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Larvicidal Effect of Selected Salts against the Filaria Vector Mosquito, *Culex quinquefasciatus* (Diptera: Culicidae) in Bangladesh

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Abstract

Culex quinquefasciatus is the principal vector of Bancroftian filariasis, an endemic disease in different part of Bangladesh. Therefore, an attempt was made to evaluate the larvicidal properties of $HgCl_2$, $AgNO_3$, $CuSO_4$, $CdCl_2$ and $CuCl_2$ against the 1st and 3rd instar larvae of *Cx. quinquefasciatus*. A batch of ten larvae was released in each cup of 0, 1, 3, 5, 7 and 10ppm salts solutions were prepared by using distilled water through serial dilution. Six replications were maintained and mortality was observed after 24 hours of exposure. The LC_{50} and LC_{90} values of $HgCl_2$ were 1.26 and 34.24ppm against 1st instar, and 4.30 and 46.24ppm against 3rd instar larvae, respectively. Among all tested salts $HgCl_2$ showed the lowest LT_{50} & LT_{90} values were 14.23 & 34.65hrs and 25.37 & 66.75hrs against 1st and 3rd instar larvae, respectively. All of the first instar larvae died, failing to pupate with every salt in each concentration (1-10 ppm) within 7 days. No pupation of 3rd instar larvae was found at 3 to 10ppm concentration of $HgCl_2$ and at 10ppm concentration of remaining four tested salts. The findings of the study revealed that among all salts $HgCl_2$ was the most effective due to strong larvicidal activity on *Cx. quinquefasciatus.* Salts are safer therefore; $HgCl_2$ should be included as one of the new agent to develop an effective larvicide against filaria vector. However, this laboratory based findings need to be established by appropriate field studies and further studies regarding the residual toxicity on the ecological components of the breeding habitats of the mosquitoes are suggested.

Keywords: Vector, Larvicidal effect, Filariasis, Salt solutions.

Introduction

Culex quinquefasciatus is the vector of the worm, *Wuchereria bancrofti* which causes lymphatic filariasis (elephantiasis) i. e. creates swelling of the limbs, urogenital organs, breast etc. with long-term disability. Lymphatic filariasis is a widely distributed tropical disease with around 120 million people infected world wide and 44 million people having common chronic manifestation [1]. It also transmits Avian Malaria, St. Louis Eencephalitis, Western Equine Eencephalitis and West Nile fever. The mosquito is also best known for their biting nuisance and, weight loss and low production of milk of animals. *Cx. quinquefasciatus* has been found to spread Bancroftian filariasis caused by parasitic nematode, *Wuchereria bancrofti* in Bangladesh [2-5]. Knight and Stone estimated that the genus *Culex* included 300 species but now the number of species is 744 worldwide, 25 in Bangladesh, most of which found in the tropical and sub-tropical regions of the world [6-10]. The highest population of *Cx. quinquefasciatus* was observed in November (19.19%) and lowest

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(0.55%) in July in different spots of Dhaka city [11]. This domestic mosquito species breeds in close association with human habitation. They preferred to breed in polluted water such as sewage water collections including cease pools; cease pits, drains and septic tank etc.

Mosquito control is urgent due to their vector nature and revival of much infectious diseases. It is suggested that the control measure may be directed to the control of either adult or larvae of mosquitoes. Different types of synthetic chemical insecticides are being used to control vector mosquitoes [12-17]. It has been reported that mosquitoes in Dhaka city have already developed resistance against some insecticides [18-19]. Mosquito resistance to some insecticide may show cross resistance to different insecticides. There have been world-wide demands for the development of alternative control strategies including the search for new type of insecticides. It is very well known that salts are more soluble in water, environment friendly and less harmful for human than synthetic insecticides. Therefore, as a part of the searching for new control agent, an experiment was designed to evaluate the larvicidal efficacy of different salt solutions against the larvae of *Cx. quinquefasciatus.*

Materials and Methods

Rearing of mosquito larvae

The larvae of *Cx. quinquefasciatus* were reared using tap water in the laboratory of dept. of Zoology, Jahangirnagar University, Savar, Dhaka, at ambient temperature (30±2)°C and relative humidity (70±5)%RH. Freshly collected larvae from Saidabad bus stop, Dhaka were brought to the laboratory and kept shortly in distilled water to remove dirty water from breeding sites and reared in earthen jar. In each rearing jar (10cmx10cmx5cm) about 500ml tap water was taken and 500 larvae were released. Amount of 0.10 g yeast granules as larval food was added to each rearing container once a day. Each container was placed inside of rearing cage (30cmx30cmx30cm) made of iron wire (6mm) and fine mesh size mosquito net to prevent egg-laying by other mosquitoes. The larvae were transferred from one rearing jar to another at regular interval to keep away from fungal contaminations. Inspections were made in 6 h intervals to measure water temperature, relative humidity, larval molting, and wastage of food if any. Sometimes a surface film or scum food was removed with a brush at regular interval to make the rearing jar free from microbial attack and yeast granules (<0.02 g/100ml) were newly added to the rearing medium, if needed. As the larvae developed, the pupae were collected using a pipette and transferred to a glass jar (covered with gauze net). About 500 pupae were transferred to a new earthen jar containing tap water for adult emergence. No food was supplied because; pupae are non-feeding stage in the life cycle of the mosquitoes.

Adult mosquitoes were caught from the rearing cages using aspirator and morphologically identified to species level under stereomicroscopes using taxonomic keys within few hours after sampling [20-25]. After identification adult mosquitoes of rearing cages were allowed to mate. A ratio of 3 females to 1 male was allowed for mating in a cage. Therefore, a number of 100 males and 300 females were imprisoned in a cage (30cmx30cmx30cm) for about 5-6 days. Cotton pads soaked with 10% glucose solutions were placed inside the cage for food supplement of the adults. Gravid females were then removed to another cage and a pigeon (*Columba livia*) was kept tight for about an hour on the roof of rearing cage for sucking blood meal by the adult mosquitoes. Five plastic cups (125ml) filled with tap water (2.5cm depth) were lined with a 3 inches wide strip of filter paper and were placed inside each cage for laying eggs. Eggs were separated and stored in air-dried condition for subsequent use. When needed those eggs were released in water of earthen bowl for hatching. For highest percentage of hatching 0.1g glucose or yeast granules sugar were mixed with 500ml distilled water as larval food.

Preparation of stock solutions

In the beginning 0.1 g salt was mixed with 100ml water for preparing stock solution of 1000ppm for each of the five salts (**$AgNO_3$**, $HgCl_2$, $CuCl_2$, $CuSO_4$ and $CdCl_2$). After that different concentrations (1, 3, 5, 7 &10ppm) of these salts were prepared through the process of serial dilution. Serial dilution is a method used to stepwise dilute substance into solution with constant dilution factor in each step. In this technique 1ml, 0.7ml, 0.5ml, 0.3ml and 0.1ml of stock solution were mixed with 99ml, 99.3ml, 99.5ml, 99.7ml and 99.9ml of water respectively for preparing 10, 7, 5, 3 and 1ppm of salt solutions.

Larvicidal activity test

For execution of the experiment with each of the salt solutions, thirty-six plastic cups (125ml) were taken, cleaned with distilled water and arranged in group 1, 2, 3, 4, 5 and 6, where each of the group having six cups. Each cup of the group 2, 3, 4, 5 and 6 were filled with 99.9ml, 99.7ml, 99.5ml, 99.3ml and 99ml of water respectively. Afterwards 0.1, 0.3, 0.5, 0.7 and 1 ml of the stock solutions of a salt were added to each cup of group 2, 3, 4, 5 and 6 respectively. Following this technique five different concentrations of tested salts were made. Cups of group 1 were used as control i.e. no salt solutions were added. The first and third instars larvae were selected for the study, because of easy differentiation of these two instars. The fourth instar larvae were avoided for the possibility of immediate pupation. Thereby a batch of ten larvae of a particular instar was collected from the rearing container and released into each cup of the group 2, 3, 4, 5, and 6. Amount of 0.02g yeast granules were added regularly to each cup as larval food. All of the plastic cups along with larvae were placed inside rearing cage to prevent any contamination and egg laying by other mosquitoes. The cups of the experiment with a particular type of salt were kept in separate cage.

The larvae which showed no signs of motion were considered dead. Their number was counted and recorded during each inspection. Inspections were made at 6 hours' interval. To eliminate the impact of the decomposing larval food, it was removed with a spuit from each cup during the last inspection of the day. A little amount (<0.02gm/100ml) of larval food was newly added to each cup if needed. The

mortality of larvae (after 24 hours), duration of larval instars, number of pupae, the mortality of pupae, and adult emergence were recorded.

Statistical analysis

LC_{50}, LC_{90}, LT_{50}, LT_{90}, 95% confidence interval were generated through probit analysis using statistical package for social sciences (SPSS®) version 20 [26]. Mean mortality of larvae, % of pupation, % of pupal mortality and % of adult emergence of mosquitoes were calculated using MS Excel, 2013.

Results

Effects of salts on 1st and 3rd instar larvae

Data showing the LC_{50} and LC_{90} values along with 95% confidence interval (CI) of all tested salts were presented in table 1. When 1st instar larvae were exposed to five different salt solutions, it was observed that the LC_{50} and LC_{90} values ranged from 1.26 to 31.77 ppm and from 34.24ppm to 79.45 ppm respectively. The LC_{50} values of $HgCl_2$, $AgNO_3$, $CuSO_4$, $CdCl_2$ and $CuCl_2$ were 1.26ppm, 6.38ppm, 16.42ppm, 21.50ppm and 31.77 ppm respectively, whereas the LC_{90} values were 34.24ppm, 45.91ppm, 47.68ppm, 59.22ppm and 79.45ppm. Mercuric chloride ($HgCl_2$) has the lowest LC_{50} (1.26 ppm) and LC_{90} (34.24 ppm) values among five salts, whereas $CuCl_2$ has the highest LC_{50} (31.77ppm) and LC_{90} (79.45ppm) values.

Whereas the third instar larvae were exposed to different concentrations of various salt solutions, the LC_{50} values ranged from 4.30ppm to 123.71ppm and LC_{90} values ranged from 46.24ppm to 418.92ppm (Table 1). The LC_{50} values of $HgCl_2$, $AgNO_3$, $CuSO_4$, $CdCl_2$ and $CuCl_2$ against 3rd instar larvae were 4.30ppm, 20.90ppm, 26.43ppm, 89.72ppm and 123.71ppm respectively, whereas LC_{90} values were 46.24ppm, 48.51ppm, 61.37ppm, 384.43ppm and 418.92 ppm.

Larval mortality of the present experiment might have been caused due to the reasons as explained by Suzuki who described that the heavy metal reacts with the cells of the larval body and finally is taken up into the cells of anal gill [27]. Animals of which the anal gills were destroyed in the solutions of heavy metal salts were certainly dead, and such animals showed the separation of cells from the cuticle of anal gills. The same phenomenon may have been occurred in the present study that the lethal action of Mercuric chloride which kills susceptible species by destroying anal gills which absorb salt actively. The mortality rate of both 1st and 3rd instar larvae of *Cx. quinquefasciatus* was directly related to the concentration of the salt solutions. Riaz et al. found the similar results that a 10% NaCl solution killed the majority of larvae of *Ae. aegypti* in the laboratory and 100% mortality were achieved within the minimum time when exposed to a 20% salt solution [28]. Wigglesworth also analyzed that fourth (final) instar larvae of *Ae. argenteus* was not affected by the solutions of 0.9 % NaCl and less. When concentrations increased to 1%, many larvae died within a week and mortality increased with the increase of salt concentrations [29].

Study showed that each of the tested salt solutions killed 1st instar larvae effectively. When 1st instar larvae were exposed to five different salt solutions, it was observed that the LC_{50} and LC_{90} values ranged from 1.26ppm to 31.77 ppm and 34.24ppm to 79.45 ppm respectively. Moreover, $HgCl_2$ kills 1st instar larvae effectively at lower concentration than other salt solutions (Table 1). It may be due to the fact that the cells of anal gills in *Ae. argenteus* (Poir.) become swollen, possibly because of the diffusion of hypertonic NaCl into the cells caused by the difference of the concentration between haemolymph and external medium [29,30]. Considering the values of lethal concentration (LC_{50} and LC_{90}) of different salt solutions of the present experiment, $HgCl_2$ is the highest effective and $CuCl_2$ is the lowest effective salts in the killing of larvae. When the third instar larvae were exposed to different concentrations of various salt solutions, the LC_{50} and LC_{90} values ranged from 4.30ppm to 123.71ppm and 46.24ppm to 418.92ppm respectively (Table 1). The solution of $HgCl_2$ showed the lowest LC_{50} value (4.30ppm), followed by higher LC_{50} values i.e. 20.90ppm, 26.43ppm, 89.72ppm and 123.71ppm were found in $AgNO_3$, $CuSO_4$, $CdCl_2$ and of $CuCl_2$ respectively. The results of the present study will be promising if we compare with the results of Wigglesworth who stated that, at 12500 ppm (1.25%) concentration of NaCl solution gave better results to control larvae of *Aedes* species in 4 to 7 days [31].

Among all tested salt solutions the lowest LT_{50} value, 5.32 hrs was found at 10 ppm concentration of $HgCl_2$ solution followed by 8.27hrs, 22.64 hrs, 25.90 hrs and 40.62hrs of $AgNO_3$, $CuSO_4$, $CdCl_2$ and $CuCl_2$ respectively. On the contrary, the lowest LT_{90} value, 10.48hrs was found at 10 ppm of $HgCl_2$ solution followed by 21.48 hrs, 45.09 hrs, 47.97 hrs and 74.42hrs of $AgNO_3$, $CuSO_4$, $CdCl_2$ and $CuCl_2$ respectively. LT_{50} values 14.23 hrs, 10.51 hrs, 8.51 hrs, 7.30hrs and 5.32hrs for 1st instar larvae were found at 1ppm, 3ppm, 5ppm, 7ppm and 10ppm concentrations of $HgCl_2$ solution respectively,

Name of salts	LC values (ppm) with confidence interval(CI) against larval stage			
	1st instar		3rd instar	
	LC_{50}	LC_{90}	LC_{50}	LC_{90}
$HgCl_2$	1.26 (0.44-2.01)	34.24 (15.39-285.22)	4.30 (3.18-5.88)	46.24 (23.06-200.16)
$AgNO_3$	6.38 (5.18-8.33)	45.91 (26.76-117.22)	20.90 (15.93-36.64)	48.51 (29.77-136.19)
$CuSO_4$	16.42 (12.93-25.80)	47.68 (28.14-117.62)	26.43 (18.01-74.57)	61.37 (32.14-362.59)
$CdCl_2$	21.50 (15.89-40.13)	59.22 (33.74-194.92)	89.72 (29.89 -504.44)	384.43 (168.24-2174.31)
$CuCl_2$	31.77 (18.81-254.42)	79.45 (33.52-425.74)	123.71 (65.66-725.18)	418.92 (238.45-3104.11)
*Data in brackets represents the 95% Confidence Limit of LC values against 1st and 3rd instar larvae.				

Table 1: Lethal concentration (LC_{50}, LC_{90}) of salt solutions against 1st and 3rd instars larvae of *Cx. quinquefasciatus*.

whereas LT_{90} values were 34.65 hrs, 21.87 hrs, 18.47 hrs, 15.78 hrs and 10.48hrs (Table 2). $HgCl_2$ has the lowest LT_{90} values, 28.58 hrs at 7 ppm concentration followed by 137.27 hrs, 177.14 hrs, 203.14 hrs and 502.15 hrs were found at 7 ppm concentration of $AgNO_3$, $CuSO_4$, $CdCl_2$ and $CuCl_2$ solutions respectively (Table 2).

Among all tested salts $HgCl_2$ showed lowest LT_{50} values; 5.32 hrs and 8.04hrs for 1st and 3rd instars larvae at 10ppm concentration respectively. Whereas at 1ppm conc. $HgCl_2$ required highest time or LT_{50} value i.e. 14.23 hrs and 25.37hrs for 1st and 3rd instars larvae respectively. The present results are similar with that of MacFie who reported that undiluted sea water killed larvae within 2 hrs to 4 hrs and 50% or more diluted seawater caused death after 24 hrs [32]. Therefore, it can be undoubtedly said from the results (Table 2) that lethal time (LT_{50} or LT_{90}) decreases gradually when increases of lethal concentrations (LC_{50} or LC_{90}) from 1ppm to 10ppm of salt solutions, though the effective minimum concentrations vary from salt to salt. Almost equal type of results has been found also in the experiment of Suzuki who observed significant negative correlation between the lethal time and lethal concentration of salts [27]. Therefore, it may be said that $HgCl_2$ shows highest larvicidal efficacy at every concentration which required minimum time and concentration to kill larvae than other tested salt solutions.

Impacts of salts on pupation and adult emergence

It was noted that all of the first instar larvae died at each concentration (1ppm to 10 ppm) of all tested salt solutions within 7days. On the other hand, it was also observed that no pupae and adult were formed from 3rd instar larvae at the concentration of 3 to 10ppm of $HgCl_2$ and 10ppm of $AgNO_3$, $CdCl_2$, $CuSO_4$ and $CuCl_2$ solutions. Lowest (5%) pupation and adult emergence (66.67%) was found at 1ppm concentration of $HgCl_2$ (Table 3). And it was also observed that long period of time (approximately 20 to 22days) was required for pupation and adult emergence of 3rd instar larvae in $AgNO_3$, $CdCl_2$, $CuSO_4$ and $CuCl_2$ solutions.

In this study all of the first instar larvae of *Cx. quinquefasciatus* were died in 0.0001 % (1ppm) and 0.0010 % (10ppm) of $AgNO_3$ solutions within 80 hrs and 48hrs respectively. Whereas 56.67%, 68% and 100% 3rd instar larvae were died in 0.0001 % (1ppm), 0.0003% (3ppm) and 0.001% (10ppm) solution within 24hrs, 24hrs and 9hrs respectively. On the other hand, first instar larvae were died in 0.0007 % (7ppm) and 0.0010 % (10ppm) solutions of $HgCl_2$ within 21 hrs and 15hrs respectively. Whereas 3rd instar larvae were died in 0.0007% (7ppm) and 0.001% (10ppm) solutions of $HgCl_2$ within 24hrs and 15 hrs respectively No pupation and adult emergence were found in $HgCl_2$ salt solutions and $AgNO_3$ successfully retard the pupation from both 1st and 3rd instar larvae.

First instar larvae of *Cx. quinquefasciatus* couldn't develop into pupae at each concentration (1 to 10 ppm) of every salt. $HgCl_2$ successfully killed 3rd instar larvae and no pupation and adult emergence were found at 3 to 10ppm (Table 3). The results of this study are nearly equal to the results of Suzuki who concluded that heavy metal salts are absorbed at a definite rate, specific to each and the animals are either killed or no pupation and emergence took place according to the quantity of the salt taken up in proportion to the concentration of salt solutions (Table 1) [27]. Here it is observed that to obtain 50% mortality in the solution of $HgCl_2$ 1st instar larvae need lower LC_{50} of 1.26ppm and LT_{50} of 14.23hrs (1ppm), where 3rd instar need higher LC_{50} of 4.30ppm and LT_{50} of 25.37hrs (1ppm) (Table 1&2). Subramaniam et al. found that *Aloe vera* and *Bacillus sphaericus* show varied degrees of larvicidal activity against various instars larvae of *Aedes aegypti* and the younger larval stages are much susceptible than later ones. Thus it can also be said that tested salts are more effective on 1st instar larvae than 3rd instar [33].

Suzuki found out the order of decreasing toxicity of heavy metal salts against larvae of *Culex pipiens pallens* were as follows: Ag> Hg> Cd> Co> Cu> Sr> Ba> Ni> Mn> Zn [27]. Whither in our study the order of decreasing toxicity on the basis of LC_{90} and LT_{90} was same and determined as follows: $HgCl_2$> $AgNO_3$> $CuSO_4$>$CdCl_2$> $CuCl_2$ for 1st and 3rd instar larvae (Table 2). Depending on % pupal mortality the order of decreasing toxicity of salt solutions was not same as the order based on LC_{90} and LT_{90} and determined as follows: $HgCl_2$> $CdCl_2$> $AgNO_3$> $CuSO_4$> $CuCl_2$ (Table 3). Therefore, according to the highest toxicity on the basis of lethal concentration (LC_{50} & LC_{90}), lethal time (LT_{50} & LT_{90}),

Name of salts	LT Values	Lethal time **(LT)** against each Concentration of a salt									
		1ppm		3ppm		5ppm		7ppm		10ppm	
		1st instar	3rd instar	1st instar	3rd instar	1st instar	3rd instar	1st instar	3rd instar	1st instar	3rd instar
$HgCl_2$	LT_{50}	14.23	25.37	10.51	17.24	8.51	13.55	7.30	10.97	5.32	8.04
	LT_{90}	34.65	66.75	21.87	36.43	18.47	30.19	15.78	28.58	10.48	17.69
$AgNO_3$	LT_{50}	27.88	151.11	22.66	141.10	17.26	102.33	14.12	54.94	8.27	38.16
	LT_{90}	52.71	456.67	48.93	366.38	31.43	252.87	26.14	137.29	21.48	105.43
$CuSO_4$	LT_{50}	98.45	183.76	62.33	165.55	36.40	102.33	28.97	75.08	22.64	42.45
	LT_{90}	188.24	545.66	102.25	478.23	61.61	312.35	55.23	177.14	45.09	132.92
$CdCl_2$	LT_{50}	158.97	281.34	92.33	176.25	39.58	102.33	34.62	84.60	25.90	63.12
	LT_{90}	332.45	789.53	202.87	565.56	67.98	361.65	57.92	203.14	47.97	144.70
$CuCl_2$	LT_{50}	297.55	478.45	154.53	294.16	141.10	234.76	66.74	179.71	40.06	130.82
	LT_{90}	588.23	985.54	497.34	845.87	366.38	776.54	154.11	502.15	74.42	383.19

Table 2: Lethal time of the 1st and 3rd instar larvae of *Cx. quinquefasciatus* for different concentrations of salt solution.

Name of salts	Concentration (ppm)	Larval mortality (%)	Pupation (%)	Pupal mortality (%)	Adult emergence (%)
$CdCl_2$	1	60	40	33.33	66.67
	3	65	35	36.43	63.57
	5	68.33	31.67	63.16	36.84
	7	81.67	18.33	63.64	36.36
	10	100	00	00	00
$CuSO_4$	1	45	55	21.21	78.79
	3	55	45	29.28	70.72
	5	75	25	33.33	66.67
	7	80	20	41.67	58.33
	10	00	00	00	00
$CuCl_2$	1	38.33	61.67	13.51	86.49
	3	43	57	12.33	87.67
	5	48.33	51.67	12.9	87.10
	7	68.33	31.67	26.32	73.68
	10	100	00	00	00
$AgNO_3$	1	56.67	43.33	26.92	73.08
	3	68	32	29.51	70.49
	5	76.67	23.33	35.71	64.29
	7	80	20	41.67	58.33
	10	100	00	00	00
$HgCl_2$	1	95	5	33.33	66.67
	3	100	00	00	00
	5	100	00	00	00
	7	100	00	00	00
	10	100	00	00	00

Table 3: Efficacy of salt on pupation, pupal mortality and adult emergence from the 3rd instar larvae of *Cx. quinquefasciatus* when treated with different concentrations of salt solutions.

pupation, pupal mortality and adult emergence, mercuric chloride ($HgCl_2$) was found as the highest potential against the laboratory reared larvae (1st and 3rd instar) of *Cx. quinquefasciatus* mosquito.

Conclusion

The study obtained the findings that $HgCl_2$ showed highest larvicidal efficacy against both 1st and 3rd instar larvae of filaria vector mosquito, *Cx.quinquefasciatus*. The LC_{50} & LC_{90} values of $HgCl_2$ were 1.26ppm & 34.24ppm and 4.30ppm &46.24ppm against 1st and 3rd instar larvae of *Cx. quinquefasciatus* respectively. In addition, The LT_{50} and LT_{90} values at 1ppm concentration of $HgCl_2$ were 14.23 hrs and 34.65hrs and, 25.37 hrs and 66.75hrs against 1st instar and 3rd instar larvae of *Cx. quinquefasciatus* respectively. The 1st instar larvae of *Cx. quinquefasciatus* were failed to pupate in the solution of each concentration (1-10ppm) of every salts. $HgCl_2$ successfully killed 3rd instar larvae and no pupation and adult emergence were found at 3ppm to 10ppm. The order of decreasing toxicity was determined as: $HgCl_2$> $AgNO_3$> $CuSO_4$>$CdCl_2$> $CuCl_2$ depending on larvicidal potentiality (LC and LT values). The findings of the present study may be helpful in developing an efficacious and eco-friendly control agent to suppress and eradicate filaria vector mosquito, especially in the areas where mosquitoes are resistant to chemical insecticides. The use of traditional insecticides in the water bodies, however, creates toxicity for human and the environment. Insecticides those derived from Natural components are safer and more promising in this aspect. However, the application of these laboratory based findings need to be established by additional research and observation about the residual toxicity of this salt on aquatic ecosystems in the field is very important.

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Conflict of Interest

We have no conflict of interest to declare

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