	260.00	180.00
40	7.77	11.43	26.20	2.29	572.50	1.29	7.00	7.40	0.20	0.30	313.00	200.00
50	6.80	10.43	26.60	2.37	592.50	1.33	7.50	7.60	0.20	0.03	310.00	220.00
60	6.80	10.80	26.50	2.62	655.00	1.47	6.50	7.80	0.20	0.01	303.00	220.00
70	8.06	12.31	26.90	2.85	711.50	1.59	6.50	8.30	0.20	0.00	300.00	240.00
80	10.84	13.87	30.10	2.95	737.00	1.65	6.50	8.40	0.20	0.07	303.00	148.00
90	13.36	14.73	30.70	3.11	776.50	1.74	7.50	8.20	0.30	0.03	410.00	180.00
Mean	7.40	11.24	26.39	2.45	618.95	1.36	6.10	7.86	0.58	0.09	283.30	198.80
Correlation with weight			0.96	0.91	0.87	0.92	0.55	0.63	-0.38*	-0.06*	0.79	-0.36*
Correlation with length			0.93	0.92	0.87	0.94	0.52	0.68	-0.37*	-0.01*	0.73	-0.35*

*Non-significant at 5%

Table 5. Correlation between weight of *Pangasius hypophthalmus* (with feed) and sewage treated water quality parameters

Days	Fish weight (g)	Fish length (cm)	Temperature (^oC)	Conductivity (ms/cm)	Total dissolved solids (ppm)	Salinity (ppt)	Dissolved oxygen (mg/l)	pH	Ammonia (mg/l)	Nitrite (mg/l)	Hardness (mg/l)	Alkalinity (mg/l)
0	3.64	8.17	23.00	2.02	565.00	0.99	4.50	7.60	0.00	0.00	260.00	180.00
10	5.82	9.68	24.10	2.03	506.00	1.14	3.00	8.20	2.50	0.05	240.00	200.00
20	6.91	10.58	24.70	2.08	523.00	1.18	3.00	7.80	1.60	0.28	176.00	180.00
30	9.71	11.85	24.90	2.19	548.00	1.23	6.50	7.20	0.80	0.30	280.00	160.00
40	13.32	12.66	26.30	2.21	553.50	1.25	7.50	7.40	0.20	0.40	306.00	240.00
50	17.07	13.29	26.70	2.31	576.50	1.30	6.50	7.80	0.30	0.03	306.00	220.00
60	22.58	14.02	26.80	2.36	589.50	1.33	6.50	7.30	0.30	0.03	292.00	160.00
70	27.48	15.04	27.00	2.48	620.00	1.39	7.50	8.20	0.20	0.01	379.00	280.00
80	34.26	16.06	30.40	2.55	636.50	1.44	6.00	8.10	0.30	0.10	385.00	174.00
90	40.86	16.88	30.70	2.70	675.00	1.51	7.00	8.20	0.20	0.28	407.00	190.00
Mean	7.40	11.24	26.39	2.45	618.95	1.36	6.10	7.86	0.58	0.09	283.30	198.80
Correlation with weight			0.96	0.99	0.94	0.95	0.61	0.45*	-0.48*	-0.01*	0.90	0.13*
Correlation with length			0.95	0.97	0.86	0.99	0.71	0.32*	-0.47*	0.10*	0.86	0.19*

*Non-significant at 5%

Non-significant correlation was recorded with Ammonia and nitrite in sewage treated water without feed and with feed. The total dissolved solids (0.87, 0.94), dissolved oxygen (0.55,0.61) and hardness (0.79, 0.90) of sewage treated water without feed and with feed were positively correlated with *P. hypophthalmus* weight, however, alkalinity of sewage treated water did not show any correlation with weight of *P. hypophthalmus*. The temperature (0.93, 0.95), conductivity (0.92, 0.97) and salinity (0.94, 0.99) of sewage treated water without feed and sewage treated water with feed, respectively showed positive correlation with the length of *P. hypophthalmus*. However, a non-significant correlation was observed between length and water quality of sewage treated water without feed and sewage treated water with feed in terms of its ammonia, nitrite and alkalinity. Data analyzed for the total dissolved solids (0.87, 0.86), dissolved oxygen (0.52, 0.71) and hardness (0.73, 0.86) of sewage treated water without feed and with feed were significant and positively correlated with the length of *P. hypophthalmus*. However, pH of sewage treated water with feed did not affect the length of *P. hypophthalmus*. In contrast, pH of sewage treated water without feed affected the length of *P. hypophthalmus* during the study period.

In the present study, pH ranged from 7.0 to 8.4 which are ideal for fish culture as earlier reported by Santhosh and Singh (2007). The suitable pH range for fish culture is 6.7 to 9.5 and the ideal level is 7.5 to 8.5. Bhatnagar and Devi (2013) observed that ammonia is the by-product of protein metabolism excreted by fish and bacterial decomposition of organic matter such as wasted food, dead plankton, sewage etc. The ammonia concentration in sewage treated water is between 0.00 to 2.5 mg/l during the observation period which is corroborated with earlier studies by Bansal et al. (1997) where the ammonia concentration from 0.2 to 3mg/l was observed in waste fed aquaculture system. In the present study, the levels of hardness in the sewage treated waters remained near to the optimum level throughout the observation period. The alkalinity observed during the study period was 76 to 280 mg/l which was in agreement with studies conducted by Sharma et al. (2019) in sewage treatment plant ranging from 63 to 626 mg/l.

CONCLUSION

The cursory analysis of growth parameters of *P. hypophthalmus* reared in three different treatments (freshwater, sewage treated water without feed and sewage treated water with feed) revealed that the fish is suitable to culture in sewage treated water. Even without any external feeding, the fish was able to thrive in the environment. A higher growth in sewage treated water with feed compared to the freshwater explains the fact that presence of nutrients in the sewage water enhances the planktonic populations which adds up in the effective feeding of the fishes. The culturing the fishes in sewage treated water would help to increase the yield of the fish as well as reduce the dependency of freshwater in fisheries sector production which is an important factor that directly affects the fish's growth rate, health, survival and economics of the system.

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