THE EFFECTS OF ACID PERTURBATION ON A CONTROLLED ECOSYSTEM

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Abstract. Duplicate, 8-compartment, continuous-flow microcosms were used to study the effects of acid addition on community function, algal community structure, and degradation of a plasticizer, diethyl phthalate. Inputs of HCl decreased the alkalinity (measured as CaCO3) from 25 to 8 mg l⁻¹, creating diurnal H⁺ activity curves that indicated that the ecosystem was being severely stressed. Removal of excess acid was accompanied by a return to a normal diurnal pH cycle. Nutrient concentrations and O₂ production did not give a definite indication of stress resulting from the addition of acid. Algal community structure and total biomass were not affected by acid inputs. Also, degradation rates of diethyl phthalate by the aquatic bacteria were similar for the control and the acid-stressed systems. These studies indicate that acid inputs can significantly disrupt normal ecosystem function, such as diurnal pH cycling, without having a measurable impact on other parameters usually monitored in aquatic ecosystems.

1. Introduction

Combustion of fossil fuels, coal and oil in particular, can result in the formation of mineral acids (HCl, H₂SO₄, and HNO₃) in the atmosphere (Gorham, 1976) that produce acid precipitation sometimes many miles from the source. Decreases in H⁺ activity (pH) in precipitation, and conversely an increase in the acidity problem, have been observed for the last several decades in Europe as well as North America (Oden, 1976). Centuries-old statues lose their features, tombstones become illegible, automobile finishes corrode, and house paints last only a few years. Equally dramatic effects of acid precipitation have been clearly observed in lakes or streams (Acid Rain, 1980), where low pH can kill the eggs of fish, salamanders, and frogs. On the other hand, no data are available that show a direct adverse effect of acid precipitation on human health. Moreover, Brock (1973) suggested that acidification can be used advantageously to control or eliminate blue-green algal blooms in lakes or streams.

The extent to which acid precipitation influences the pH of a natural water is largely dependent upon the buffering capacity of that water. Alkalinity is in part a function of the total carbonate species (CO₂ + HCO₃⁻ + CO₃²⁻) which are excellent buffering agents. At a pH above 7 the relation tends towards the HCO₃⁻ and CO₃⁻² species, and aquatic systems will not be affected as much by acid inputs. At a pH below 7 a shift occurs towards CO₂ which decreases the alkalinity and buffering capacity. This leads to a less stable system, and rapid changes may occur in the biota behavior.

The objectives of the experiment were to study the effects of acid addition on the chemistry or nutrients, the standing crop of the microbial communities, and the ability

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of the microbial communities to degrade a toxic substance such as diethyl phthalate (DEP) in a large laboratory microcosm.

2. Materials and Methods

2.1. Facility

The study was conducted in the EPA’s Aquatic Ecosystem Simulator (AEcoS). The facility is a controlled environmental chamber that houses a 19.5 m long, 46 cm wide and 51 cm deep 'U-shaped' flume. The flume is divided into two independent flow channels (designated A and B), each subdivided into eight 250-l compartments called Continuously Stirred Tank Reactors (CSTRs). Each CSTR is equipped with an outlet weir such that the effluent from an upstream compartment constitutes the influent for the next downstream compartment.

The flume, constructed of Plexiglas, is lined with adhesive-backed, 4-mil Teflon film. Uniform mixing in each CSTR is accomplished by Teflon-covered Plexiglas paddle-wheels that are suspended longitudinally down the channel.

2.2. Colonization

Prior to the input of diethyl phthalate, biological communities were established in CSTRs 3-8 by inoculating each CSTR with a 4-l inoculum from three local ponds and a stream. The CSTRs were reinoculated and cross inoculated (between Channels A and B) each week. We wanted to set up an ecosystem without a toxicant input to establish reference and control data. After a 24-week period of colonization, pH, DO, and nutrient levels

Fig. 1. AEcoS experimental setup.