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IMPACT OF AGRICULTURAL INSECTICIDE VAPONA ON A FRESHWATER CATFISH HETEROPNEUSTES FOSSILIS: A TOXICITY STUDY

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Abstract

This study investigates the critical toxicity of Vapona in the air-breathing freshwater catfish, Heteropneustes fossilis (Bloch). The LC50 values (median lethal concentration) were determined using a static bioassay method over 24, 48, 72, and 96-hour exposure periods. The LC50 values for 24, 48, 72, and 96 hours of Vapona were found to be 400, 378, 320, and 275 ppm, respectively. An increased mucus secretion was observed at higher concentrations, suggesting a physiological response to the toxicant. The potential causes of mortality in the fish were also analyzed and discussed.

Keywords: Heteropneustes, Insecticide, Toxicity, Vapona

INTRODUCTION

Vapona is a widely used insecticide in Nepalese agriculture. It is primarily applied for the protection of cereal crops against insect pests. However, its constituents pose significant risks to aquatic organisms, particularly fish. The harmful effects of biocides and nitrogenous chemicals on fish have been extensively reported in prior studies.

Mayhew (1955) contributed early to understanding insecticide toxicity in various fish species. Basak and Konar (1976), Panwar *et al.* (1976) and Prasad (2013) have further elaborated on these findings. Mathur (1959) and Prasad (2015) conducted studies on the harmful effects of organic pesticides on fish. Mathur (1975) specifically investigated the impact of Aldrin on the fishes of Jabalpur. Subsequent studies by Ghosh and Konar (1979) corroborated these findings, highlighting the poisonous effects of Aldrin. In 1981, Singh and Singh carried out research to find out how Aldrin and Parathion affected the gonadotropic potency, ovarian absorption, and survival of the *Heteropneustes fossilis* freshwater catfish species.

Building on these foundational studies, the present research aims to quantify the toxic effects of Vapona on *Heteropneustes fossilis*, using LC50 values as a key metric. This study also explores the physiological responses of the fish to varying concentrations of Vapona and discusses the probable mechanisms leading to mortality.

METHODS

Specimens of *Heteropneustes fossilis*, measuring 9-14 cm in length and weighing 12-20 g, were gathered from natural sources. After being exposed to a potassium permanganate solution at a concentration of 0.1%, the fish were kept in laboratory conditions for 14 days. The adjustment was done by placing the fish in big glass aquaria filled with tap water. The subjects were provided with fish food twice daily, however, feeding was discontinued 24 hours prior to the commencement of the studies. The physico-chemical parameters of the water used are given below:

Table 1. Physico-Chemical Parameters of Water

Serial no.	Factors	Values
1.	Temperature	15 -18° C
2.	Free Carbon-dioxide	2 – 4 ppm
3.	Dissolved Oxygen	6.8 – 7.5 ppm
4.	pH	7.3 – 7.9
5.	Total alkalinity	144 ppm

Distilled water was used to make stock solutions of Vapona. The necessary test concentrations were achieved by diluting the original solution following the procedures specified in the Standard Methods by APHA *et al.* (1975).

In order to ascertain the LC50 values for *H. fossilis*, five test solutions containing varying concentrations of Vapona (200, 250, 300, 350, and 400 ppm) were formulated. Groups of ten fish were added to each test solution, while a control group was maintained in a different aquarium. The test solutions did not alter throughout the 96-hour experiment. The fish's opercular movements were recorded one, three, and five hours after they were added to the test solutions. For a maximum of 96 hours, the mortality of fish was carefully monitored at 24-hour intervals. Three iterations of the procedures were carried out to validate the results, and graphical approaches were utilized to calculate the LC50 values.

RESULTS

The lethal concentration (LC50) values of Vapona for *Heteropneustes fossilis* were determined to be 400 ppm after 24 hours, 378 ppm after 48 hours, 320 ppm after 72 hours, and 275 ppm after 96 hours.

Table 2. *Opercular Movements in H. fossilis in various concentrations of Vapona*

Concentration in ppm	Number of opercular movements per minute in diff. hours		
	1st	3rd	5th
Control	39	39	39
200	50	47	45
250	51	46	44
300	52	44	41
350	55	42	40
400	60	40	36

Table 3. *Mortality in H. fossilis in varoius concentrations of Vapona*

Concentration in ppm.	Percentage mortality of fish in different hours			
	24hrs	48hrs	72hrs	96hrs
Control	00	00	00	00
200	00	00	10	20
250	10	10	20	40
300	20	20	40	60
350	30	40	60	80
400	50	60	80	100

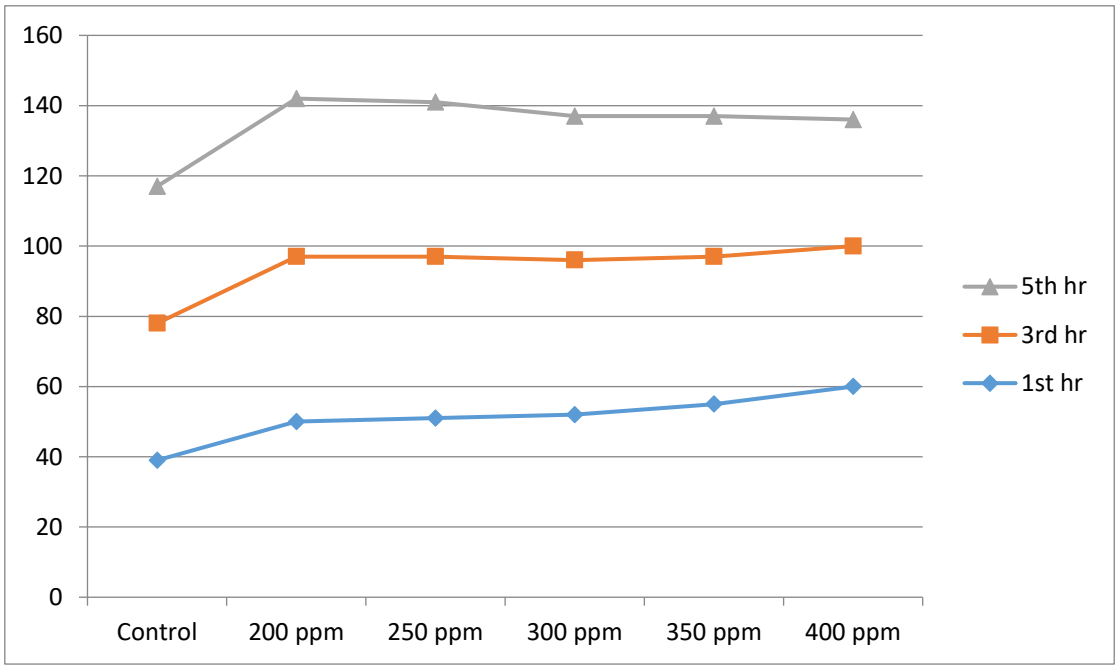

Fig. 1. Opercular movements in *H. fossilis* in various concentrations of Vapona.

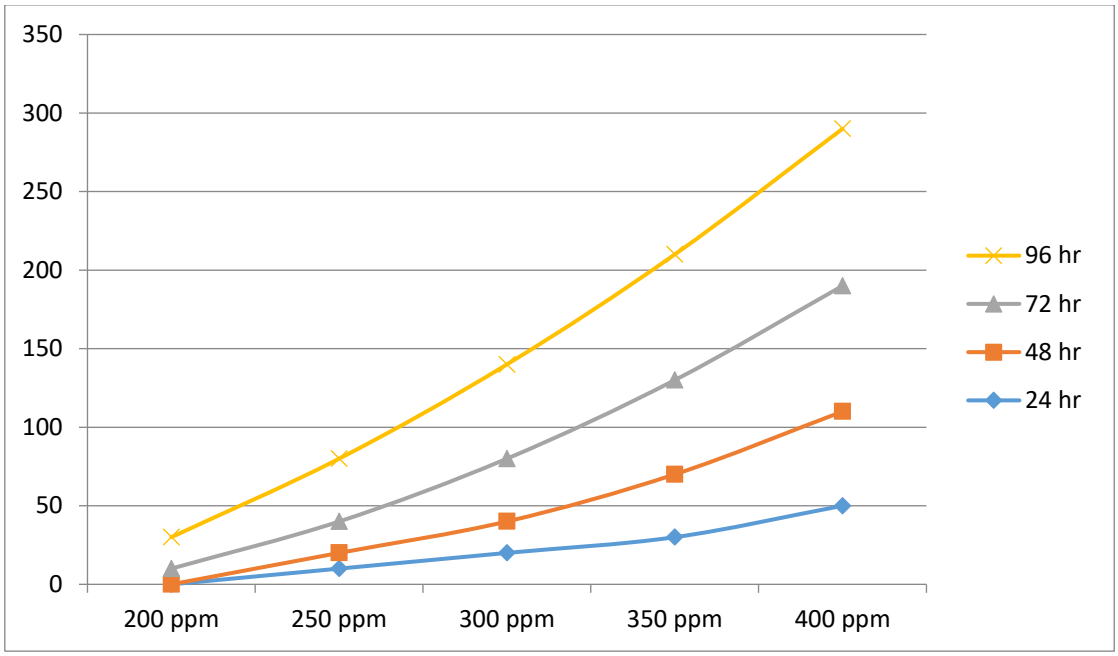

Fig. 2. Lc50 value in various concentrations of Vapona for *H. fossilis*.

DISCUSSION

Each group of test fish displayed unique physiological responses upon exposure to Vapona solutions in this investigation. At first, the fish exhibited heightened excitability, which was then followed by muscle spasms resulting in abrupt and forceful movements. Opercular motions exhibited an initial increase during the first hour, followed by a progressive decline during the third and fifth hours. The fish regularly emerged to inhale atmospheric air and made efforts to jump out of the containers. The observed behaviour align with the results reported by Hall *et al.* (1933) and Ambrose (1942), who documented elevated metabolic rates and oxygen consumption in fish that were subjected to di-nitro-phenol. Verma *et al.* (1978) observed comparable alterations in behaviour as a result of pesticide treatments. Srivastava and Srivastava (1979) observed that *Channa punctatus* exhibited discomfort and heightened swimming activity as a result of exposure to urea.

A huge quantity of mucus was observed being secreted, forming a layer inside the operculum, covering the gills, and coating the body. The results agree with the studies conducted by Wong *et al.* (1979) regarding heavy metals, as well as with the findings of Srivastava and Srivastava (1979) on the toxicity of urea. Panwar *et al.* (1984) reported similar results while using pesticides. The mucus secretion is presumably caused by the

interaction between Vapona and the mucus-secreting glands in the gill epithelium, resulting in inflammation. The fish presumably asphyxiated as a result of a thick layer of mucus on its gills, causing it to rise to the surface in quest of oxygen (Ansari, 1984, Prasad, 2019). Srivastava and Srivastava (1979) observed similar behavioral tendencies caused by stress induced by urea. Furthermore, the presence of mucus could form a thick coating on the fish's body, impeding the regulation of osmotic processes. This could potentially be the reason for the fish mortality observed in the Vapona test solutions.

In their study, Rao *et al.* (1980) observed that the rate of oxygen consumption in *Labeo rohita* increased in response to higher concentrations of endosulfan, reaching its maximum at a certain level. Nevertheless, below this threshold, the rate of oxygen consumption declined until the creature perished. The observed rise in activity and escape attempts following three hours of exposure to Vapona can be attributed to hyperactivity and heightened mucus secretion. Carpenter (1930) made similar observations on the toxicity of lead.

Afterwards, the test fish exhibited lethargy, settled to the bottom, and ultimately perished. According to Abel (1974), fish mortality in acute toxicity trials is likely caused by many mechanisms, such as changes in membrane permeability, protein denaturation, and interference with active transport owing to chemical toxicity. These factors potentially influenced the death rate of fish in this study. According to Wong *et al.* (1977), mortality was attributed to a combination of asphyxiation resulting from the reaction between dissolved particles and gill-secreted mucus, as well as metabolic obstruction. This study also found that the mucus covering the gills could prevent the emission of ammonia.

Ghosh and Konar (1979) discovered that the lethal concentration (LC50) of Aldrin for *Tilapia mossambica* after 96 hours of exposure was 0.36 parts per million (ppm). Gupta and Rajbanshi (1979) found that the 96-hour LC50 value for *H. fossilis* was 22.01 mg Cu/L in their study. In a more recent investigation conducted by Dhaneker *et al.* (1985), it was discovered that the lethal quantity of mercury in *H. fossilis* after 96 hours was precisely 1.00 ppm. The study determined that the 96-hour LC50 value of Vapona for *H. fossilis* was found 275 ppm, indicating that Vapona is specifically hazardous to this species.

The colour of the fish faded progressively from black to dark grey. Srivastava and Srivastava (1979) documented comparable alterations in the colouration of *Channa punctatus* in their study as a result of exposure to urea-induced stress. Fujii and Novales (1969)

proposed that hormone-driven processes may be responsible for stable and gradual colour changes. The alteration in the colour of the fish under urea stress is probably a result of both hormone activity and urea's influence on hormone control (Srivastava and Srivastava, 1979).

CONCLUSION

This study provides a detailed analysis of the acute toxicity of Vapona to the air-breathing freshwater fish *Heteropneustes fossilis*. The LC50 values observed for 24, 48, 72, and 96 hours were 400, 378, 320, and 275 ppm respectively, indicating a time-dependent increase in toxicity. The fish exhibited several behavioral and physiological responses to Vapona exposure, including increased opercular movements, attempts to gulp atmospheric air, and profuse mucus secretion, which likely contributed to respiratory distress and mortality.

The observed behavioural changes align with previous studies on the effects of various toxicants on fish, confirming the general pattern of increased metabolic rates and stress-induced responses. The profuse mucus secretion observed in the study has been noted in other contexts of toxic exposure and appears to play a significant role in the suffocation and eventual death of the fish by impairing gas exchange and osmoregulatory functions.

The species-specific nature of Vapona toxicity is evident when comparing the LC50 values to those of other chemicals and fish species reported in the literature. The findings suggest that *H. fossilis* has a relatively higher tolerance to Vapona compared to other species exposed to different insecticides and pollutants.

Additionally, the study highlights the potential impact of Vapona on fish physiology and behaviour, underlining the need for careful consideration and regulation of insecticide use in agricultural practices to prevent adverse effects on aquatic ecosystems. Future research should focus on the long-term effects of sub-lethal Vapona concentrations, the potential for bioaccumulation, and the impacts on different life stages of fish to develop comprehensive risk assessments and mitigation strategies.

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