

Research Article



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*Chironomus riparius*의 급성 및 만성영향에 의한 농약의 퇴적토 독성평가

박정은, 황은진, 장희라*

Sediment Toxicity Assessment of Pesticides using *Chironomus riparius* Acute and Chronic Effect

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Received: 12 June 2017 / Revised: 16 June 2017 / Accepted: 23 June 2017

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Abstract

BACKGROUND: Pesticides is exposed in an aquatic environment and effected to benthic animals. Especially, sediment-associated pesticides is required for determination of sediment toxicity on aquatic organisms. This study was conducted to evaluate the impact of six pesticides (chlorfluazuron, difenoconazole, dithianon, flufenoxuron, flutianil, pendimethalin) on *Chironomus riparius* in aquatic ecosystems.

METHODS AND RESULTS: Chlorfluazuron, difenoconazole, dithianon, flufenoxuron, flutianil and pendimethalin were used as a model compounds, which have a sediment-associated potential ($K_{oc} > 3$). Acute and chronic toxicity tests on *Chironomus riparius* were performed at six concentrations of each pesticide with four replicates of each based on OECD test guideline 235 and 218. The calculated 48-h EC_{50} values of chlorfluazuron, flutianil, pendimethalin, difenoconazole, dithianon and flufenoxuron were 6.72, 2.55, 2.27, 0.77, 0.30 and 0.11 mg/L, respectively. Flufenoxuron was the lowest 48-h EC_{50} value in this study. The No Observed Effective Concentration (NOEC) and the

Lowest Observed Effect Concentration (LOEC) of flufenoxuron for *Chironomus riparius* in 28-days test were 30 and 60 $\mu\text{g}/\text{kg}$, respectively.

CONCLUSION: Pesticides of the sediment-associated have the potential effect for *Chironomus riparius* in aquatic ecosystems. Therefore, sediment toxicity assessment of these pesticides should be further investigated to evaluate the impact to benthic organisms.

Key words: *Chironomus riparius*, GLP, OECD, Pesticide, Sediment toxicity

서론

(log K_{oc})가 3
가 (Zhou and Rowland, 1997).

Chironomus riparius (*C. riparius*)
1

가
(Tiina, 2000).

riparius OECD test guideline 235 (OECD, 2011) 218

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(OECD, 2004) 가 가 가 가 , 가 , 가 가 가 가 48 EC₅₀ (50% effective concentration) <1 mg/L 21 NOEC (no observed effect concentration) <0.1 mg/L chlorfluazuron, difenoconazole, dithianon, flufenoxuron, flutianil, pendimethalin , OECD test guideline *C. riparius*

가 DT₅₀ (50% degradation time) ≥ 30 day, log K_{oc} (organic carbon-water partition coefficient) ≥ 3, daphnia 48 EC₅₀ (50% effective concentration) < 1 mg/L 21 NOEC (no observed effect concentration) < 0.1 mg/L

(Di Toro, 1991, Maund , 가 , 1997).

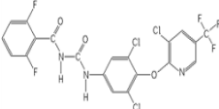
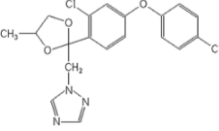
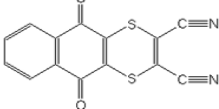
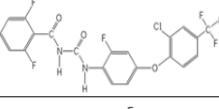
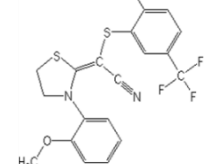
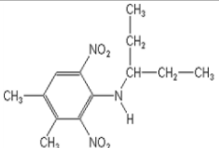
EC₅₀ NOEC가

재료 및 방법

시험약제 및 시약

chlorfluazuron (98.9%, Flukar, USA), difenoconazole (99.5%, Chem Service, USA), dithianon (99.5%, EPA Research Triangle Park, N.C., USA), flufenoxuron (98.1%, Sigma-Aldrich, USA), flutianil (98.0%, Wako, Japan), pendimethalin (98.7%, Dr. Ehrenstorfer GmbH, Germany)

Table 1. Chemical structures and physico-chemical properties of test pesticides (Turner, 2015)

Common name	Chemical structure	MW ^{a)}	log Kow ^{b)}	log K _{oc}	Soil degradation DT ₅₀	Aquatic invertebrates (Daphnia) (mg/L)
chlorfluazuron		540.7	5.9	4.6	6 weeks-few months	Acute 48h LC ₅₀ 0.000908
difenoconazole		406.3	4.4	3.8	3 months-1 year	Acute 48h EC ₅₀ 0.77
dithianon		296.3	3.2	3.1	2.6-37.6 day	Acute 48h EC ₅₀ 0.26
flufenoxuron		488.8	4.0	3.6	42 day	Acute 48h EC ₅₀ 0.00004
flutianil		426.5	2.9	3.0	297.3 day ^{c)}	Chronic 21d NOEC 0.007 ^{c)}
pendimethalin		281.3	5.2	4.2	3-4 months	Acute 48h EC ₅₀ 0.28

a) Octanol-water partition coefficient

b) Organic carbon-water partition coefficient, Calculate K_{oc} from Kow (Hemond H. F. and E. J. Fechner, 2000)

c) EU Regulatory & Evaluation Data as published by EC Verified data used for regulatory purposes (PPDB, 2017)

Table 2. Test conditions of acute and chronic test for *Chironomus riparius*

Parameters	Conditions
Cage	30×30×30 cm
Temperature	20±2°C
Photo period	16 hour light, 8 hours dark
Quantity of light	700~800 Lux
Dilution water	M4 medium
Culture soil	quartz sand
Feeding	fish flake food Tetra Min [®] , 250 mg/cage/day
pH	6~9
DO	at least 60% of the air saturation value
Hardness	190~220 mg/L as CaCO ₃
<p>lindane (99.5%, Sigma-Aldrich, USA) , chlorfluazuron (Table 1). Acetone (Merck, Germany) 0.63, 1.25, 2.5, 5, 10 20 mg/L, difenoconazole HPLC , M4 0.094, 0.188, 0.375, 0.75, 1.5 3 mg/L, dithianon OECD test guideline 235 Cell culture 0.031, 0.063, 0.125, 0.25, 0.5 1 mg/L, flufenoxuron medium ACS reagent Sigma-Aldrich (USA) 0.016, 0.031, 0.063, 0.125, 0.25 0.5 mg/L, flutianil Merck (Germany) . 0.63, 1.25, 2.5, 5, 10 20 mg/L, pendimethalin 0.16, 시험생물 및 사육환경 0.31, 0.63, 1.25, 2.5 5 mg/L , (<i>C. riparius</i>) (M4) (acetone) . mL 5 4 100 , 1 , 24 48 OECD test guideline 218 235 . 24 48 50% Effected (Table 2). M4 concentration (EC₅₀) 95% EPA probit pH, , 1 analysis program (version 1.5) . pH .</p> <p>양성대조시험 깔따구(<i>C. riparius</i>) 만성독성시험 EC₅₀ (<i>C. riparius</i>) OECD flufenoxuron 28 OECD TG 235 218 test guideline 218 1 , lindane M4 , 313 g 3 L 0.008, 0.016, 0.032, 0.063, 0.125, 0.25 0.5 mg/L (M4) 2 , (acetone) , 2.82, 5.63, 1252 g, 4687.6 g, CaCO₃ 3.1 g 7 11.25, 22.5 45.0 μg/kg (M4) , 2) (acetone) . ± 2SD pH 6~9, 19~20°C, 16 , (standard deviation) 95% 8 600~800 Lux . (Moser H. and J. Römbke, 2009). 10 0.5 mg/ day, 11 1.0 mg/day 깔따구(<i>C. riparius</i>) 급성독성시험 Tetra Min[®] (Tetra, USA) 1 1 (<i>C. riparius</i>) 48 OECD . test guideline 235 1 , 0, 30, 60, 80, M4 . pH 6~9, 100 150 μg/kg , (M4) 19~20°C, 16 , 8 600 (acetone) . ~800 Lux . 4 10 g</p>	

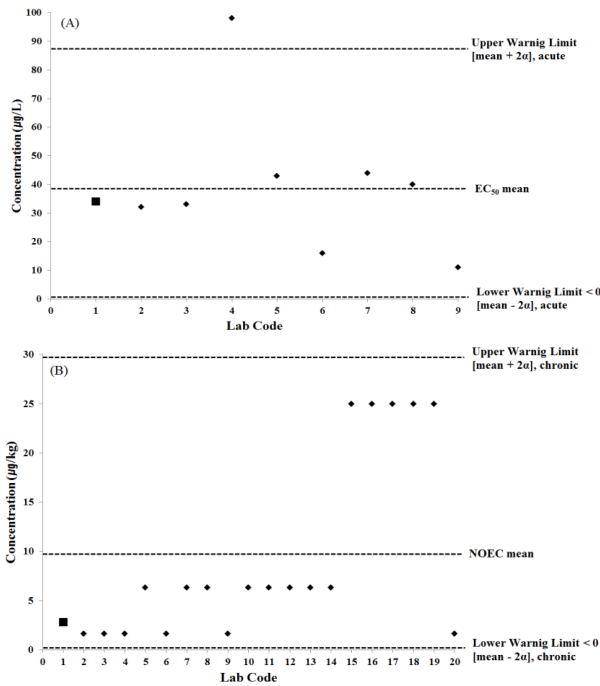


Fig. 1. EC₅₀ and NOEC evaluation of boric acid for sediment toxicity tests with *Chironomus riparius* ((A) acute EC₅₀, (B) chronic NOEC).

$$f_i = \frac{1}{n_e} \sum_{i=1}^m \left[\frac{1}{\left(\frac{day_i - l_i}{2} \right)} \right] \quad (1)$$

$$ER = n_e / n_a \quad (2)$$

$$\bar{x} = \sum_{i=1}^m \frac{f_i \left[\frac{1}{\left(\frac{day_i - l_i}{2} \right)} \right]}{n_e} \quad (2)$$

EC₅₀ 95% EPA probit analysis program (version 1.5), NOEC LOEC ANOVA (Dunnnett's) analysis 0.05 (α)

결과 및 고찰

양성대조시험

lindane (*C. riparius*) EC₅₀ 0.034 (0.025~0.045) mg/L, NOEC 2.82 µg/kg, lindane EC₅₀ NOEC ±2SD 95%

Weltje (2009) lindane 48h-EC₅₀ (Lab code 2~9) 39.0 µg/L, Streloke Köpp (1995) NOEC (Lab code 2~20) 9.4 µg/kg (Lab code 1) 95% (Fig. 1).

급성독성시험

Chlorfluazuron, flutianil, pendimethalin, difenoconazole, dithianon flufenoxuron (*C. riparius*)

70 g 가, M4 320 mL 가 7 가, 20 10 28 1 1 (ER) (1) (ER) , ne (2) , i , m

Table 3. EC₅₀ and EC₅₀ ratio of pesticides for *Chironomus riparius*

Pesticide	Exposed period	EC ₅₀ , mg/L (95% C.L.) ^{a)}	24 h-EC ₅₀ /48 h-EC ₅₀
chlorfluazuron	24 h	14.50 (10.94~22.53)	2.16
	48 h	6.72 (5.38~8.43)	
difenoconazole	24 h	1.52 (1.16~2.13)	1.99
	48 h	0.77 (0.58~1.02)	
dithianon	24 h	0.44 (0.33~0.62)	1.48
	48 h	0.30 (0.23~0.38)	
flufenoxuron	24 h	0.42 (0.30~0.63)	3.90
	48 h	0.11 (0.073~0.15)	
flutianil	24 h	5.90 (4.08~9.23)	2.32
	48 h	2.55 (1.83~3.46)	
pendimethalin	24 h	8.85 (4.73~68.38)	3.90
	48 h	2.27 (1.75~3.11)	

^{a)} Confidence Limits

Table 4. Effects of flufenoxuron on emergence and development of *Chironomus riparius* for 28 days

Concentration (mg/kg)	Emergence (%)		Development ratio (day ⁻¹)	
	Replication	Average±SD ^{a)}	Replication	Average±SD
Control	1	80		0.0482
	2	85	85±0.04	0.0454
	3	90		0.0447
	4	85		0.0447
		0.0458±0.002		
Solvent control	1	85		0.0463
	2	80	81±0.05	0.0446
	3	75		0.0455
	4	85		0.0452
		0.0454±0.001		
0.03	1	90		0.0448
	2	75	78±0.10	0.0441
	3	80		0.0441
	4	65		0.0451
		0.0445±0.001		
0.06 ^{b)}	1	70		0.0439
	2	60	60±0.08	0.0421
	3	50		0.0422
	4	60		0.0440
		0.0431±0.001		
0.08 ^{b)}	1	35		0.0413
	2	30	34±0.03	0.0412
	3	35		0.0420
	4	35		0.0443
		0.0422±0.001		
0.10 ^{b)}	1	25		0.0404
	2	15	19±0.05	0.0415
	3	20		0.0411
	4	15		0.0427
		0.0414±0.001		
0.15 ^{b)}	1	10		0.0409
	2	10	10±0.04	0.0386
	3	5		0.0408
	4	15		0.0423
		0.0407±0.002		

^{a)} Standard deviation

^{b)} The mean for this concentration is significantly less than the control mean at alpha=0.05 (1-sided) by Dunnett's test

48h-EC₅₀ 6.72, 2.55, 2.27, 0.77, 0.30 and 0.11 mg/L , 48
 flufenoxuron 가 (Table 3). , Kim
 24h-EC₅₀ 48h-EC₅₀ 1.48~3.90 48 (2009) .
 , flufenoxuron 3.90
 가 . (C. riparius) 만성독성시험
 (C. riparius) 가
 , 24 flufenoxuron
 C 85% 81%

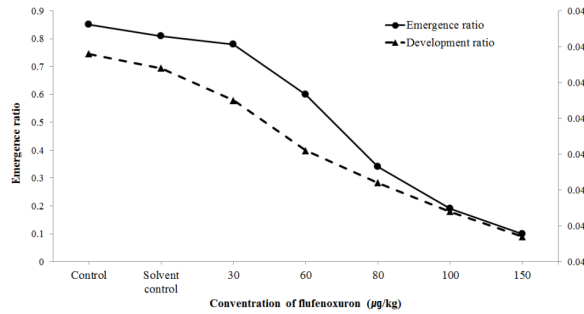


Fig. 2. Relationship between Emergence, development ratio and test concentration for flufenoxuron during 28 days.

70% ,
0.03, 0.06, 0.08, 0.10 0.15 mg/kg
78%, 60%, 34%, 19% 10%
0.0458/day
0.0454/day , 0.03, 0.06, 0.08, 0.10 0.15
mg/kg 0.0445/day, 0.0431/
day, 0.0422/day, 0.0414/day 0.0406/day ,
28d-NOEC 0.03 mg/
kg, 28d-LOEC 0.06 mg/kg (Table 4).

Flufenoxuron (*C. riparius*)

가 가

, 0.03~0.08 mg/kg
(Fig. 2), (0.15 mg/kg)

가

Flufenoxuron

(*Danio rerio*) (*Daphnia magna*)

NOEC >0.0012 mg/L 0.0001 mg/L ,
(*C. riparius*) NOEC 0.03 mg/kg ,

UN GHS (Global Harmonized System of classification and labelling of chemicals)

NOEC<0.1 mg/kg chronic 1

(ECHA, 2011, UN, 2011)

(*C. riparius*) 28d-NOEC

(*Danio rerio*) (*Daphnia magna*) NOEC

25 3000 , NOEC<0.1 mg/
kg .

kg

가

,

가

48 EC₅₀ (50%

effective concentration)<1 mg/L 21

NOEC (no observed effect concentration)<0.1 mg/L

가

Acknowledgement

This study was supported by KEITI (Korea Environmental Industry & Technology Institute), Republic of Korea (Project No. 2014001370007).

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