Artemia nauplii after 24 and 48 hrs using SPSS ver.13.0 IBM software [33].

3. RESULTS

The 24 and 48hrs LC_{50} values for *Artemia* nauplii exposed to Malathion and Glyphosate were depicted in Table 1. The 24 and 48hr LC_{50} values of Malathion to *Artemia* nauplii were 58.3 and 17.3 ppm, respectively and those for glyphosate were 0.028 and 0.019 ppm, respectively.

Table 1: The LC_{50} values of Malathion and Glyphosate to *Artemia* nauplii after 24 and 48hrs exposure

S. No	Pesticides	LC_{50}	
		24hr	48hr
1.	Malathion	58.3 ppm	17.3 ppm
2.	Glyphosate	0.028 ppm	0.019 ppm

An overall significant effect of Malathion and Glyphosate on the mortality of *Artemia* nauplii was revealed ($P < 0.05$; Tables 2 & 3). Different concentrations of Malathion and Glyphosate also had significant effect ($P < 0.05$).

Table 2: Comparative toxicity (mortality %) of Malathion and Glyphosate to *Artemia* nauplii after 24hrs exposure (ANOVA)

Variable	Source	Sum of Squares (mortality %)	df	Mean square	F	Sig.
Malathion Vs *Artemia* nauplii	Between groups	63.067	4	15.767	236.50	.000*
	Within groups	0.667	10	0.067	--	--
	Total	63.733	14	--	--	--
Glyphosate Vs *Artemia* nauplii	Between groups	71.067	4	17.767	133.250	.000*
	Within groups	1.333	10	0.133	--	--
	Total	72.400	14	--	--	--

Note: *Significant level is expressed at 95% confident interval ($P < 0.05$)

Table 3: Comparative toxicity (mortality %) of Malathion and Glyphosate to *Artemia* nauplii after 48hrs exposure (ANOVA)

Variable	Source	Sum of Squares (mortality %)	df	Mean square	F	Sig.
Malathion Vs *Artemia* nauplii	Between groups	71.600	4	17.900	134.250	.000*
	Within groups	1.333	10	0.133	--	--
	Total	72.933	14	--	--	--
Glyphosate Vs *Artemia* nauplii	Between groups	103.067	4	25.767	193.250	.000*
	Within groups	1.333	10	0.133	--	--
	Total	104.400	14	--	--	--

Note: *Significant level is expressed at 95% confident interval ($P < 0.05$)

4. DISCUSSION

The present study was aimed to evaluate the short-term toxicity of the two highest market selling organophosphorus pesticides namely, Malathion and Glyphosate on 24hr old (instar I) larvae of *Aretmia*. The brine shrimp *Artemia* has many advantages as a marine test organism and widely used for the evaluation of different types of contaminants including pesticides and heavy metals [34, 27, 35-38, 28, 39]. It also a play a main food supply for the millions of shorebirds, and also used as major food source in marine and fresh water aquaculture [38,40].

The results showed differences in sensitivity of *Artemia* against two pesticides namely Malathion and Glyphosate (Table 1), the 24 and 48hr LC_{50} values of Malathion on *Artemia* nauplii were 58.3 and 17.3 ppm, respectively. In an earlier study, a group researcher reported 24hr LC_{50} value of 81.5 ppm for Malathion to the freshwater anostracan, *Streptocephalus proboscidius* nauplii [41]. A group of scientists have found 24hr LC_{50} value of 67.7 ppm for Malathion to *S. sudanicus* nauplii [42]. However, some of them reported 24hr LC_{50} value of 6.4 ppm for Malathion to *S. proboscidius* nauplii [43]. Likewise, a researcher observed a 24hr LC_{50} value of 24.5 ppm for Malathion to *Branchinecta sandiegonensis* [44]. Table 4 summarizes the toxicity of Malathion and Glyphosate used in earlier studies as well as in the present study to different branchiopods**.**

Table 4: Toxicity of (LC_{50}) of Malathion and Glyphosate to branchiopods

Pesticides	Test organisms	Hours (LC_{50})	Values	Source
Malathion	*S. proboscidius* 24hr nauplii	24hr LC_{50}	81.5	Crisinel *et al.* (1994)
Malathion	*S. Sudanicus* 24hr nauplii	48hr LC_{50}	67.7	Lahr *et al.* (2001)
Malathion	*S. proboscidius* 24hr nauplii	24hr LC_{50}	6.4	Verschueren (2001)
Malathion	*B. sandiegonensis* 24hr nauplii	24hr LC_{50}	24.5	Ripley *et al.* (2003)
Malathion	*S. dichotomus* 24hr nauplii	24hr LC_{50}	14.1	Arun Kumar and Jawahar Ali (2014b)
Malathion	*S. dichotomus* 24hr nauplii	48hr LC_{50}	12.3	Arun Kumar and Jawahar Ali (2014b)
Malathion	*Artemia* 24hr nauplii	48hr LC_{50}	1.00	Sidharta (1997)
Malathion	*C. dubia*	24hr LC_{50}	0.00318	Nelson and Roline (1998)
Malathion	*D. magna*	48hr LC_{50}	0.003	Rassoulzadegan and Akyurtalkli (2002)
Malathion	*Artemia* 24hr nauplii	24hr LC_{50}	58.3	Present study
Malathion	*Artemia* 24hr nauplii	48hr LC_{50}	17.3	Present study
Glyphosate	*T. platyurus* 24hr nauplii	24hr LC_{50}	0.35	Foctman *et al.* (2000)
Glyphosate	*B. sandiegonensis* 24hr nauplii	24hr LC_{50}	0.0118	Ripley *et al.* (2003)
Glyphosate	*B. thailandensis* 24hr nauplii	24hr LC_{50}	0.319	Boonsoong and Bullangpoti (2012)

Glyphosate	*S. dichotomus* 24hr nauplii	24hr LC_{50}	0.026	Arun Kumar and Jawahar Ali (2014b)
Glyphosate	*S. dichotomus* 24hr nauplii	48hr LC_{50}	0.014	Arun Kumar and Jawahar Ali (2014b)
Glyphosate	*D. magna*	48hr LC_{50}	42	Alberdi *et al.* (1996)
Glyphosate	*D. magna*	48hr LC_{50}	250	Raipulis *et al.* (2009)
Glyphosate	*Artemia* 24hrs nauplii	24hr LC_{50}	0.028	Present study
Glyphosate	*Artemia* 24hrs nauplii	48hr LC_{50}	0.019	Present study

According to a study, the 48hr LC_{50} value of Malathion (Technical grade) to *Artemia salina* was 1.00 ppm [45]. At the same time, two researchers observed 48hrs LC_{50} value of was 12.3 ppm to *S. dichotomus*, which is lower than the value observed in the present study [2]. However, in other study, they documented a 24hr LC_{50} value of 0.00318 ppm for *Ceriodaphnia dubia* [46]. The 48hrs LC_{50} values of technical and commercial grades of Malathion to *D. magna* were 0.028 ppm and 0.003 ppm, respectively [47].

As shown in Table 1, the 24 and 48hr LC_{50} values of Glyphosate to *Artemia* nauplii were 0.028 and 0.019 ppm, respectively. From these results it is obvious that Glyphosate was significantly more toxic to *Artemia* nauplii than Malathion ($P < 0.05$). A group of researchers has demonstrated that the 24hr LC_{50} value for Glyphosate on anostracan, *Thamanocephalus Platyurus* was 0.35 ppm [48]. However, some of them observed 24hr LC_{50} value of 0.0118 ppm for Glyphosate to *B. Sandiegonensis* [44]. Whereas reported 24hr LC_{50} value of 0.319 ppm for Glyphosate to *B. Thailandensis* nauplii. Fairy shrimp, *S. dichotomus* exposed to Glyphosate showed an LC_{50} of 0.014 ppm, which is lower than the present study of 0.019 ppm for brine shrimp, *Artemia* in 48 hours [2]. A scientist observed that *Artemia franciscana* exposed to Glyphosate and Zinc in combination produced an increase in lethality compared to shrimp exposed only to Glyphosate and Zinc separately [39].

According to some study, the 48hr LC_{50} value of Glyphosate was 42 ppm to *D. magna* [49]. A group of scientists has reported almost five times for the same species higher at 48hr LC_{50} (250 ppm) [50]. A researcher also reported that fish and aquatic invertebrates were more sensitive to Glyphosate than terrestrial organisms [51]. The LC_{50} values observed in the present investigation for *Artemia* 24hr old nauplii (instar I) exposed against Malathion and Glyphosate were comparatively lower, which might be due to differences in experimental conditions and sensitivity of the species. Toxicity of a xenobiotic is governed by many factors, such as water temperature, purity of the toxin, life stage of organism, size of the individual etc.

From the results, it was clear that *Artemia sp.* is more sensitive to the exposure of the organophosphate Glyphosate than that of Malathion. The residues of organophosphate can be easily accumulated in the tissues of *Artemia* either by direct contact or by ingestion and the secondary effects might be observable in predators of *Artemia* in aquatic environments [31]. In conclusion, the branchiopod microcrustacean *Artemia* proved to be an excellent ecotoxicological bioindicator for marine and saline environments polluted with organophosphate residues and may be considered as an important bio monitoring tool for future toxicological analysis.

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