Title: Acute and chronic toxicity of nitrate to brook trout *Salvelinus fontinalis*

Project ID: DNR Project #140

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Period of Contract: July 1, 1998- June 30, 2000

Funding: DNR

Focus Area: GSI (Groundwater/Surface Water Interactions)

Key Words: nitrate, brook trout, groundwater, toxicity

Background/Need: Nitrates in surface waters of the Little Plover River, a cold groundwater fed stream located in central Wisconsin, have increased from about 2 mg/L NO_3-N in the 1960s to over 8 mg/L NO_3-N by 1997. In groundwater upwelling zones on the Little Plover River, nitrate concentrations can exceed 28 mg/L NO_3-N. Nitrate may be a potential problem for the successful recruitment of cold water species such as brook trout, because they prefer to spawn in groundwater upwelling zones in streams and lakes. Water from upwelling zones flush fines from the redd, provide oxygen, and remove metabolic wastes produced by the embryos. Typical incubation times range from 32 to 165 days depending on temperature. During incubation, the embryo is buried in the substrate, where it may be exposed to high concentrations of nitrate for an extended period, until emergence or swim-up.

Objectives: The purpose of this study was to determine the acute and chronic toxicity of nitrate to feral and domestic brook trout (*Salvelinus fontinalis*) embryos and larvae, in moderately hard and soft water and to predict the potential for nitrate toxicity to brook trout in Wisconsin streams.

Methods: The acute and chronic toxicity of nitrate to brook trout embryos and fry was measured in short-term (96-h) and long-term (96-d) exposures. The endpoints measured were mortality and growth. Two domestic strains and one feral strain were tested.

Results and Discussion: Exposure to nitrate at environmentally realistic concentrations significantly increased mortality in brook trout embryos and reduced growth or biomass in long-term exposures. The lowest observable effect concentration was 6.25 mg/L NO_3-N for both mortality and growth of feral brook trout. The lowest observable effect concentration was 12.5 mg/L NO_3-N for mortality in domestic brook trout embryos and 100 mg/L NO_3-N for biomass reduction. Mortality was greater in soft water compared to hard water and the effect was independent of nitrate concentration. The 96-hour LC_{50} values for the domestic and feral brook trout were 2151.4 and 2645.3 mg/L NO_3-N respectively.

Conclusions: Concentrations of nitrate in groundwater are a concern because they influence surface water and because trout actively seek out groundwater upwelling zones for spawning. The Little

Plover River derives more than 40% of it base flow from groundwater. Concentrations of nitrate in groundwater feeding central Wisconsin streams such as the Little Plover River and the Plover River range from 2.8 to 37.8 mg/L NO_3-N. In some areas of upwelling in the Little Plover River, nitrate concentrations average 15.5 mg/L and specific sites of upwelling have reached 28 mg/L NO_3-N. Projected nitrate concentrations for areas of surface water for the Plover River, WI are estimated to reach 28.1 mg/L NO_3-N under current land practices by 2005. Trends in the Whiting, WI (Central Wisconsin sand plains near Stevens Point) well-field and Little Plover River support the notion that nitrate concentration will rise to over 8 mg/L in the surface water.

Concentrations of nitrate in the surface waters of the mid-west U. S. are a concern because they fall within ranges that are harmful to aquatic organisms. Fifty-three rivers sampled by the USGS in 1994 and 1995 in the 9 mid-western states (Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, Ohio and Wisconsin) indicated. Eighty-eight percent had concentrations that exceeded 2mg/L NO_3-N, while 43 % had concentrations exceeding 6 mg/L NO3-N. Kincheloe et al. (1979) suggested 2 mg/L NO_3-N as a guideline for protection of developing salmonid embryos in soft water. Effect levels reported for domestic and feral brook trout in this study support the need for a similar guideline.

Under current conditions, there is the potential to have increased embryo mortality in brook trout in coldwater streams, especially in areas with high agricultural uses. To fully understand how nitrate affects aquatic organisms, in-situ tests should be performed to validate laboratory studies. Additional research is needed to expand our knowledge of ancillary effects seen in the current experiment, such as effects on behavior, nitrate avoidance and effects on different species of coldwater organisms.

Related Publications: none yet submitted

Final Report: A final report containing more detailed information on this project is available for loan from Wisconsin's Water Library, University of Wisconsin - Madison, 1975 Willow Drive, Madison, Wisconsin 53706 (608) 262-3069.