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ACUTE TOXICITY OF DIMETHOATE (AN ORGANOPHOSPHATE PESTICIDE) TO FISH

Chandra Sekhara Rao Jammu[1*], Anjali T. P.[2], Sudharani Ch.[3] and Satya Sri M.[4]

[1]Assistant Professor, Department of Zoology, Dr. S.R.K. Govt. Arts College, Yanam, UT of Puducherry.
[2,3,4]II M.Sc. Zoology, Dr. S.R.K. Govt. Arts College, Yanam, UT of Puducherry.

***Corresponding Author: Chandra Sekhara Rao Jammu**
Assistant Professor, Department of Zoology, Dr. S.R.K. Govt. Arts College, Yanam, UT of Puducherry.

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ABSTRACT

Indiscriminate usage of pesticides in agriculture is posing a great threat to the environment and its associated fauna. Pesticides from site of their application through various ways ultimately reach aquatic bodies and change the quality of the medium. Any change in the habitat due to a particular toxicant definitely affects the tolerance limit of aquatic fauna and negatively influence their growth, survival and reproduction. These negative consequences created by pesticides are ultimately leading to a disturbance in the delicate balance of ecosystem. It is important to evaluate the acute and chronic effects of various pesticides on various non-target species such as fish. In Aquatic toxicology studies, acute and chronic tests are useful to estimate the concentrations of certain pesticides that cause direct and irreversible damage to the aquatic organisms. In the present review, an attempt has been made to elucidate the toxic impact of dimethoate on fish, a non-taget species.

KEYWORDS: Aquatic pollution, Acute toxicity, Dimethoate, Organophosphate, Bioindicator, Bioassay.

INTRODUCTION

Increased awareness on aquatic pollution due to pesticides necessitated acute and chronic toxicity tests to evaluate the efficacy of those contaminants and to extrapolate their permissible levels in the environment. In assessing their safety levels for various organisms such as fish in an aquatic environment, the first task is to determine the acute toxic LC_{50} value.[1] The median tolerance limit of any pollutant is meant as an elementary guide in the field of Ecotoxicology.[2] Without reference to the median tolerance limit, no information on sublethal effects can be deduced.[3] Pesticides released into aquatic ecosystems can be accumulated into various aquatic fauna either through the direct pesticide uptake from water or uptake via contaminated food. It has been reported that the rate of pesticide accumulation is greater in freshwater fish than in marine fish.[4] The behavioral response in fish is an indication of the internal disturbances of body functions and often an integrated effect of the underlying biochemical, morphological, or physiological disturbances.[5] It is very essential to find out the damaging effects of pesticides on fish since they form an important link in food chain and their contamination by pesticides imbalance the aquatic ecosystem.[6] Exposure to pesticides can also induce various morphological alterations and the degree of damage in morphological aspects of fish is directly linked with the duration of exposure.[7]

DIMETHOATE INDUCED ACUTE TOXICITY IN FISH

Many researchers evaluated the acute toxicity of Dimethoate in various fish species. Acute toxicity testing of a particular toxicant and comparing those values with the already available toxicity information on that particular toxicant is needed for its safe utility and its hazard assessment.

Acute Toxicity of Dimethoate to Fish

S. No.	Name of the Fish	Toxicity Value	Exposure Period in hours	Author / s
1	*Cyprinus carpio*	1.89mg/L 1.78mg/L 1.70mg/L	24 48 72	Sharma *et al*., 2022[8]
2	*Clarias gariepinus*	5.56µg/L	96	Okogwu *et al*., 2022[9]
3	*Mugil cephalus*	854.10µg/L	96	Dake *et al*., 2021[10]

4	*Clarias gariepinus*	29.05mg/L	96	Oghale *et al*., 2021[11]
5	*Gambusia affinis hollobroki*	63.33mg/L	96	Ahmed and Hassan, 2020[12]
6	*Arius dussumieri*	5.99mg/L	96	Rathod, 2019[13]
7	*Rasbora daniconius*	9.136ppm	96	Lokhande, 2017[14]
8	*Cyprinus carpio*	1.1ppm	96	Qayoom *et al*., 2016[15]
9	*Oreochromis niloticus*	0.234ppm	96	Ajitha and Jayaprakash, 2015[16]
10	*Catla catla*	23.5mg/L 22.5mg/L 21.5mg/L	24 48 72	Hussain *et al*., 2015[7]
11	*Oreochromis niloticus*	25.00mg/L	96	Hassanin and Asely, 2015[17]
12	*Channa punctatus*	19.10µg/L	96	Ali *et al*., 2014[18]
13	*Labeo rohita*	24.55µl/L	96	Dey and Saha, 2014[19]
14	*Clarias batrachus*	4.00µl/L	96	Verma *et al*., 2014[20]
15	*Labeo rohita*	0.398ppm	72	Binukumari and Vasanthi, 2013[21]
16	*Labeo rohita*	17.532mg/L 17.321mg/L 16.721mg/L 16.350mg/L	24 48 72 96	Nagaraju and Rathnamma, 2013[22]
17	*Colisa fasciatus*	22.15mg/L 21.99mg/L 21.74mg/L 21.65mg/L	24 48 72 96	Singh, 2013[23]
18	*Chana punctatus*	21.27ppm	96	Paithane *et al*., 2012[24]
19	*Danio rario* Embryo Fingerling Adult	 24.64mg/L 21.64mg/L 60.00mg/L	 72 96 96	Ansari and Ansari, 2011[25]
20	*Labeo rohita*	34ppm	24	Logaswami *et al*., 2010[26]
21	*Heteropneustes fossilis*	15.92mg/L 13.42mg/L 12.39mg/L 11.34mg/L	24 48 72 96	Srivastava *et al*., 2010[27]
22	*Cyprinus carpio*	1.84µg/L 1.78µg/L 1.68µg/L 1.61µg/L	24 48 72 96	Singh *et al*, 2009[28]
23	*Channa punctatus*	3ppm	24	Shereena *et al*., 2009[29]
24	*Punctius ticto*	5.070ppm	96	Ganeshwade *et al*., 2009[30]
25	*Rasobora daniconius*	3.936ppm		
26	*Heteropneustes fossilis*	3.38mg/L 3.23mg/L 3.08mg/L 2.98mg/L	24 48 72 96	Pandey *et al*., 2009[31]
27	*Clarias batrachus* *Heteropneustes fossilis*	4.5ml/L	96	Verma and Chand, 2007[32]
28	*Oreochromis niloticus*	40mg/L	96	Swelium, 2006[33]
29	*Cyprinus carpio*	26.11mg/L	96	De Mel and Pathirathne, 2005[34]
30	*Prochilodus lineatus* Larva 3 day old Recently hatched	 10.44µg/L 11.81µg/L	 96 48	Campagna *et al*., 2004[35]
31	*Channa punctatus*	17.92mg/L	24	Srivastava and Singh, 2001[36]
32	*Catla catla*	0.007mg/L	96	Kumar and Singh, 2000[37]
33	*Lepomes macrochirus*	6mg/L	96	C.C.M.E, 1999[38]
34	*Oreochromis niloticus*	14.84mg/L	96	Pathirathne and Athauda, 1998[39]
35	*Clarias batrachus*	65mg/L	96	Begum and Vijayaraghavan, 1995[40]
36	*Colisa fasciatus*	13.0mg/L 11.4mg/L	24 48	Shukla, 1995[41]

		10.0mg/L 9.3mg/L	72 96	
37	*Cyprinus carpio*	0.1ml/L	96	Satyadevan *et al*., 1993[42]
38	*Lepomes macrochirus* *Onchorynchus mykiss*	0.78mg/L 0.79mg/L	96	Vittozzi and Angelis, 1991[43]
39	*Lebistes reticulatus*	19mg/L	96	Gupta, 1984[44]
40	*Saccobranchus fossilis*	4.57µg/L	48	Verma *et al*., 1979[45]
41	*Terapon jarbua*	700µg/L	96	Lingaraja and Venugopalan, 1978[46]

BEHAVIOURAL AND MORPHOLOGICAL ALTERATIONS IN FISH EXPOSED TO DIMETHOATE

Behavioural alterations exhibited by fish due to toxic impact of pesticides are a result of an inbuilt mechanism of fish to overcome the physiological stress and hence, the behavioral characteristics are effective sensitive indicators of toxicant.[11] *Cyprinus carpio* exposed to Dimethoate showed gradual lowering of the opercular movements along with erratic swimming and loss of balance.[8] Dimethoate exposed *Clarias gariepinus* exhibited abnormal behaviors such as erratic swimming, frequent air gulping, sudden jerk movement and rapid opercular movement.[9]

Dimethoate exposed *Mugil cephalus* showed abnormal swimming such as loss of buoyancy, increased opercular movements, erratic movements, mucus secretion and discoloration of the skin.[10] Ekprikpo[47] observed altered behavioural characters such as erratic swimming, jerky movement, surfacing, air gulping, changes in air gulping index, opercular ventilation count, tail fin movement, restlessness, barbell deformation and loss of reflex in *Heterobranchus longifilis* exposed to dimethoate. Khan *et al*.[48] noticed prominent behavioural anomalies in *Cyprinus carpio* exposed to dimethoate such as mucus secretion, convulsions, uncoordinated movements and imbalanced swimming. Oghale *et al*. [11] reported change in skin colour, jerking, restlessness and erratic swimming in *Clarias gariepinus* when exposed to dimethoate.

Rathod[13] observed jerky movement, increased opercular movements, abnormal swimming movement, secretion of mucus, loss of equilibrium, gulping, increased surfacing activity when *Arius dussumieri* exposed to dimethoate. According to Lokhande[14], exposure to dimethoate in *Rasbora daniconius* showed erratic and jerky movement, fast swimming, surfacing activity, hyper excitability, loss of balance, finally fish settling to the bottom of the test chamber. Qayoom *et al*.[15] observed uncoordinated movements, convulsions, excessive mucus secretion, and imbalanced swimming which ended in a collapse to the bottom of the aquarium in dimethoate exposed *Cyprinus carpio*.

Uncoordinated movements, erratic swimming, convulsions, excess mucus secretion, decreased opercular movements, loss of balance, drowning and change in body pigmentation, muscle fasciculation, moribund lethargy, refusal of feeding and respiratory distress are the altered characters showed by *Catla catla* by Dimethoate intoxication.[7] Pazhanisamy[49] reported altered behavoiurs in *Labeo rohita* such as frequent jumping, erratic swimming, spiraling, convulsions and tendency to escape from the aquaria, fast jerking, hyper excitability, lack of orientation, inactiveness, paralysis and loss of equilibrium due to dimethoate stress.

Ansari and Ansari[50] observed notable changes in *Danio rerio* such as increased opercular movement, surface to bottom movements and lack of equilibrium due to sub lethal exposure and restlessness and sudden, quick and jerky movements at lower concentrations of dimethoate. *Catla catla* exposed to dimethoate showed an initial increase and gradual decrease in opercular beats due to toxic stress.[51] Ansari and Ansari[25] observed restlessness, aggregations at one corner of aquarium, erratic and jerky swimming, frequent surfacing, increased mucous secretion and loss of balance in *Danio rerio* when exposed to Dimethoate. They also observed significant changes in the fish such as expanded pectoral and pelvic fins and rolling movement in the vertical position due to toxic stress. Dogan and Can[52] observed that sub lethal concentrations of dimethoate resulted in erratic and hysteric swimming, movement in the circling manner, lack of appetite and equilibrium, fish lying at the bottom of the aquarium, convolution and loss of movement in *Oncorhynchus mykiss*. Due to dimethoate exposure, *Labeo rohita* showed behavioural changes such as erected swimming and rapid opercular movement and fish trying to jump out of the test medium.[26] Behavioural changes such as increased opercular movement, sluggishness, lethargic and abnormal swimming, loss of buoyancy and muscular tetany were observed in *Heteropneustes fossilis* against dimethoate intoxication.[27]

At higher concentration of dimethoate, *Heteropneustes fossilis* showed uncoordinated behaviours such as erratic and jerky swimming, attempt to jump out of water, frequent surfacing and gulping of air, decrease in opercular movement and copious secretion of mucus all over the body.[31] Singh *et al*.[28] reported erratic swimming, increased surfacing, decreased rate of opercular movement, copious mucus secretion, reduced agility and inability to maintain normal posture and balance with increasing exposure time in *Cyprinus carpio*. A notable change in body color from silvery white to pale white was also observed. De Mel and Pathirathne[34] observed hyperactivity and erratic movements in dimethoate exposed *Cyprinus carpio*. Pathirathne and Athauda[39] reported behavioral changes in dimethoate exposed *Oreochromis niloticus* such as erratic swimming and lethargy.

DISCUSSION AND CONCLUSIONS

From the above findings, it is evident that the observed variations in fish mortality are dependent on the concentration as well as exposure period. Toxicity of Dimethoate on various fish species revealed that mortality depends upon the sensitivity of the species used for the experiment.[22] In air breathing fishes, LC_{50} values are much higher than in carps for the same pesticide, probably because the fishes with accessory respiratory organs can adaptively shift towards aerial breathing when the water is contaminated. Even in carps, the variation in LC_{50} values may be attributed to the different tolerance limit of different species. The observed variations in LC_{50} values for the same species and toxicant are depending on age and condition of test species along with experimental factors. During the development, sensitivity may change with some compounds showing higher sensitivity in embryos whereas others are more toxic to larvae. Early life stages (Embryo and Larvae) of fish are the most sensitive to Dimethoate than fingerlings.[25,35] The observed variations in LC_{50} values for the same species and toxicant are depending on the size of the fish selected. Small fishes generally have potentially weak immune system to carry out the elimination of the toxicant from the body. Rapid distribution of pesticides in the body of small sized fish leads to the higher uptake of a toxicant.[15]

Any change in the behavior of fish indicates the deterioration of water quality due to the effect of this organophosphate on fish behavior.[8] The decreased opercular movement in the test fish will help the fish to improve resistance against the toxic stress by reducing the absorption of dimethoate through gill, to increase the period of its survival in such toxic environment.[51] The observed erratic and abrupt swimming in test fish after pesticide exposure may be triggered by deficiency in nervous and muscular coordination which may be due to accumulation of acetylcholine in synaptic and neuromuscular junctions,[53] leading to overstimulation of cholinergic receptors. Accumulation of acetylcholine in synaptic and neuromuscular junctions is due to the obstruction in AChE activity. AChE inhibition also decreases the feeding rate due to impairment of impulse transmission.[54] Upon exposure to the pesticide, increase in surfacing and gulping of surface waters appears to be an attempt by the fish to avoid breathing in the poisoned water. Moreover, hypoxic condition also contributes to increase in surfacing.[15] Increased mucus secretion after dimethoate exposure is probably an adaptive response to counter the irritating effect of the pesticide on body surface and mucous membrane.[28] Changes in body color from silvery white to pale white may be caused by impairment of pituitary functions due to the reduction in number and size of chromatophores and their pigment content.

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