Cadmium Toxicity and Accumulation in Southern Naiad

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Cadmium salts are considered significant water pollutants not only because of their direct toxicity in water in the 0.01 mg/l range but also due to their ability to be concentrated and incorporated into the food chain by aquatic organisms and plants.

The present investigation was conducted to determine the effects of three different levels of cadmium on the uptake and accumulation of this metal by a local pondweed, the southern naiad.

A 21-day static bioassay, utilizing artificial oxygenation of test solutions, was conducted using duplicate exposure chambers for each exposure level. Each of the chambers contained 3 liters of test solution, which was renewed every 48 hours. Growlux fluorescent tubes provided light (9-hour photoperiod) of approximately 200 foot-candles of illumination at the water's surface. Tap water was used following aeration for 6 days in order to remove the residual chlorine and to equilibrate the test water to laboratory temperature.

The test species, Najas quadulepensis Spreng., was acclimitized to laboratory conditions for 2 weeks prior to exposure. The roots were removed from each specimen and 2 grams of the plant material (6-to -8-inch sections) were placed in each container. The plants were exposed for 3 weeks, with metal analyses of the tissues at time 0, 11 days, and 21 days. Stock solutions of 3 Cd $SO_4 \cdot 8H_2O$ were used for preparation of test solutions and standards. Physiochemical parameters were as follows: total hardness, 180 $\pm$ 24 as $CaCO_3$; temperature, 25.1 $\pm$ 0. 7°C; dissolved oxygen, 6.2 $\pm$ 0.5 mg/l; total alkalinity, 45.7 $\pm$ 11.9 mg/l as $CaCO_3$; chloride, 197 $\pm$ 28 mg/l; sulfate, 129 $\pm$ 18 mg/l; and pH, 7.7 $\pm$ 0.2.

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After the specified exposure period, the plant tissues were rinsed, dried for 24 hours at 100°C, and then ashed in a Tracer-lab Model 600L Low Temperature Asher for 24 hours. Metal determinations were performed on a Jarrell-Ash Atomic Absorption Spectrophotometer Model 82-362.

The exposed plants demonstrated reductions of chlorophyll, turgor, and stolon development while no such toxic effects were noted in the controls. As may be seen in the following table, the quantity of Cd accumulated as the exposure levels increased:

Cd Exposure Level, mg/l	Cd accumulation, ug/g Ash (X ± S.D.) Length of Exposure		
(X ± S.D.)	Time 0	11 days	21 days
0.0005 ± 0.0001 (Control)	6.6 ± 0.7	6.9 ± 0.3	7.1 ± 0.1
0.007 ± 0.002	--	51.3 ± 1.4	60.4 ± 1.7
0.09 ± 0.02	--	3901.4 ± 111.1	4357.9 ± 89.9
0.83 ± 0.12	--	5243.4 ± 103.4	5429.3 ± 60.6

In all of the exposure levels, with the exception of the 0.007 mg Cd/l level, an equilibrium developed between the levels of Cd in the water and in the tissues. This was based on the absence of significant additional accumulation after the eleventh day of exposure. There was a significant increase in accumulation in the plants exposed to 0.007 mg Cd/l between the 11th and 21st day of exposure; toxic effects were less than the other exposure levels, and apparently the plants were still capable of accumulating Cd at a rate and level that was not yet toxic.

Toxic reactions and Cd accumulation by the plants increased as the exposure levels increased, which suggested that (a) Cd accumulation, ca. 1000 fold, was a direct function of the exposure level, and (b) the detoxifying mechanism was overtaxed at a more rapid rate at the higher levels resulting in an earlier impairment of physiological function. This physiological impairment resulted in the inhibition of additional Cd accumulation at the higher levels; however, significant additional accumulation and only slight toxic effects at the lower levels suggested that tissue damage was not sufficient to significantly inhibit further Cd accumulation. Therefore, it is evident that this common aquatic plant is capable of introducing potentially toxic quantities of cadmium into the food chain of higher organisms, e.g. sunfish and waterfowl.