VOLUME 8 ISSUE 1 2022

ISSN 2454-3055

INTERNATIONAL JOURNAL OF ZOOLOGICAL INVESTIGATIONS

Forum for Biological and Environmental Sciences

Published by Saran Publications, India

International Journal of Zoological Investigations Vol. 8, No. 1, 447-454 (2022)

International Journal of Zoological Investigations
Contents available at Journals Home Page: www.ijzi.net
Editor-in-Chief: Prof. Ajai Kumar Srivastav
Published by: Saran Publications, Gorakhpur, India

ISSN: 2454-3055

Distillery Effluent Affects Condition Factor and Organosomatic Index of the Fish *Mystus vittatus*

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Received: 10th March, 2022; **Accepted:** 30th March, 2022; **Published online:** 11th April, 2022

https://doi.org/10.33745/ijzi.2022.v08i01.050

Abstract: The distillery unit or chemical division of Balrampur Chini mill, Balrampur discharges its effluent directly into river Sawan, a tributary of river Rapti at the downstream. Biomarker or physical indices act as indicator of stress that is somehow affecting the organism ability to grow, reproduce, survive and adapt in a given environment. The present investigation was designed to study the effect of sublethal concentrations (10% 20% and 30%) of distillery effluent on the health indices like condition factor, hepatosomatic and gonadosomatic index of *Mystus vittatus* after exposure to 30 days. The result of present investigation showed that all the four parameters (CF, HSI, GSI and oxygen consumption rate) decreased significantly ($P<0.05$) as compared to control. Changes in, CF, HSI, GSI and oxygen consumption rate might reflect metabolic and physiologic disturbances under the effect of industrial effluent. So changes in these indexes were used to determine and monitor the industrial effluent toxicity in aquatic animals. Thus, this paper gives an overview of the manipulation of fish, *Mystus vittatus* as a biomarker of industrial effluent through alterations in condition factor, hepatosomatic, gonadosomatic index and oxygen consumption rate.

Keywords: Distillery effluent, *Mystus vittatus*, Condition factor, Hepatosomatic index, Gonadosomatic index, Oxygen consumption rate

Citation: Tiwari Santosh Kumar and Prakash Sadguru: Distillery effluent affects condition factor and organosomatic index of the fish *Mystus vittatus*. Intern. J. Zool. Invest. 8(1): 447-454, 2022.
https://doi.org/10.33745/ijzi.2022.v08i01.050

Introduction

The natural aquatic system is getting extensively contaminated with toxic materials released from both naturally occurring and anthropogenic sources. These potentially toxic substances enter into the body of aquatic animals via food, skin and water and are detoxified in their body's organs by various mechanisms. The level of detoxification depends upon type of toxic material, its concentration, exposure period and various environmental factors. Industrial waste water may have devastating impacts on the ecological balance of the recipient habitats and their diversity. Aquatic organism uptake pollutants or toxicants directly from their surrounding environment through food chain. These excess amounts of toxic substances are accumulated in various tissues which result in loss of appetite, growth, reproduction and metabolic disorders along with changes in biochemical and hematological parameters as well as physiologic functions as a result of weakening of immune system. Although these effects show differences among the species, they may alter the status of a population and energy flow within the ecosystem, thus resulting disturbances in ecological balance. Thus, polluted water may lead to the destruction of the beneficial species either directly by affecting the aquatic forms of life or indirectly through breaking the biological food chains such as fish and their habitat and behavioral pattern.

Among the aquatic fauna, fish appear to be particularly susceptible to industrial effluents toxicity as they are continually exposed to it through gills, skin and intake effluent contaminated food. Thus, it may not only provide insight into overall aquatic health but may also act as a biomarker or sentinel for potential impacts on food chain (Verma and Prakash, 2019). Sensitivity of fish to industrial effluent in terms of 96 h LC_{50} depends upon the concentrations and nature of effluents discharged by the industries, exposure periods, and fish species exposed because the indigenous as well as exotic carps were susceptible to industrial waste water than catfishes and air-breathing fishes due to their physiological condition (Tiwari and Prakash, 2021).

Biomarker is an indicator of stress that is somehow affecting the organism's ability to grow, reproduce, survive and adapt in a given environment. Some physical indices such as Condition factor (CF), Hepatosomatic index (HSI) and Gonadosomatic index (GSI) of an animal act as biomarker and have been routinely used in monitoring the health status of animal. The condition factor, hepatosomatic and gonadosomatic index reflect the growth, metabolic and reproductive status of an organism, respectively. So changes in these indexes were used to determine and monitor the industrial effluent toxicity in aquatic animals. Although, CF, HSI and GSI are responsive to pollution but they can also be affected by other factors like temperature and food availability. Very few fish toxicologists had used these condition indices as a biomarker of fish health in relation to industrial pollution. The presence of any toxic material in the medium induces the surfacing activity of aquatic animals due to enhanced oxygen demand for respiration, so determination of Oxygen uptake by aquatic animal can also be used as biomarker of pollution level of waterbodies.

Changes in biological functions of aquatic animals including fish under the effect of effluent allow in determining the health condition of fish which also reflect the state of pollution in the environment. Present study was undertaken to determine the impact of distillery effluent on condition factor, hepatosomatic and gonadosomatic index as well as oxygen uptake rate of *Mystus vittatus*.

Materials and Methods

The healthy *Mystus vittatus* (7.0-8.0 cm; 8.0-9.0 g) were collected from local freshwater ponds of Balrampur and washed with 1% solution of $KMnO_4$ for 5 min to remove dermal infection and then transferred to the plastic jar containing 50 L dechlorinated tap water for acclimatization. Fish were acclimated to laboratory conditions for 15 days at room temperature and were fed daily on commercially available food.

The LC_{50} value of distillery effluent for *Mystus vittatus* at 96 h has been reported as 3.38% (v/v) (Tiwari and Prakash, 2021). Based on 96 h LC_{50}, fish were exposed to sublethal concentrations (2.0%, 2.5% and 3.0% v/v) for the period of 30 days. A control group was maintained in an identical environment. The fish were regularly fed once a day in amounts 2% of their total body with commercial food and the medium was changed once in every two days to maintain the concentration of effluent and also to remove metabolic wastes.

For determination of condition factor, hepatosomatic and gonadosomatic index, the fish were taken out from each jar at the end of exposure periods (10, 20 and 30 days) and were anaesthetized using ethylene glycol monophenyl ether. Fish were then washed with tap water, dried with Whatman paper to remove residues from their skin and their total length and weight were determined. Weights of the liver and gonad tissues were also determined after dissecting from each fish. Total length, weight and organ weight values were used to determine the hepatosomatic index (HIS), gonadosomatic index (GSI) and condition factor (CF) of fish by using the following formula:

$$\% \text{ HSI} = \frac{\text{Liver weight (g)}}{\text{Total Body weight (g)}} \times 100$$

$$\% \text{ GSI} = \frac{\text{Gonad weight (g)}}{\text{Total Body weight (g)}} \times 100$$

$$\% \text{ CF} = \frac{\text{Total Body weight (g)}}{\text{Total Length}^3 \text{ (cm}^3\text{)}} \times 100$$

The oxygen consumption by fish was determined by using standard methods (Sharma and Kumar, 2013). The rate of oxygen uptake per gram weight of fish per hour was calculated at 24, 48, 72 and 96 h after distillery effluent exposre and the values are expressed as $mlO_2/g/h$.

All data have been presented as mean ± standard error. Statistical significance between control and experimental group was calculated by student's t- test.

Results and Discussion

Physical and chemical alterations occurring in the environment cause stress in aquatic animals which in turn results in metabolic, physiologic, biochemical, behavioural changes that have negative effects on growth, development and reproduction (Heath, 1995). The present study showed that condition factor (CF), hepatosomatic index (HSI) and gonadosomatic index (GSI) were significantly decreased in distillery effluent exposed fish (Table1).

Condition factor (CF) is a useful index for monitoring of feeding intensity and growth rates in fish. It provides only the general well-being of the fish or used to assess the growth conditions of the fish. It is strongly influenced by both biotic and abiotic environmental conditions and can be used as an index to access the states of aquatic ecosystem in which fish live (Prakash and Verma, 2019). A high value of condition factor reflects good environmental quality, while a low value of condition factor reflects poor environmental quality. Thus, it reflects the impact of water quality on the general health state of fish which differs according to the environmental factors, age, sex and reproduction period.

In the present study condition factor significantly decreases in distillery effluent exposed fish, *Mystus vittatus* (Fig. 1). This decrease in condition factor may be due to increase in metabolic rate, enhancement of fat metabolism as part of toxic action and decline in stored glycogen in liver. Condition factor has been reported to be decreased in *Gobio gobio* (Bervoest *et al.,* 2003), *Gasterosteus aculeatus* (Sanchez *et al*., 2008) and *Mystus vittatus* (Verma and Prakash, 2019) whereas increased in *Astyanax fasciatus* (Alberto *et al*., 2005) and not affected in *Clarias gariepinus* under the effect of heavy metals (Hmound, 2011). El-Serafy *et al*. (2013) reported that the condition factor decreased in fish exposed to heavy metal Cu and Cd. Thus, it can be concluded that the decrease in condition factor under the effect of distillery effluent might be a result of loss in appetite or excessive use of energy to compensate requirements.

Hepatosomatic index (HSI) is the main indicator of metabolic activity in animals. It provides more specific information relating to the function of liver in response to the pollution. In a poor environment, fish usually have a smaller liver (with less energy reserved in the liver). It is more advantageous over

Table 1: Effects of sublethal concentrations of distillery effluent on Condition factor, Hepatosomatic index and Gonadosomatic index of *Mystus vittatus* (N=6)

Parameters	**Experimental Group**	**Exposure periods in days**		
		10	**20**	**30**
Condition factor (CF)	Control	1.73±0.25	1.76±0.26	1.80±0.31
	2.0 %	1.65±0.35 (-4.62%)	1.51±0.22* (-14.20%)	1.38±0.23* (-23.33%)
	2.5 %	1.55±0.23 (-10.40%)	1.42±0.25* (-19.31%)	1.30±0.18** (-27.77%)
	3.0%	1.46±0.31 (-15.60%)	1.33±0.27* (-24.43%)	1.22±0.27** (-32.22%)
Hepatosomatic index (HSI)	Control	1.65±0.22	1.66±0.14	1.64±0.21
	2.0 %	1.60±0.12 (-3.03%)	1.53±0.27* (-7.83%)	1.47±0.11* (-10.36%)
	2.5 %	1.55±0.11 (-6.06%)	1.46±0.24* (-12.05%)	1.32±0.22** (-19.51%)
	3.0%	1.48±0.16 (-10.30%)	1.38±0.23* (-16.87%)	1.29±0.19** (-21.34%)
Gonadosomatic index (GSI)	Control	0.59±0.11	0.61±0.16	0.62±0.13
	2.0 %	0.55±0.27 (-6.78%)	0.52±0.21 (-14.75%)	0.50±0.17* (-19.35%)
	2.5 %	0.46±0.11 (-22.33%)	0.42±0.21* (-31.15%)	0.39±0.22** (-37.10%)
	3.0%	0.41±0.21 (-30.51%)	0.38±0.19* (-37.70%)	0.35±0.13** (-43.55%)

*Significant at P<0.05 ; ** significant at P< 0.01

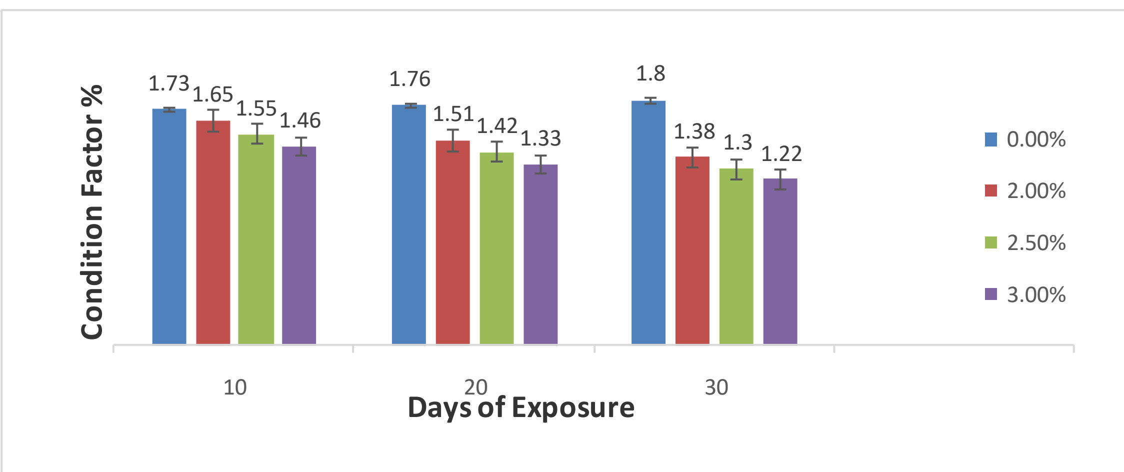

Fig. 1: Effect of distillery effluent on condition factor of *Mystus vittatus.*

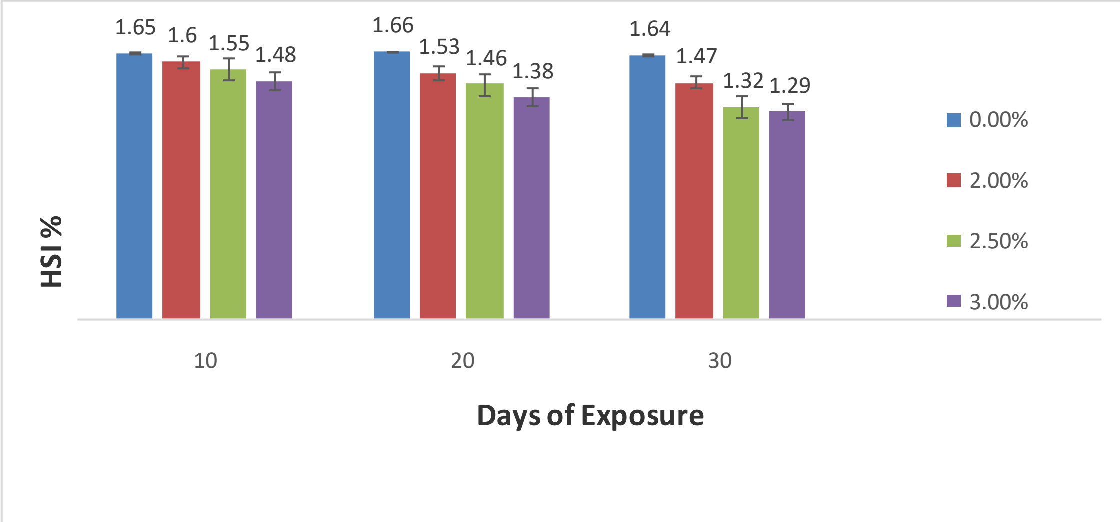

Fig. 2: Effects of distillery effluent on hepatosomatic index of *Mystus vittatus*.

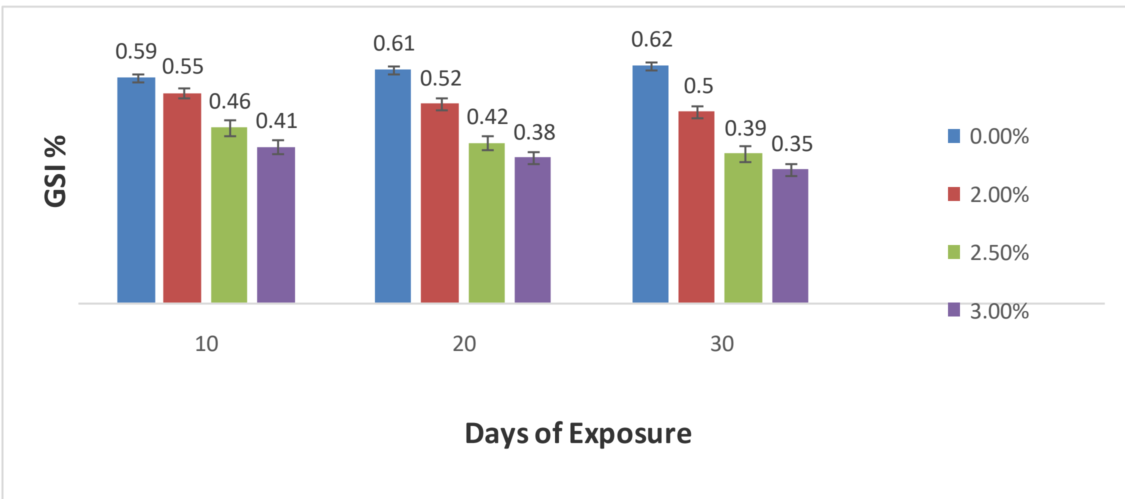

Fig. 3: Effects of distillery effluent on gonadosomatic index of *Mystus vittatus*.

condition factor since liver plays a central role in detoxification of contaminants. In the present study hepatosomatic index of distillery effluent exposed fish, *Mystus vittatus* significantly decreased (Fig. 2) due to decrease in liver size. Bekmezci (2010) and Verma and Prakash (2019) have reported that heavy metals decreases the hepatic somatic index of *Clarias gariepinus* and *Mystus vittatus,* respectively probably due to depletion of energy reserves in liver. El-Serafy *et al*. (2013) reported that the HSI decreases in fish exposed to heavy metal Cu and Cd. Thus stress condition developed under the effect of metals and the excess usage of energy reserves in response to increase in requirement might cause the decrease in hepatosomatic index.

Gonadosomatic index (GSI) is other important parameter that reflects both the state of population for the continuity of generation and changes in organisms under the effect of pollutant. In the present study gonadosomatic index decreased in distillery effluent exposed fish, *Mystus vittatus* (Fig. 3). GSI decreased in *Mullus barbatus* under the effect of heavy metals, possibly due to

Table 2: Alterations in the Oxygen uptake (O_2ml/g/h) of *Mystus vittatus* at sublethal concentrations of distillery effluent (N=6)

Experimental group	Exposure Periods (Hours)			
	24	48	72	96
Control	0.612±0.53	0.609±0.34	0.605±0.27	0.604±0.14
2.0 %	0.557±0.31 (-8.99%)	0.532±0.39 (-12.64%)	0.492±0.42 (-18.68%)	0.412±0.22 (-31.78%)
2.5%	0.472±0.31 (-22.88%)	0.373±0.25 (-38.75%)	0.358±0.12 (-40.82%)	0.318±0.31* (-47.35%)
3.0%	0.319±0.41 (-47.88%)	0.289±0.33* (-52.54%)	0.211±0.21** (-65.12%)	0.201±0.27** (-66.72%)

*Significant at P<0.05 ; ** significant at P< 0.01

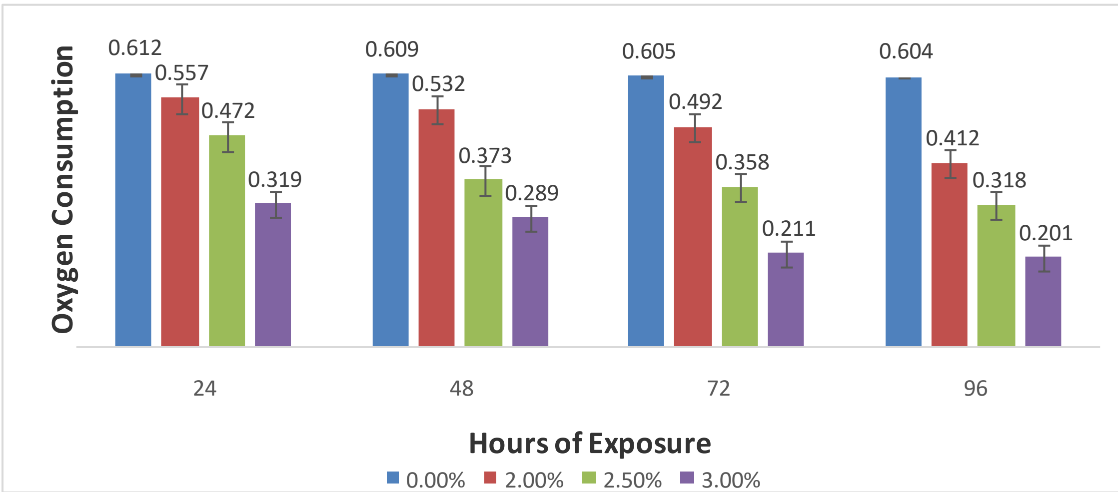

Fig. 4: Effects of distillery effluent on oxygen uptake (O_2ml/g/h) of *Mystus vittatus*.

structural deformation of DNA and an increase in liver ethoxyresorufin-O-deethylase activity (Martinez *et al.,* 2012). Verma and Prakash (2019) reported that GSI decreases in arsenic exposed fish. Randak *et al*. (2008) reported that heavy metals had negative effects on gonad size in *Leuciscus cephalus* possibly as a result of a decrease in the amounts of 11-keto-testesteron, ethoxyresorufin-O-deethylase and vitelline. In the present study the increasing concentration of distillery effluent with increasing exposure periods might have toxic effect in gonads, resulting a decrease in GSI of *Mystus vittatus.* Thus decrease in GSI in effluent exposed fish compared to control was probably due to inhibition of enzymes functioning in synthesis and release of reproductive hormones.

In the present study *Mystus vittatus*, total oxygen consumption was decreased (8.99%-66.72%) to a significant level as compared to control after short-term exposure to sublethal concentration of distillery effluent (Table 2; Fig. 4). The effect was more pronounced as the concentration and duration of exposure increased. Significant decrease in oxygen consumption of fishes has been reported by few investigators after exposure to toxicant such as-- heavy metal exposed *Channa* *punctatus* (Sornaraj *et al*., 1995), pesticides exposed *Clarias batrachus* (Ray and Kumar, 2013) and industrial effluent exposed *Cyprinus carpio* (Prakash and Singh, 2020). In the present study the oxygen consumption was also decreased in distillery effluent exposed *Mystus vittatus.* The decrease in oxygen consumption in distillery effluent exposed fish was due to degeneration of gill epithelium that caused oxygen debt in blood and also loses its effective mechanisms for 'histoxic anoxia' in which gill tissue not only suffers from oxygen debt but also loses its effective mechanism for removing carbon dioxide from blood (Prakash and Singh, 2020). Anoxia or hypoxia increases carbohydrate consumption and thereby induces a sort of respiratory stress on organisms even at a sublethal concentration resulting in additional expenditure of energy. Thus distillery effluent altered the oxygen consumption rate and caused deleterious changes in the physiology of gills of *Mystus vittatus* by damaging the gill epithelium leading to the loss of mucous secretion.

Conclusion

Changes in condition factor, hepatosomatic index, gonadosomatic index and oxygen consumption rate in effluent exposed fish showed that toxicant/pollutant altered the metabolic and physiological activities of fish. Thus the present study proved that condition factor (CF), hepatosomatic index (HIS),gonadosomatic index (GSI)and oxygen uptake rate of fish can be helpful in monitoring toxic responses of the industrial waste water as well as general health condition of aquatic animals inhabiting in the polluted waterbodies. Because effluent affects the biological potential of aquatic animals, hence precaution should be taken to avoid disposal of effluent wastes near fish culture grounds.

Acknowledgements

Authors are grateful to Principal and Management Committee, M.L.K. (P.G.) College, Balrampur for providing necessary laboratory facilities.

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