Bull Environ Contam Toxicol (2008) 80:247–250
DOI 10.1007/s00128-007-9354-9

Effect of Fenoxaprop-*p*-ethyl on Natural Plankton of the Seyhan Dam: A Microcosm Study

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Received: 20 July 2007 / Accepted: 26 December 2007 / Published online: 13 January 2008

Abstract Fenoxaprop-*p*-ethyl, a herbicide that is commonly used in Çukurova region, was studied for possible adverse impacts on the Seyhan dam plankton and water quality variables in laboratory microcosms for 40 days. Water containing natural plankton, and sediment were collected from the Seyhan dam. The herbicide was added to six microcosms in 0.1, 1, and 10 mg L^{-1} concentrations. Two microcosms were used as reference groups. The results indicate that pennat diatom, Cladocera, and Copepoda at 10 mg L^{-1} contaminations and centric diatom and Chlorophyta at 1 mg L^{-1} contamination were affected. This herbicide did not alter water quality.

Keywords Fenoxaprop-*p*-ethyl · Herbicide · Plankton · Seyhan dam

Herbicides are widely used in agriculture to reduce or destroy weeds, mainly to avoid competition for nutrients and light between crops and weeds. An undesirable side-effect of the use of herbicides is that they may enter aquatic ecosystems via run-off, spray-drift or accidental spill. Contamination of aquatic ecosystems with herbicides has been reported to have direct toxic effects on populations of phytoplankton, epiphyton, and macrophytes. When these primary producers are affected, indirect effects on ecosystem functioning and animal populations can also be expected by reducing the food supply (Cuppen et al. 1997; Perschbacher and Ludwig 2004). Single species laboratory tests can only provide basic information on ecotoxicity in aquatic ecosystems. In last years, test systems were enhanced. Much of these systems have aquatic microcosm and mesocosm tests that provide realistic studies of the effects of single chemicals at the population, community, and ecosystem levels of biological organization (Perschbacher et al. 1997; Van den Brink 1997; Traas et al. 1998; Perschbacher and Ludwig 2004).

Fenoxaprop-*p*-ethyl is one of the members of the aryloxyphenoxypropionate herbicide family which is used only for control of annual and perennial grass in spring barley, winter wheat and winter rye, and for control of wild oat in fallow fields. This herbicide is widely used in Çukurova region in Turkey. Seyhan dam is a mesotrophic lake in Çukurova region and major land use in the common watershed of lake is agriculture and urban settlement (Çevik et al. 2007). The purpose of this investigation was to examine the potential effect of Fenoxaprop-*p*-ethyl on natural plankton communities of the Seyhan dam in laboratory microcosm systems.

Materials and Methods

The study was conducted at the Çukurova University, Fisheries Faculty at Biyo-assay Laboratory. Laboratory microcosm experiments were carried out in 10 glass aquaria (39 cm × 29 cm × 27 cm) placed in a temperature-controlled room at 22 ± 2. Microcosms were illuminated with fluorescent lights on a 12 L:12 D photo period at approximately 150 μmol. Glass aquaria were filled with the lake water and sediment. The sediment and overlying lake water were collected from Seyhan dam to provide a representation of a naturally occuring water and sediment environment in an impounded surface water

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body. The sediment was sieved through a 5-mm sieve and homogenized by hand. Initially each microcosm received a 0.7-cm layer of lake sediments, 25 L of lake water. Microcosms were covered with transparent plastic film to reduce evaporation. Over an acclimatization period of 3 weeks, a biocoenosis was allowed to develop in the microcosms. Meanwhile, the water was circulated using a pump with air to achieve similarity between the communities in the systems.

The initial doses (0.1, 1, 10 mg/L) of the herbicide Fenoxaprop-*p*-ethyl was applied to six microcosms (two microcosms for each concentration), while other two systems served as reference. The experiment was conducted for 40 days. Water samples (500 mL) were collected on days 0, 3, 6, 9, 13, 17, 20, 27, 34 and 40, and passed over a 55-μm mesh net for qualitative and quantitative analysis of plankton. Drawn waters were used for nutrient analyses (According to APHA 1995). Plankton samples were fixed with Lugol's iodine solution and were calculated using Sedgwick-Rafter (APHA 1995).

The statistical analyses were made by SPSS statistical software package. ANOVA and Duncan's Multiple Range Test were used to test for significant differences among all water quality variables and plankton numbers of the reference and microcosms at different contamination levels.

Results and Discussion

The physicochemical variables measured are given in Table 1. There were no statistically significant differences for these variables from each other or from references ($p < 0.05$). During the first 9 days, values of ammonia concentrations in all microcosms were high. While this trend was low and stabilized after the 13th day, NO_2–N and NO_3–N concentrations were observed to be increasing. On 40th day, the study was terminated because of decreasing dissolved oxygen values in each microcosm.

Biotic community composition was similar in all microcoms. Bacillariophyta especially pennat diatom was the dominant producer and dominant organism. The zooplankton were represented by Cladocera and nauplii larvae that it was evaluated as Copepoda. Phytoplankton was relatively greater than zooplankton.

There was a significant difference among the treatments ($p < 0.05$) (Table 2). While in 10 mg L^{-1} contamination level, pennat diatom, Cladocera and Copepoda were different than the other contaminations, centric diatom and Chlorophyta were different in 1 mg L^{-1} and in 10 mg L^{-1} contaminations. With increasing contaminations, the number of plankton in microcosms decreased slightly. But at highest contamination, plankton was found to be the lowest (Figs. 1 and 2).

On 34th and 40th days, centric diatom wasn't found in 10 mg L^{-1} contamination. After the 13th day, Cladocera was completely absent in 10 mg L^{-1} contamination. Cladocera disappeared by the 20th day in 0.1 mg L^{-1} contamination, in 27 days at 1 mg L^{-1} contamination, and by the 34th day in reference group. Since nauplii larvae appeared in all microcosms, except the 10 mg L^{-1} contamination, zooplankton number increased after the 27-day.

The results indicated that 10 mg L^{-1} Fenoxaprop-*p*-Ethyl contamination altered plankton qualitatively and quantitatively. Fenoxaprop-*p*-Ethyl has a negative effect on centric diatom and Chlorophyta at 1 mg L^{-1} contamination. The LC_{50} of Fenoxaprop-*p*-ethyl for *Scenedesmus subspicatus* was 0.51 mg L^{-1} (72 h), EC_{50} for *Daphnia magna* was 0.56 mg L^{-1} (48 h) (Song and Zhao 2005). Increase and decrease of water quality variables were not statistically different by concentration. Therefore, the decrease in plankton number is due to the direct effect of the herbicide.

Perschbacher and Ludwig (2004) observed no effect exposure to direct rates (0.05 kg active gradient ha^{-1}), 1/10 and 1/100 of direct rates of Quizalofob on phytoplankton biomass and productivity, zooplankton population and water quality. Fluazop, another aryloxyphenoxypropionate herbicide, was also found to have no effects in the direct rates (0.10 kg active gradient ha^{-1}), 1/10 and 1/100 of direct rates contaminations

Table 1 Mean, maximum, and minimum values of the water quality variables in microcosms

Variables	Mean ± SE	Min–Max
NH_4–N (mg L^{-1})	3.13 ± 3.81	0.079–8.7
NO_2–N (mg L^{-1})	0.51 ± 0.05	0.006–0.870
NO_3–N (mg L^{-1})	0.74 ± 0.08	0.018–1.425
PO_4–P (mg L^{-1})	0.004 ± 0.0003	0.002–0.009
pH	8.23 ± 0.06	7.25–8.86
DO (mg L^{-1})	6.56 ± 0.19	4.12–9.49

Table 2 Duncan's multiple range test results for the reference and different contamination in microcosms

Organisms	Reference	0.1 mg L^{-1}	1 mg L^{-1}	10 mg L^{-1}
Pennat diatome	183.5^a	162.2^a	185.6^a	57.4^b
Centric diatome	6.6^c	5.43^c	3.6^a	1.8^b
Chlorophyta	64.2^c	57.1^c	43.7^a	12.4^b
Cladocera	7.7^a	5.5^a	4.6^a	1.7^b
Copepoda	0.5^a	0.2^a	0.2^a	0.0^b

Means followed by the same letter are not statistically different by ANOVA and Duncan's New Multiple Range Test. $\alpha = 0.05$

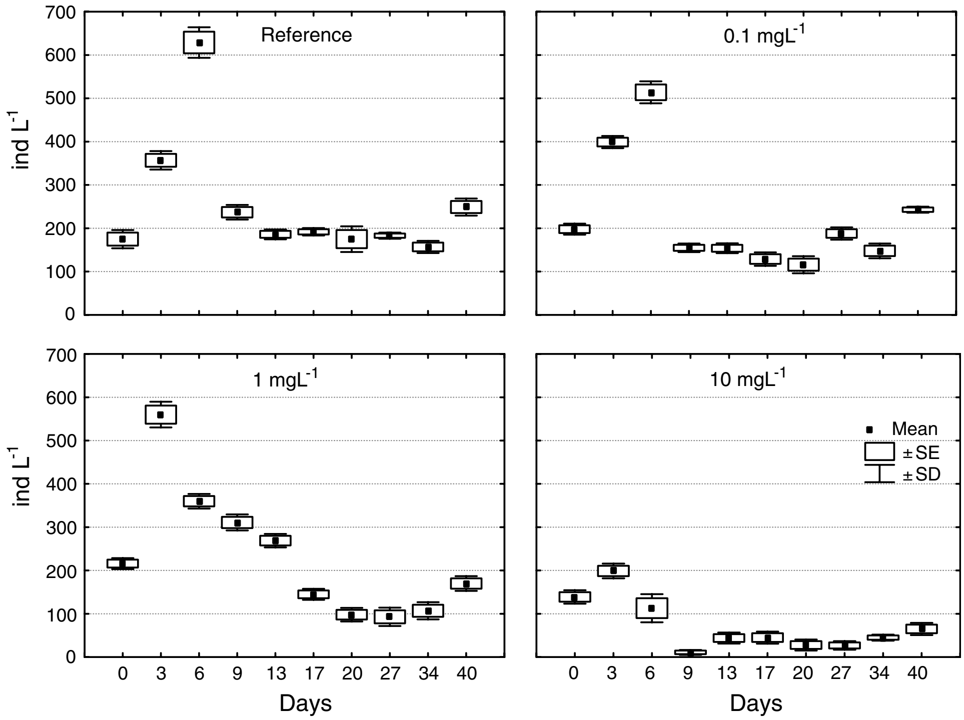

Fig. 1 Changes in total phytoplankton number in microcosms at different contamination levels

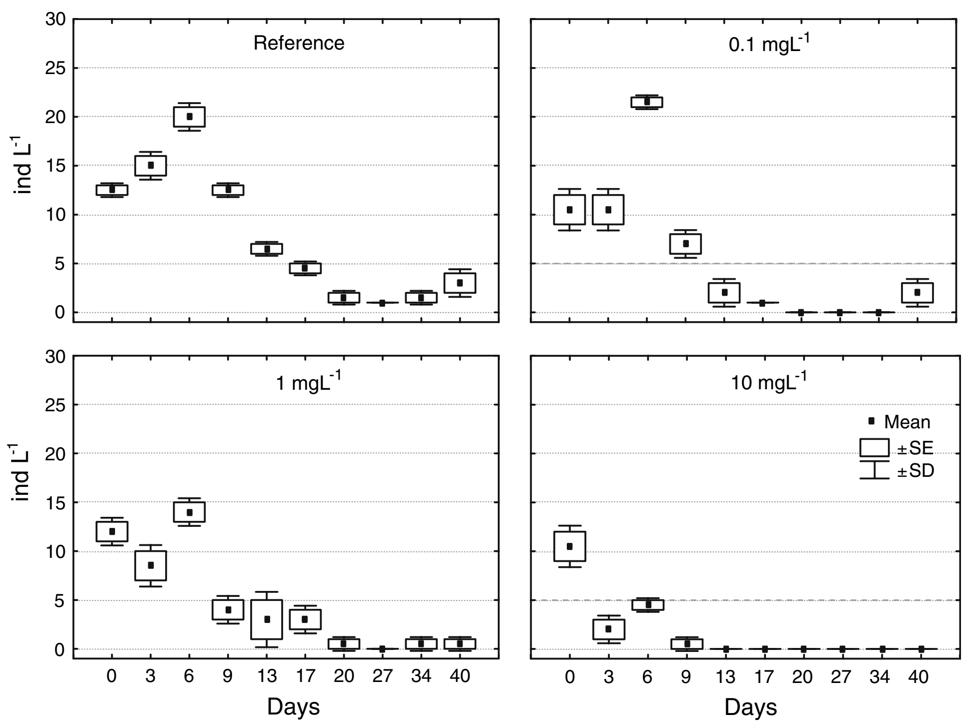

Fig. 2 Changes in total zooplankton number in microcosms at different contamination levels

(Perschbacher et al. 1997). Contamination methods of these two studies are different than our study. While Quizalofob and Fluazop were sprayed onto surface to outdoor mesocosms, Fenoxaprop-*p*-Ethyl was put into microcosms water column.

These herbicides are usually aerially applied. However exposure of aquatic ecosystems to pesticides is not only via run-off or spray-drift but also via accidental spill or washing of pesticide packings. This study showed that if an aquatic environment is contaminated with 1 mg L^{-1} Fenoxaprop-*p*-ethyl or more, plankton will be affected.

Acknowledgment This work was supported (FBE2002 YL348) by the research fund of Çukurova University, Turkey.

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