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Acute toxicity of potassium permanganate to fingerlings of the Indian stinging catfish, *Heteropneustes fossilis* (Bloch, 1794)

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Abstract
The acute toxicity of KMnO4 to various fish species has been studied. A limited amount of information is available about the toxicity of KMnO4. However, there are very scanty or no data for stinging cat fish species. The present study was undertaken to ascertain the changes in hydrological parameters as well as the lethal toxicity effect on *Heteropneustes fossilis* fingerlings with response to Potassium Permanganate (PP) after every one hour of exposure period. Live and healthy fingerlings of *Heteroneustes fossilis* (mean weight, 3.7±1.30 g and mean length, 7.32±1.53 cm) and rohu, *Labeo rohita* (mean weight, 5.5±0.88 g and mean length, 5.36±1.0 cm) of either sex were procured from local fish market located at Naihati of West Bengal, India. They were transported in separate oxygenated polythene bags to the laboratory for experiment and were maintained in the laboratory for a minimum period of 14 days & fed with commercial pelleted feed of size 2 mm. Approximately 20 % of Water exchange was done on daily basis. Mortality during the period of acclimatization was observed which is less than two percent. The toxicity bioassays of Potassium Permanganate was conducted separately for 2h, 3h, and 4 h of exposures to the fingerlings of *Heteropneustes fossilis* in controlled laboratory conditions following the methods of APHA (2002) to get the 100% mortality of the test fish. Lethal Concentrations of this toxicant at which the test organisms died (LC_5 to LC_{95}) calculated by the method of Probit Analysis (Finney, 1971).Impacts of Potassium Permanganate on different hydrological parameters like Temperature, pH, Conductivity and Dissolved oxygen of test water were assessed following the methods of (APHA, 2002) during this Experiment. Data generated from the estimation of water quality parameters were analyzed statistically following the methods of (Gomez and Gomez, 1984) using Statistical Software's (SPSS and MS Excel). Effects of Potassium Permanganate on Hydrological Parameters were also observed. In the present investigation, the role of the $KMnO_4$ as piscicides was evaluated. It was observed that about 95% hardy fingerlings of *Heteropneustes fossilis* could be removed at the concentration of only 20-25mg/l $KMnO_4$ only for 4h. From the analysis it was found out that the lethal dose of $KMnO_4$ is comparatively very high. In addition, the toxic effect of $KMnO_4$ retains up to several days. Therefore, it should not be recommended as an ideal Piscicide. However, it is strongly encouraged to use $KMnO_4$ as disinfectant, therapeutants and prophylactic.

Keywords: Acute toxicity, potassium permanganate, fingerlings, *Heteropneustes fossilis*

Introduction
A wide variety of chemicals such as Potassium Permanganate, Calcium Oxide, Malachite Green, Hyamine, Formalin, Calcium Hydroxide, Acriflavin, Sodium Chloride, Copper II Sulphate and Boric Acid are used during fish management [15, 9]. Among these chemicals Potassium Permanganate is a strong oxidizing agent [20, 21] and is used on a routine basis in fish culture for various purposes. It is an inorganic chemical commonly used as an oxidizing agent. It is applicable for variety of sectors i.e. analytical chemistry, industry, agriculture, municipal water treatment, human health and safety, medicine, groundwater remediation, biotechnology and aquaculture. It is very safe, easily available and cost effective chemical and may be used as Piscicide in controlled conditions. However Potassium Permanganate is potentially toxic to humans and other organisms including several fish species [22, 24, 26] but it is not included in regulatory categories. The Environmental Protection Agency [8] registered $KMnO_4$ safe for use in cooling towers, evaporative condensers, ornamental ponds, cooling fountain aquaria, poultry drinking water and human sanitizations. Formulations of $KMnO_4$ are therefore available as ready to use liquids, pellets, tablets, powder or crystals. In our study, the Indian stinging catfish, *Heteropneustes fossilis* was selected as the test organism due to its

commercial value in aquaculture. It is a benthopelagic (bottom feeder), omnivorous feeder that occasionally feeds at the surface. They are able to tolerate adverse aquatic conditions where other cultivable fish species cannot survive [23]. It is widely cultivated and used as experimental fish [19]. The species is having delicious taste, high marketing value, nutritional and medicinal properties [5]. But though this is an exotic fish illegally introduced into our country for which aquatic ecosystem faces a lots of problems [16]. A limited amount of information is available about the toxicity of KMnO4. The acute toxicity of KMnO4 to various fish species has been studied [6, 26]. However, there are very scanty or no data for stinging cat fish species. Therefore the objective of this research is to ascertain the changes in hydrological parameters as well as the lethal toxicity effect on *Heteropneustes fossilis* fingerlings with response to Potassium Permanganate (PP) after every one hour of exposure period.

Materials & methods

Procurement of fingerlings for study purpose: Live and healthy fingerlings of *Heteroneustes fossilis* (mean weight, 3.7±1.30 g and mean length, 7.32±1.53 cm) and rohu, *Labeo rohita* (mean weight, 5.5±0.88 g and mean length, 5.36±1.0 cm) of either sex were procured from local fish market located at Naihati of West Bengal, India.

Observation of Mortality during acclimatization: They were transported in separate oxygenated polythene bags to the laboratory for experiment and kept in aquarium filled with clean pond water (Temperature: 24-28^{0}C, pH: 7.9-8.2, Conductivity: 0.58-6.0 mS, DO: 6.5-7.2 mg/l, Total Alkalinity: 90-120 mg/l as $CaCO_3$, Total Hardness: 300-320 mg/l as $CaCO_3$) separately. All fishes were maintained in the laboratory for a minimum period of 14 days & fed with commercial pelleted feed of size 2 mm. Approximately 20 % of Water exchange was done on daily basis. Mortality during the period of acclimatization was observed which was less than 2%.

Calculation of LC_5 to LC_{95}: The toxicity bioassay of Potassium Permanganate was conducted separately for 2h, 3h, and 4 h of exposures to the fingerlings of *Heteropneustes fossilis* in controlled laboratory conditions. The mortality percentage of the test organisms were recorded after every one hour of exposure. Two types of bioassays i.e. Range Finding Bioassays & Lethal Toxicity Bioassays were conducted following the methods of [1] to get the 100% mortality of the test fish. Lethal Concentrations of this toxicant at which the test organisms died (LC_5 to LC_{95}) calculated by the method of Probit Analysis [10] using EPA Probit Analysis Program (Version 1.5). Analytical grade Potassium Permanganate ($KMnO_4$) of Merck India Ltd. was used for the experiment. Impacts of Potassium Permanganate on different hydrological parameters like Temperature, pH, Conductivity and Dissolved oxygen of test water were assessed following the methods of [1] during this Experiment (Table-1).

Statistical Data analysis: Data generated from the estimation of water quality parameters were analyzed statistically following the methods of [11] using Statistical Software's (SPSS and MS Excel).

Results & Discussion

Effects of Potassium Permanganate on Hydrological Parameters

Temperature of test water was not varied significantly (P>0.05) during the experiment of $KMnO_4$ and this finding was in agreement with [22]. But pH of water decreased sharply (P<0.05) from control in all the treatments and at the every exposure period (Table-1). There were no significant variations (P>0.05) of pH between the LC_{50} and LC_{95} concentrations of $KMnO_4$ after 2hr and 4hr of exposures. But there were significant variations between LC_5 and two other concentrations (i.e., LC_{50} and LC_{95}) at all the exposure periods. However, pH significantly increased (P<0.05) with the increase in the exposure periods after treatment of LC_5 concentration of $KMnO_4$. This might be due to rapid breakdown of $KMnO_4$ for oxidation overtime. Conductivity increased remarkably (P<0.05) from control to the treatment of LC_5 concentration of $KMnO_4$ after 2hr and 4hr of exposures (Table-1). This is might be due to the formation of acidic compounds after oxidation process of $KMnO_4$ with other prevailing organic matters. But it decreased significantly from control after 3hr of exposure. After 3hr of exposure, conductivity decreased with the increase in the concentration of $KMnO_4$. After 2hr and 4hr of exposures conductivity decreased from the LC_5 to LC_{50} and LC_{95} concentrations of $KMnO_4$. Decrease in conductivity could be due to neutralization of the anions and cations in the aquatic environment by $KMnO_4$ through various redox reactions. But there were no significant variations of conductivity in between LC_{50} and LC_{95} concentrations after 2hr and 4hr of exposures. Dissolved oxygen concentrations sharply increased (P<0.05) from control to all the treatment during all the exposure periods (Table-1). This could be due to its oxidizing property [4] which releases free oxygen in the aquatic environment which in turn, dissolved in water and increases DO concentration of water [20]. Another reason for increase in DO might be due to its control over the microbial decomposition processes which needs sufficient quantity of dissolved oxygen of the water. But, DO concentrations varied insignificantly (P>0.05) among the different concentrations of KMnO4 and different duration of exposures. But conductivity would further increase when its redox property reduced overtime. The effectiveness of $KMnO_4$ is related to the amount of oxidizable material in the water that is the $KMnO_4$ demand. It has been found to be effective in treatment of bacterial, fungal and protozoal external parasitic pathogens of fish; for water clarification; control of oxygen depletion condition by oxidizing dissolved organic matter resulting the reduction of the biological oxygen demand. Similar Oxidizing property of Potassium Permanganate to enhance water clarity and quality in fish ponds were reported by different investigators [3, 27, 28].

Effects of Potassium Permanganate on Piscicidal activities

Piscicidal activity of Potassium permanganate ($KMnO_4$) to *Heteropneustes fossilis* at different exposure period have been presented in Table-2. It was observed that the mortality of fishes increased significantly (P<0.05) with the increase in the concentrations of $KMnO_4$. After 2h of exposure 5%, 50% and 95% mortality recorded at the concentrations of 22 (15- 27), 52 (47- 59) and 114 (90- 181) mg/l respectively.

The Piscicidal activity of $KMnO_4$ increased significantly (*P*<0.05) after 3h of exposure compared to 2h of exposure. There were 12 mg/l (9- 14) mg/l, 25mg/l (23- 27) mg/l and 45 mg/l (39- 57) mg/l $KMnO_4$ for 5%, 50% and 95% mortality of fish respectively after 3h of exposure. The toxicity of $KMnO_4$ significantly increased with the increase in the concentration of $KMnO_4$ after 4 h of exposure and the concentrations were 12 mg/l (9- 14) mg/l, 19 mg/l (17- 20) mg/l and 30 mg/l (27-40) mg/l for 5% (LC_5), 50% (LC_{50}) and 95% (LC_{95}) mortality of test fish respectively (Table-3). In the present investigation, the role of the $KMnO_4$ as piscicides to control *Heteropneustes fossilis* was estimated. It was found out that about 95% hardy fingerlings of *Heteropneustes fossilis* could be removed at the concentration of only 20-25mg/l $KMnO_4$ only for 4h. A very few reports is available about the Piscicidal activity of $KMnO_4$. Potassium permanganate ($KMnO_4$) is a strong oxidizing agent and is commonly used in aquatic systems to improve available oxygen, to treat infectious diseases and parasites, to detoxify fish poisons, and to control algae [17].

A very few reports from various researchers is available about the Piscicidal activity of $KMnO_4$ which is comparable with our present findings [18] reported that a 48-h LC_{50} value of 5.7 mg KMnO4/L for the oligochaete *Dero digitata*. Marking and Bills reported that toxicity of KMnO4 to 10 species of fish changed little after 24 h during 96-h exposure studies. But, its major application as a therapeutant and prophylactic for fish diseases were recorded since 1918. Previous research on the therapeutic use of KMnO4 as a disinfectant has overlooked its toxicity to non target aquatic organisms [7]. In addition, uncertainty over the mode of toxic action of KMnO4 has produced questions on whether toxicity can be attributed to the permanganate ion alone or from a combination with elemental manganese (Mn2_) [7, 13, 26]. Many studies have investigated the effect of elemental manganese alone on fish and other aquatic organisms [2, 14].

From the results of the analysis it was found out that using $KMnO_4$ as disinfectant, therapeutants and prophylactic is ideal from culture point of view. Similar observations were reported by other researchers. More recently, a few studies have evaluated the mode of toxicity of KMnO4 as formulated for aquaculture therapeutics [6] have observed that exposure to KMnO4 produces minimal signs of stress and limited pathology when the exposure is in the range suggested for therapeutic use. It has also been shown in [26, 29] that for channel catfish, the lethal effect of exposure to KMnO4, above the recommended therapeutic concentration found to be due to significant loss of electrolytes, leading to changes in plasma chloride, osmolality and hematocrit of whole blood [12] also described that the disruption of ion regulation would be less related to metallic manganese toxicity than to the strong oxidative effect of the permanganate ion.

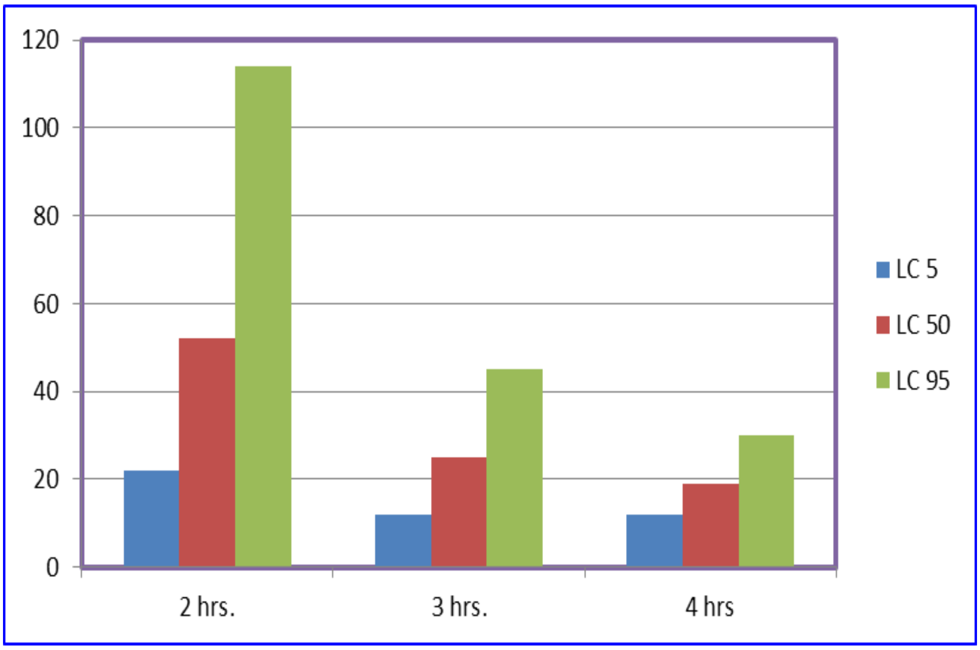

Fig 1: Lethal concentrations of $KMnO_4$ to the fingerlings of *H.fossilis* at 2h, 3h and 4h of exposures

Table 1: Effect of different concentrations of Potassium Permanganate on pH, Conductivity and DO of the test water at different hours of exposure period

Parameter	Exposure period (Hours)	Control	LC_5	LC_{50}	LC_{95}
pH	2	8.60± 0.01	8.1± 0.02	8.23± 0.10	8.23± 0.02
	3	8.59± 0.19	8.37± 0.10	8.2± 0.15	8.25± 0.10
	4	8.57± 0.10	8.47± 0.10	8.25± 0.10	8.33± 0.10
Conductivity (mS)	2	0.46± 0.01	0.48± 0.01	0.43± 0.00	0.44± 0.01
	3	0.45± 0.00	0.45± 0.01	0.42± 0.01	0.42± 0.00
	4	0.47± 0.00	0.49± 0.01	0.44± 0.01	0.45± 0.00
DO (mg/l)	2	5.8± 0.50	9.5± 0.24	9.79± 0.24	9.2± 0.25
	3	5.7± 0.44	10.4± 0.50	10.56±0.10	10.4± 0.34
	4	6.0± 0.10	11.14±0.03	10.92±0.02	11.12± 0.67

Table 2: Concentrations of Potassium Permanganate used for 2 h, 3 h & 4 h lethal toxicity bioassays**.**

Concentrations (mg/l) of Potassium Permanganate (PP)		
2 h	**3 h**	**4 h**
25	16	16
28	18	18
30	20	20
42	22	22
45	25	25
50	28	28
55	30	30
60	42	
65	45	
	50	

Table 3: Piscicidal properties of potassium permanganate (PP) at different doses and time

Concentration (mg/l)	2 hrs.	3 hrs.	4 hrs
LC_5	22 (15- 27)	12 (9- 14)	12 (9- 14)
LC_{50}	52 (47- 59)	25 (23- 27)	19 (17- 20)
LC_{95}	114 (90- 181)	45 (39- 57)	30 (27- 40)

Conclusion
Though the stinging catfish is a high value species and has potential for culture system, so further research is needed to know the potential piscicidal effects of Potassium Permanganate on the fingerlings of *Heteropneustes fossilis*. The lethal dose of Potassium Permanganate is comparatively very high. In addition, the toxic effect of this $KMnO_4$ retains up to several days. Therefore, it should not be recommended as an ideal Piscicide. However, it is strongly encouraged to use Potassium Permanganate ($KMnO_4$) as disinfectant, therapeutants and prophylactic. It was also concluded that it should be used in aquatic system to enhance the availability of oxygen, to control diseases, to neutralize fish toxins and to minimize the growth of algae owing to its strong oxidizing and prophylactic properties.

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