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"IMPACT OF INDUSTRIAL AND MUNICIPAL DISCHARGES ON GROWTH COEFFICIENT AND CONDITION FACTOR OF MAJOR CARPS FROM LAHORE STRETCH OF RIVER RAVI"

H. A. Shakir and J. I. Qazi

Department of Zoology, University of the Punjab, Lahore Pakistan
Corresponding Author E-mail: ammisheikh@yahoo.com

ABSTRACT

River Ravi, Pakistan is just like a wastewater carrier due to anthropogenic activities. This study investigate the growth profile of *Catla (C) catla*, *Cirrhinus (C) mrigala* and *Labeo (L) rohita* netted from three downstream polluted sites; Shahdera: B, Sunder: C and head Balloki: D and compared with less polluted site, Siphon: A (control) upstream during low (winter) and high (post monsoon) flow seasons of river Ravi. Weight and total length of sampled specimens were not significantly different ($P>0.05$) in different seasons and sites. Condition factor (K) in *C. mrigala* was estimated as 0.97-1.05, *L. rohita* 1.03-1.18 and for *C. catla* 1.14-1.27. Log transformed regression were used to test the growth. Growth coefficient (b) were measured highest 3.19 and 3.16 in *C. mrigala*, 3.21 and 3.17 in *L. rohita*, 3.16 and 3.11 for *C. catla* at control site while lowest in *C. mrigala* 3.08 and 3.07, *L. rohita* 3.08 and 3.06, in *C. catla* 3.03 and 3.01 at site C during high and low flow respectively. The 'b' results ($P<0.001$) represented positive allometric growth pattern with lower value during low flow than high flow season in sampled species. Reduction in 'b' value in downstream polluted sites indicated adverse effect of aquatic pollution on fish growth. However, the last downstream sampling locality showed more or less stabilized situation with a small recovery as compared to third study area. Further large scale studies covering long distances downstream from the city Lahore may reveal pollutants stresses' recovery level or otherwise situation of inhabitant fish species.

Key words: Municipal sewage, industrial effluents, carp fish species, growth, river Ravi, Pakistan.

INTRODUCTION

With blowing up human population and increasing industrialization and urbanization, water contamination by agriculture, sewage and industrial sources has a major concern. In developing countries, heavy industrial developments, albeit meet the needs of increasing populations, have been contaminating rivers through effluents loaded with different chemicals. River Ravi in Pakistan is one of the example which is deteriorating due to high influx of untreated urban sewage and industrial effluents. There are many industrial and municipal sources which are leading to increased level of metals in water, sediments and rivers inhabitant organisms (Rauf, *et al.,* 2009; Jabeen, *et al.*, 2012). There are seven major pumping stations discharging municipal sewage of Lahore city (Second largest city of Pakistan) into the river. Furthermore there are two drains (Hudiara Drain loaded with around 212 industries effluents situated in India and Pakistan. Deg Nullah carries the effluents from more than 149 industrial units) dispose off industrial effluents into river Ravi (Saeed and Bahzad, 2006).

Municipal and industrial toxicants, such as metals pose serious risk to many fish species and are regarded to be cytotoxic, mutagenic and carcinogenic (More, *et al.,* 2003). Metals affect fish morphology, growth, feeding, biochemical process, physiology, reproduction (Kerambrun, *et al.,* 2011; Kuz'mina, 2011; Yousafzai and Shakoori, 2011) and cause detrimental effects on health and wellbeing (Vosyliene and Jankaite, 2006). Fish growth is considered as biomarker for riverine pollution because it integrates all effects within fish. Understanding of the growth in fish is very important for more specific fishery management. The growth curve appears as a sigmoid one, which may vary for the same fish at different seasons or for the same fish from different localities. Metals stressed fish reduce feeding uptake in start and short toxicant exposure (Kuz'mina, 2011) but feed uptake increased when exposure prolonged with reduced food consumption and assimilation suggested that catabolic process exceed than anabolic process and resultantly reduced growth of the exposed fish, *C. mrigala, C. catla* and *L. rohita* (Hussain, *et al*., 2010, 2011).Water pollution due to heavy metals and their metabolites has been reported to exert deleterious effects by inhibiting growth rate of fish (Jezierska and Witeska, 2001; Hayat, *et al*., 2007), affecting negatively gonads' maturation and reproduction (Farag, *et al.,* 1995; El-Boray, *et al.,* 2003), changing spawning behaviour, duration and number of eggs per spawn (Barakat, 2004), affecting adversely the egg and embryo viability (Speranza, *et al.,* 1997), survival of fry (Norberg-king, 1989; Barakat, 2004) and reducing the development and fish survival, especially at the beginning of exogenous feeding (Stominska and Jezierska, 2000).

For these reasons, information about the effects of anthropogenic pollution on freshwater ecosystems is very important because metallic toxicity become more severe day by day due to ill-management of effluents dispose off in adjacent areas of river Ravi. Indian major carps *(C. catla, L. rohita, C. mrigala*) are preferable fish species among human inhabitants of the river's surrounding area due to their delicious taste. Since the carps' natural breeding requires a riverine environment and it does not occur within ponds, it is vital for the concerned authorities to maintain fish health and reproduction through regular assessment of the growth of these species. The present investigation was undertaken to assess the impact of industrial pollution and municipal discharge on growth coefficient and condition factor of *C. mrigala*, *L. rohita* and *C. catla* inhabitant of up and downstream sites at different flow seasons of the Lahore stretch of river Ravi.

MATERIALS AND METHODS

Study area: During its course through Lahore, the second largest and an industrial city of Pakistan, the river Ravi gets heavily contaminated with industrial as well as domestic origin effluents. Major domestic sewage pumping stations and industrial effluents inlets are shown in fig. 1. As can been seen from this figure, fishes were sampled from four localities. Brief description of the same sampling sites had been earlier described by Shakir *et al*. (2013).

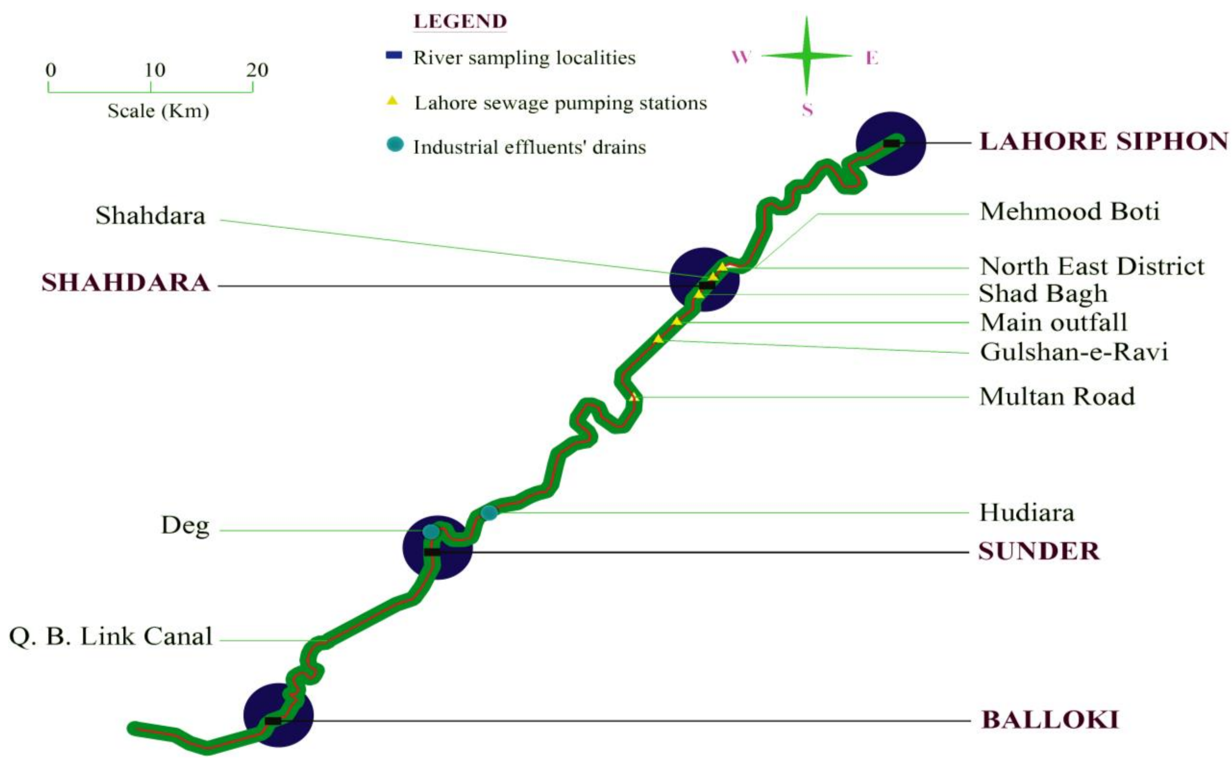

Figure 1 Map of the river Ravi Lahore stretch showing four study sites and major urban pollution

Fish Sampling: Two hundred and sixteen representative fish specimen thaila, *C. catla* (surface feeder) rohu, *L. rohita* (column feeder), mori, *C. mirgala* (bottom feeder) weighing from 250 to 1000 g were collected from the selected four sites during high (Sep.-Oct. 2010) and low (Nov.-Dec. 2009) flow seasons of river Ravi. Patti (gill nets) of about 6 feet wide and 40 feet long with a cork line at the top rope and metal line with the ground nylon rope made locally were used by professional local fishermen. The nets were set at sampling site approximately 3-4 hours before sunset and lifted 1-2 hours after sunrise. The four fishermen on two wooden boats shared a single patti (net). To reduce the unnecessary disturbance and stress, motor-driven boats were not used, as the fish would be disturbed with sound from engine. Nine fish specimen each of the three species of comparable size range for a given collection were saved from triplicate netting per site. Each fish specimen was washed with water, kept in separate polythene bags placed on ice immediately transported to the laboratory.

Measurement of morphometric characters: In laboratory, each specimen was subjected to morphometric studies after coding in the same day of sampling. The morphometric measurements of each specimen were recorded using scale, length measuring tray, length measuring tape, Vernier caliper and electronic digital top-pan balance (Chyo, Japan). The wet weight of fish after blot-drying excess water in the body and total length i.e., from the tip of the snout to distal end of the caudal fin ray were measured. The relationship between wet weight (W) in g and total length (TL) in cm typically taken by the exponential form $W= a(TL)^b$ or in linear form (Regression equation) Log W=log a + b log L where a =intercept = regression coefficient, b = slope = growth factor/growth coefficient. Condition factor (K) were calculated by standard relation (Carlender, 1970) $K= (W \times 100)/ (TL)^3$

Statistical analysis: The data were statistically analyzed by using the general linear model (Minitab software 16) to compare the effects of different sampling sites, season, and fish species on different morphometric parameters. Here if potential variations for these components were linked to the variations between the sites, seasons, these effects were declared low significant if $P<0.05$; significant if $P<0.01$ and highly significant if $P<0.001$. The growth coefficient and exponential equation were calculated using regression analysis (Minitab software 16) for each fish species in two flow seasons at each sampling site.

RESULTS AND DISCUSSION

Total length and weight were not significantly different ($P>0.05$) at different sites and flow season (table 1). The mean weight range between 636-650g and 652-665g in *C. mrigala,* 627-641g and 634-647g in *L. rohita,* 621-641g and 633-643g in *C. catla* and length range between 39.5- 40.2g and 39.5-40.3g in *C. mrigala,* 37.4-37.6g and 37.7-38.1g in *L. rohita,* 36.7-37.2g and 36.5-36.8g in *C. catla* were measured during high and low flow of the Ravi, respectively. The high degree of correlation between total length and weight of all three fish species is indicated by their high value of correlation coefficient (r). These high values of 'r' (nearly one) depict high precision in regression equations (table 2). Growth coefficient (b) ranged between 3.08-3.19 and 3.07-3.16 were recorded in *C. mrigala*, 3.08-3.21 and 3.06-3.17 in *L. rohita,* 3.03-3.16 and 3.01-3.11 in *C. catla* during high and low flow respectively. The value of 'b' in studied fish species indicated positive allometric growth as described by wootten (1998) that if 'b' significantly larger or smaller than 3.0 represent allometric growth and a value greater than 3 indicates that the fish becomes heavier (positive allometric) for its length. Apart from present study, many researchers have reported allometric growth in same or different fish species (Salam and Janjua, 1991; Zafer, *et al*., 2003; Shakir, *et al*., 2008). In present study, 'b' was measured highest 3.19 and 3.16 in *C. mrigala*, 3.21 and 3.17 in *L. rohita*, 3.16 and 3.11 for *C. catla* at site A while lowest in *C. mrigala* 3.08 and 3.07, *L. rohita* 3.08 and 3.06, in *C. catla* 3.03 and 3.01 at site C during high and low flow respectively. The trend of 'b' is noticeable in this study for sampled fishes which was reduced up to site C and then more or less stabilized at site D and rather showed a small recovery as compared to third study areas in comparison with control (site A) during low flow as well as high flow. The fluctuation in 'b' value at different polluted sites refers toxicant effluents discharge have negative bearing on growth compared to less polluted site (control). The result is in line of Rao *et al.* (2005) which reported the variation in 'b' of *Liza parsia* (Hamilton-Buchanan) from the polluted sampling station (b=2.50) in comparison with unpolluted sampling station (b=2.52). Rauf *et al.* (2009) described heavy metal contamination in the sediment of river Ravi (Lahore Siphon to Balloki headworks) and reported highest concentration of copper in Taj Company nulla, while minimum concentration of cadmium at Lahore Siphon. Jabeen *et al*., (2012) reported that toxicity of metals fluctuated significantly in sampling fish species at all the three sampled stations viz. Shahdara bridge, Balloki headworks and Sidhnai barrage with season. These workers documented that health status of river Ravi at three main public fishing sites, with respect to eco-toxicity of Al, As, Ba, Cr, Ni and Zn was above the recommended permissible standards. The significant decrease in the value of 'b' of fish sampled from site B, C, D (fig. 2) represent reduction in weight gain as compared to control fish which is related to metal toxicity stress as reported by Hassain *et al.* (2010) in *C. mrigala* during metal mixture exposure. However, it was also observed by Giguere *et al.* (2004) that controlled fish species gain significantly more weight than stressed fish *(Perca flavescens)*. In present investigation, the value of 'b' were lower during low flow than high flow in all fish species (table 2). Seasonal variation reinforce the pollutant effects on fish species as suggested by Iman *et al.* (2010) that *Tilapia zilli*, *Oreochromis niloticus, Hemichromis bimaculatus* and *Clarias gariepinus* showed low 'b' value in dry season than wet season in Wasai reservoir, Nigeria.

Condition factor (K) is an indicator of fish plumpness and favorable environment condition. The values of 'K' significantly differed at different sites, seasons and fish species. Mean 'K' in *C. mrigala* (1.00) was measured while in *L. rohita* (1.16) and in *C. catla* (1.24) (table 1). 'K' range was found to be greater than 1 for *L. rohita* (1.03-1.18) and *C. Catla* (1.14-1.27) but 'K' fluctuate between 0.97- 1.05 with mean 'K' value at site A (0.98), B (1.0), C (1.04) and D (0.98) in *C. mrigala*. Nikos (2004) reported that fish adequately fed had 'K' greater than 1 while undernourished fish had a 'K' less than 1. Present study results are within the range of *C.*

catla (1.16) and *C. mrigala* (1.08) reported by Memon *et al.* (2011) for *C. mrigala*, *L. rohita* and *C. catla* raised under control condition. Fish with high value of K are heavy, while fish with a low K value are lighter for its length (Wootton, 1998). K fluctuated between fish species and within fish species due to feeding differences, climate and environmental conditions, (Lizama *et al.*, 2002). The three Indian major carps in the present study reported are herbivores and increase in 'K' at downstream sites (table 1) might be indication of better food due to increase in primary and secondary productions which in turn can be associated with presence of cattle farms along the river Ravi and fertilizers' run off as indicated by downstream elevated values of nitrate, nitrite and phosphate (Shakir, *et al.*, 2013). Abid and Ahmed (2009) reported that the growth performance in fish, *Labeo rohita* is associated with diet.

On the other hand, the higher K values at highly polluted sites in comparison with control refer the disturbance in fish physiology and biochemistry as suggested by Hedayati and Safahieh (2011) that toxic substance in yellowfin seabream caused several changes in the enzymatic, biochemical and hormonal parameters of the experimental fish. Biochemical responses can be affected by environmental factors, such as Physico-chemical profiles of aquatic medium, seasons, fish nutrition status, age and health (Lohner, *et al.*, 2001). Metal' stressed fishes, *C. mrigala*, *L. rohita* and *C. catla* showed higher feed intake than control (Hassain, *et al.*, 2010, 2011). Higher feed intake refers to disturbance in metabolism. Variations in the energy reserves (carbohydrates, protein and lipids) are indicative of long term exposure of toxicant stressor (Mayer, *et al*., 1992).

Table 1 Mean weight, total length and condition factor of sampled fish species from four sampling sites, seasons with standard error of means and significance.

Fish Species	Biometric data	Sampling sites				Flow Season		SEM and Significance	
		Siphon	**Shahdera**	**Sunder**	**Balloki**	**Low**	**High**	**Sites**	**Season**
Cirrhinus mrigala	Total length	40.23	39.89	39.47	40.04	39.98	39.84	0.881	0.623
	Weight	650.17	650.67	655.83	647.67	657.42	644.75	43.956	31.081
	Condition factor	0.97	1.00	1.04	0.98	1.00	0.99	0.009***	0.006
Labeo rohita	Total length	37.67	37.81	37.64	37.58	37.80	37.55	0.831	0.588
	Weight	630.28	640.50	644.11	632.28	640.58	633.00	42.227	29.859
	Condition factor	1.15	1.15	1.18	1.16	1.16	1.17	0.013	0.009
Catla catla	Total length	36.88	37.00	36.93	36.57	36.68	37.01	0.838	0.593
	Weight	627.11	638.56	641.78	630.50	637.22	631.75	42.727	30.213
	Condition factor	1.22	1.23	1.24	1.26	1.26	1.21	0.011	0.008***

Here *** represent significance at P<0.001.

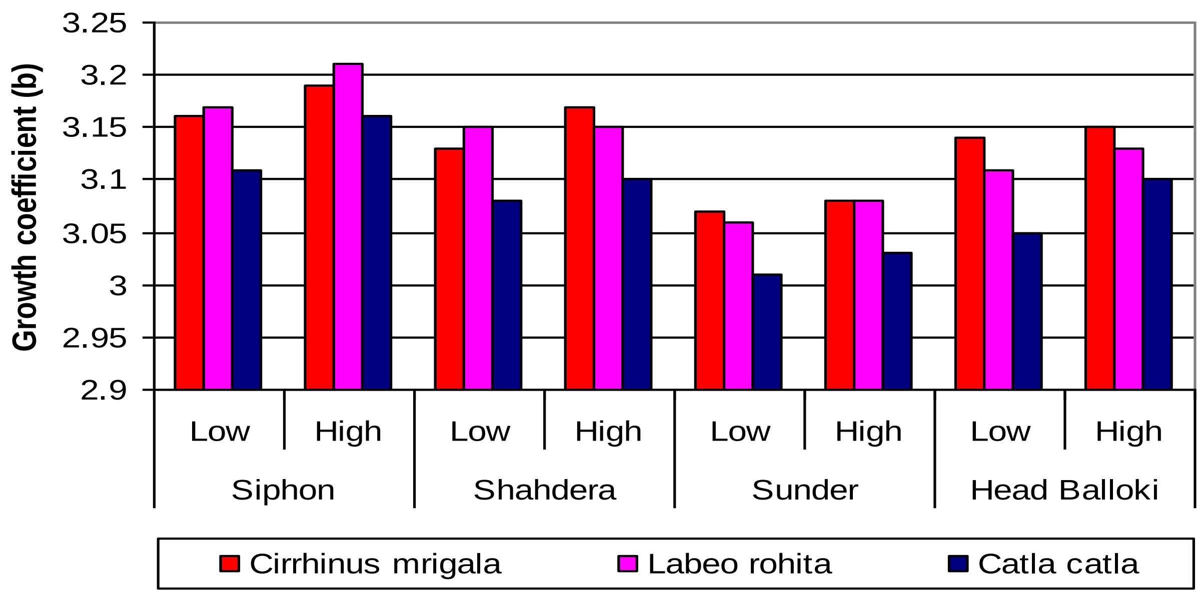

Figure 2 Growth coefficient (b) of sampled fish species from selected sampling sites with flow seasons

Table 2 Mean weight, total length, condition factor and regression equation with significance for sampled fish species from four sampling sites and seasons.

Site	Flow Season	Weight (g) Range (Mean± SEM)	Length (cm) Range (Mean± SEM)	Condition factor (K) g/cm^3 Range (Mean± SEM)	Regression equation Log W=Loga + bLogL	Exponential equation $W_t=a(TL)^b$	r	P
				Cirrhinus mrigala				
A	Low	413-965 (650±61.3)	34.5-45.2 (40.3±1.19)	0.92-1.04 (0.97±0.014)	Log W = - 2.28 + 3.16Log L	$W_t = 0.00531(TL)^{3.16}$	0.980	<0.001
	High	358-903 (650±62.0)	33.3-44.9 (40.2±1.26)	0.91-1.03 (0.98±0.012)	Log W = - 2.31 + 3.19Log L	$W_t = 0.00485(TL)^{3.19}$	0.990	<0.001
B	Low	410-917 (665±61.8)	34.2-44.9 (39.9±1.22)	0.93-1.07 (1.02±0.013)	Log W = - 2.20 + 3.14Log L	$W_t = 0.00628(TL)^{3.14}$	0.985	<0.001
	High	381-932 (636±62.2)	33.8-45.4 (39.8±1.24)	0.89-1.01 (0.98±0.014)	Log W = - 2.28 + 3.17Log L	$W_t = 0.00522(TL)^{3.17}$	0.982	<0.001
C	Low	409-935 (662±63.1)	33.5-44.3 (39.5±1.25)	0.98-1.10 (1.05±0.013)	Log W = - 2.10 + 3.07Log L	$W_t = 0.00800(TL)^{3.07}$	0.985	<0.001
	High	375-915 (649±59.5)	33.2-44.9 (39.5±1.23)	0.99-1.07 (1.03±0.008)	Log W = - 2.12 + 3.08Log L	$W_t = 0.00760(TL)^{3.08}$	0.995	<0.001
D	Low	369-907 (652±64.4)	33.9-44.5 (40.2±1.30)	0.88-1.05 (0.98±0.016)	Log W = - 2.24 + 3.14Log L	$W_t = 0.00581(TL)^{3.14}$	0.975	<0.001
	High	371-948 (643±62.8)	33.5-45.2 (39.9±1.27)	0.94-1.03 (0.99±0.011)	Log W = - 2.24 + 3.15Log L	$W_t = 0.00575(TL)^{3.15}$	0.990	<0.001
				Labeo rohita				
A	Low	367-879 (634±58.0)	32.7-41.9 (37.7±1.14)	1.05-1.20 (1.15±0.015)	Log W = - 2.20 + 3.17Log L	$W_t = 0.00626(TL)^{3.17}$	0.985	<0.001
	High	329-863 (627±59.4)	32.1-41.7 (37.6±1.16)	0.99-1.24 (1.15±0.027)	Log W = - 2.26 + 3.21Log L	$W_t = 0.00545(TL)^{3.21}$	0.952	<0.001
B	Low	364-886 (645±60.8)	32.5-42.7 (38.1±1.20)	1.06-1.20 (1.14±0.013)	Log W = - 2.17 + 3.15Log L	$W_t = 0.00670(TL)^{3.15}$	0.989	<0.001
	High	348-898 (636±60.6)	32.2-41.9 (37.5±1.18)	1.04-1.26 (1.17±0.021)	Log W = - 2.19 + 3.17Log L	$W_t = 0.00640(TL)^{3.17}$	0.971	<0.001
C	Low	404-879 (647±60.7)	32.9-41.9 (37.7±1.18)	1.12-1.21 (1.18±0.012)	Log W = - 2.03 + 3.06Log L	$W_t = 0.00938(TL)^{3.06}$	0.989	<0.001
	High	392-889 (641±60.9)	32.5-42.2 (37.6±1.20)	1.13-1.22 (1.18±0.011)	Log W = - 2.12 + 3.08Log L	$W_t = 0.00760(TL)^{3.08}$	0.995	<0.001
D	Low	398-862 (636±57.5)	33.1-42.5 (37.7±1.13)	1.10-1.22 (1.16±0.014)	Log W = - 2.11 + 3.11Log L	$W_t = 0.00773(TL)^{3.11}$	0.985	<0.001
	High	321-872 (628±59.8)	31.7-41.9 (37.4±1.20)	1.01-1.28 (1.17±0.028)	Log W = - 2.14 + 3.13Log L	$W_t = 0.00728(TL)^{3.13}$	0.948	<0.001
				Catla catla				
A	Low	350-882 (633±61.0)	30.1-41.2 (36.7±1.18)	1.16-1.29 (1.24±0.017)	Log W = - 2.08 + 3.11Log L	$W_t = 0.00838(TL)^{3.11}$	0.984	<0.001
	High	316-859 (621±61.3)	30.4-41.8 (37.0±1.25)	1.12-1.27 (1.19±0.016)	Log W = - 2.18 + 3.16Log L	$W_t = 0.00667(TL)^{3.16}$	0.988	<0.001
B	Low	368-875 (639±61.1)	30.5-41.3 (36.8±1.18)	1.19-1.30 (1.25±0.015)	Log W = - 2.03 + 3.08Log L	$W_t = 0.00928(TL)^{3.08}$	0.988	<0.001
	High	358-902 (638±61.4)	31.4-42.2 (37.2±1.21)	1.14-1.26 (1.20±0.013)	Log W = - 2.08 + 3.10Log L	$W_t = 0.00840(TL)^{3.10}$	0.990	<0.001
C	Low	385-856 (643±58.5)	30.6-40.7 (36.7±1.14)	1.20-1.34 (1.27±0.015)	Log W = - 1.92 + 3.01Log L	$W_t = 0.01206(TL)^{3.01}$	0.986	<0.001
	High	364-873 (641±59.5)	30.9-41.4 (37.1±1.19)	1.18-1.28 (1.22±0.010)	Log W = - 1.96 + 3.03Log L	$W_t = 0.01091(TL)^{3.03}$	0.993	<0.001
D	Low	361-869 (634±60.0)	29.8-40.9 (36.5±1.15)	1.18-1.40 (1.27±0.026)	Log W = - 1.98 + 3.05Log L	$W_t = 0.01049(TL)^{3.05}$	0.960	<0.001
	High	349-886 (627±60.5)	30.6-41.5 (36.7±1.19)	1.20-1.31 (1.24±0.012)	Log W = - 2.07 + 3.10Log L	$W_t = 0.00852(TL)^{3.10}$	0.993	<0.001

The present study reveals the adverse effect of river Ravi pollutants especially at site C on growth and health status of inhabitant fish species. The growth coefficient results warrant for immediate measures to save the river's ecological role by keeping it free from the untreated effluents' pollution. This information helps Government authorities to assess the effluents discharge affects on aquatic fauna. Further downstream large scales studies may are imperative to assess growth performance and health aspects of same fishes and other fish species from different sites of studied river.

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