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ENVIRONMENTAL ACIDIFICATION AND ITS CONSEQUENCES FOR THE TOXICITY OF WEAK ACIDS AND BASES TO AQUATIC ORGANISMS

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INTRODUCTION

In acidified waters adverse effects on fish and other aquatic organisms have frequently been observed.
Although water pH appears to be the master environmental variable it is not at all certain whether the observed effects are caused by hydrogen ions as such or by other associated factors.
One of the associated factors may be the increased toxicity of weak acidic or basic compounds to aquatic organisms. In this respect the use of a calculative method is proposed to assess quantitatively the effect of pH on their toxicity.

THEORETICAL BACKGROUND

The method is based on the concept of additive toxicity of protonated and deprotonated forms (ref. 2, 5, 6).
For a weak acid the following equation can be derived:

$$1/LC_{50} = T_m - (T_m - T_i).K_a/([H^+]+K_a)$$

where $1/LC_{50}$ is an expression of total toxicity, with the LC_{50} being the total concentration in mol/l producing 50% mortality, T_m is the toxicity of the molecular or protonated form (HA), and T_i is the toxicity of the ionized or deprotonated form (A^-) of a weak acid; K_a is the acidic-ionization constant.
In parallel for a weak basic compound a similar equation can be given.

ANALYSIS OF DATA

An analysis of acute toxicity data at different pH levels as reported in literature was made on basis of the method.
Plotting $1/LC_{50}$ data at the respective pH values against $K_a/([H^+]+K_a)$ a linear relationship is found.
The linear relationship is obtained by the standard least-squares technique and T_m and T_i can be calculated from the slope and the intercept of the resulting straight line.
From the calculated values of T_m and T_i, LC_{50}s at other pH levels can easily be estimated.

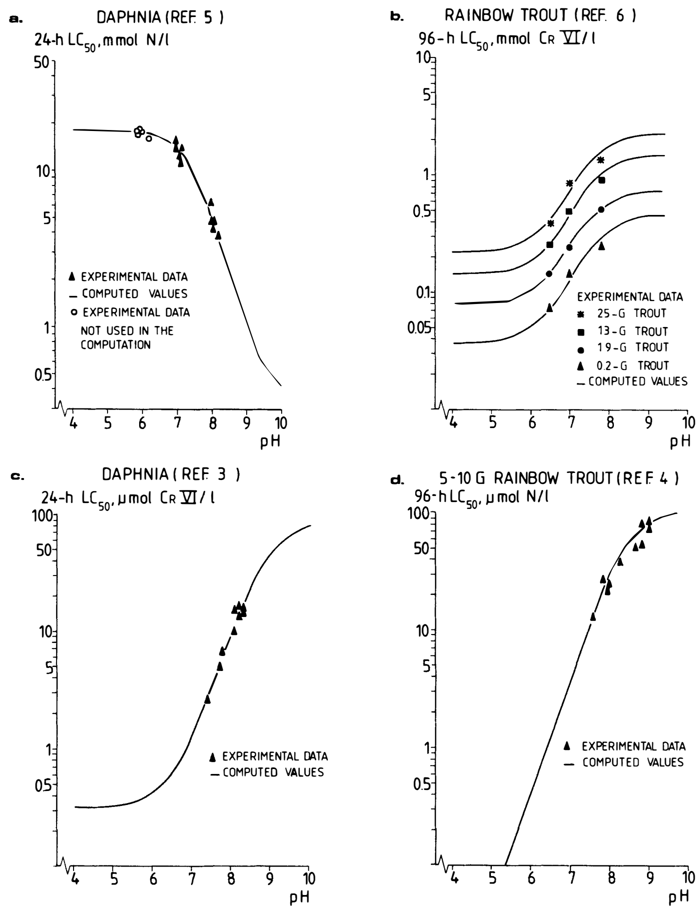

Fig. 1 The relation between pH, experimental and computed LC_{50}s for total ammonia (a), chromium (b, c) and nitrite (d).

RESULTS AND DISCUSSION

Results are presented in figure 1. Linear correlation coefficients with a high level of significance were found.

From the analysis of the three compounds, nitrite toxicity to rainbow trout is predicted to be the most sensitive to acidification. By extrapolation it is estimated that 96-h LC_{50}s for nitrite and this organism decrease by at least a factor 100 when pH is decreasing from pH 7 to pH 4-5.

Huey et al. (ref. 1) found for nitrite and bluegill a decrease of the 48-h LC_{50} by a factor of 60 when pH was decreased from pH 7.2 to pH 4.0.

The toxicity of the two other compounds is mainly influenced at pH levels above pH 5.

However, also at these pH levels substantial changes in toxicity are predicted to occur.

Considering these findings it is recommended that when important denominators of toxic effects are to be identified in acidified waters, more attention is paid to the change in toxicity of weak acids and bases with a change of pH.

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