Journal of Ecological Research, 3, 9-12 (2001)

EFFECT OF EXPERIMENTAL CHLORINE WATER TREATMENT BEDS ON MACROINVERTEBRATE ABUNDANCE AND DIVERSITY IN CROOKED CREEK

David Hayes, Megan McElroy, Elizabeth Skinner and Rachel Skokan

ABSTRACT

Usage of experimental chlorine beds in central Pennsylvania has been under the analysis of the Pennsylvania Department of Environmental Protection. These beds, if effective, have the potential to drastically decrease money spent on sewage treatment. We analyzed the effects of the effluent sewage water, particularly the chlorine levels, on the abundance and diversity of macroinvertebrates in Crooked Creek. We found that there was a highly significant ($P < 0.001$) difference of macroinvertebrates between upstream and downstream surveys. There was a higher abundance of macroinvertebrate species upstream, indicating that the chlorine beds may be affecting macroinvertebrate populations.

Keywords: Abundance, chlorine, experimental chlorine beds, macroinvertebrates, streams, taxic diversity

INTRODUCTION

Macroinvertebrates are one of the primary indicators of stream quality. The number and type of species can give great insight into the presence and form of water pollution. We employed this indicator in testing the water of a small stream flowing into the Juniata River of central Pennsylvania.

A small township in central Pennsylvania has developed an experimental design as an economic alternative to traditional sewage treatment. The township of Hesston has created two chlorine beds with which to treat the area's human waste. These sites are located behind the Hesston post office and along Backbone Ridge, at the Northeast Extension. Sewage flows by pipe into a large collecting tank, where it is siphoned into another tank to be processed by bacteria. It then proceeds to a chlorinated sand bed where the sewage is disinfected. The treated waste is released into nearby Crooked Creek via a pipe. Juniata College operates a small water laboratory that tests the effluent water from these beds and reports to the Pennsylvania Department of Environmental Protection. This laboratory has noted extreme fluctuations in the levels of chlorine present in the effluent sewage water.

Chlorine is used widely as a disinfectant for wastewater treatment. Chlorine acts as a disinfectant when it comes in a form that is missing an electron. When this occurs, the chlorine steals electrons from other sources like microorganisms. This makes the chlorine toxic to microorganisms, like bacteria and viruses. It may also be detrimental to the health of other organisms, such as macroinvertebrates. The toxicity of chlorine increases when the concentration and various forms of chlorine are taken into account, as some are more toxic than others. Mattice and Tsai (1984) studied the effect of the various forms of chlorine on mosquito fish and found that some forms of chlorine used in waste treatment are lethal to these fish. Because of these possible lethal consequences for stream life, we tested the effects of effluent and the chlorine beds on the abundance and taxic diversity of macroinvertbrates in Crooked Creek. We hypothesized that macroinvertebrates should be more abundant and taxonomically diverse upstream from the effluent pipes and chlorine beds than downstream.

METHODS

Sites similar in substrate, flow rate, water depth and width were located 25 m upstream from the effluent pipes and 25 m downstream. Water from each test site was tested for chlorine levels using a HACH kit. A two-sample t-test was used to determine if there was a difference between the chlorine levels at the two sites.

Ten random macroinvertebrate samples were taken at each site using a small Surber-like sampler (area = 0.015 m^2). The samples were lumped per site and macroinvertebrate abundance was compared using a chi-squared test. Simpson's diversity index, based on the taxa collected, was calculated for each site as follows:

$$D = 1/\sum_{i=1}^{s} P_i^2$$

where s = taxic richness (calculated by adding up the number of taxa found in each community), and P = the proportion of the total number of individuals in the community that belong to the i th species.

RESULTS

The total abundance of macroinvertebrates (see Table 1) was significantly greater above than below the chlorine beds ($\chi^2 = 31.567$, df = 1, $P < 0.0001$). At least 10 taxa were collected upstream and six downstream. Simpson's diversity index, based on the taxa collected was 3.4072 upstream and 3.875

Table 1. List of macroinvertebrate taxa and the number collected upstream and downstream from effluent pipes and chlorine beds in Crooked Creek.

Upstream	Number Collected
Miscellaneous annelids	8
White annelids	1
Pristina (Annelida)	1
Noteridae (Coleoptera)	6
Pseshinus herricki (Coleoptera)	2
Pentaneura (Chironomidae: Diptera)	65
Simulium (Diptera)	1
Ephemerellidae (Ephemeroptera)	28
Heptogeniidae (Ephemeroptera)	12
Oligoneuridae (Ephemeroptera)	1
Trichoptera	8
Plecoptera	2
Total	135
Downstream	
Sphaeriidae (Bivalvia)	1
Chiromidae (Diptera)	8
Tipulidae (Diptera)	2
Ephemerellidae (Ephemeroptera)	14
Heptageniidae (Ephemeroptera)	6
Hydropsychodriae (Trichoptera)	4
Total	35

downstream. Chlorine levels did not differ significantly upstream (0.067 mg/L) versus downstream (0.060 mg/L; $t = 1.00$, df = 6, $P = 0.356$).

DISCUSSION

The results from our experiment both supported and challenged our hypothesis. We thought that there would be a higher abundance and diversity of macroinvertebrates upstream of the experimental chlorine beds in Crooked Creek, due to the toxicity of chlorine being released into downstream waters. The results from the Chi-square test supported our hypothesis, as it was found that there was a statistically significant higher abundance of macroinvertebrates upstream of the chlorine beds. This suggests that some factor, possibly the chlorine beds, affects the abundance of macroinvertebrates between the two sites. However, a more rigorous statistical analysis using non-lumped samples at each site would be required to verify this finding.

Although there was no significant difference between the chlorine levels at the two sites at the time that the tests were run, that does not necessarily rule out the chlorine beds as the factor causing the difference in macroinvertebrate life upstream and downstream. The Juniata Water Lab has discovered great fluctuations in the chlorine levels over time (see Fig. 1). At the time that the water was tested,

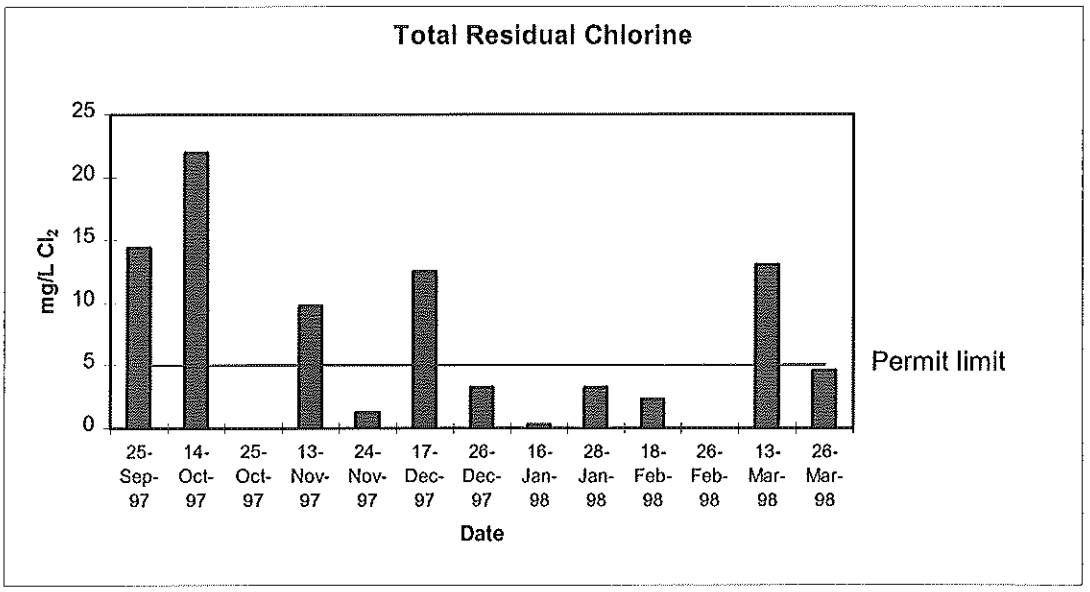

Figure 1. Chlorine fluctuations in the Northeast Extension effluent sewage based on observations by the Juniata Water Lab (unpublished work).

chlorine levels may been low after they had been previously high. Chlorine levels may have been diluted by several consecutive days of rain before the water was tested. Future work should test chlorine levels daily or at least weekly over a great time period.

Although more taxa of macroinvertebrates were found upstream than downstream, the Simpson's Diversity index was slightly lower upstream than downstream. This unexpected result may have been due to the low relatively even abundance of macroinvertebrates downstream, thus contributing to a higher diversity measure, which combines both species richness and relative abundance.

Maltby et al. (2000) also conducted a similar experiment using macroinvertebrates in a whole effluent toxicity (WET) test. They examined the effects of effluent discharges on two macroinvertebrate species: *Gammuras pulex* and *Daphnia magna*. They found decreased *D. magna* survival and *G. pulex* feeding and survival rates downstream of the discharge. They also discovered that chlorine was the principal toxicant in the discharges, and played a large role in decreasing the survival rates.

We conclude that there is a strong possibility that the experimental chlorine water treatment beds affected the macroinvertebrate populations in Crooked Creek. To confirm this, further prolonged sampling is needed of macroinvertebrate abundance and diversity in relation to chlorine levels in Crooked Creek.

ACKNOWLEGDGEMENTS

We thank Chuck Yohn for his assistance with the chemical testing, and Doug Glazier for his patience, goofy humor, and assistance.

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