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EFFECTS OF THE CLEAN WATER ACT ON WATER QUALITY: A TEMPORAL COMPARISON OF WATER QUALITY ON THE SUSQUEHANNA RIVER BASIN.

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ABSTRACT

The establishment of the Clean Water Act in 1972 was a new approach intended to eliminate the discharge of pollutants into the nation's waters by 1985 and to achieve water-quality levels that are fishable and swimmable by 1983. The goal of this study was to investigate the effect of legislation on water quality in the Susquehanna River Basin. We compared data of five water-quality parameters between two periods of time: 1973-1982 to 1983-1993. The water parameters included: total nitrogen, dissolved oxygen, pH, phosphorus and aluminum. We found that pH levels (P = 0.029), dissolved oxygen (P = 0.021) and aluminum levels (P < 0.001) improved between 1972-82 to 1983-93. However nitrogen at all stations and phosphorus (P = 0.048) at two stations did not show an improvement. Given that nitrogen and phosphorus primarily come from farm runoff, the Clean Water Act of 1972 seemed not to be effective in dealing with non point sources of pollution.

Keywords: Clean Water Act, legislation, Susquehanna River, water quality

INTRODUCTION

The 1972 amendments to the Federal Water Pollution Control Act, commonly known as the Clean Water Act, created the nation's landmark environmental legislation (CEQ Report 1993). The fundamental goals of this Act were to eliminate the discharge of pollutants into the nation's waters by 1985 and achieve water quality levels that are fishable and swimmable by 1983 (EPA 2001). State governments and industry responded to regulations that control the discharge of pollutants into waterways, by reducing discharges, becoming more efficient in water use, reducing the production of wastes and improving the recycling of waste products (CEQ Report 1993).

The Clean Water Act was not as effective as it was previously thought. Its goals were too ambitious, lack of enforcement and control of non point sources of pollution were some of its major flaws (Copeland 1999) and therefore, several amendments have been necessary. Major amendments after 1972 have been The Clean Water Act of 1977, Municipal Wastewater Treatment Construction Grants Amendments of 1981, and Water Quality Act of 1987.

According to the EPA, the quality of the U.S. waters have improved dramatically as a result of the implementation of the pollution control programs established in 1972 by the Clean Water Act (EPA 2001). However, enforcement of the act and its amendments has been a continuous process and a number of problems remain (Copeland 1993). Evaluation of the implementation of these amendments is needed in order to know the effects that legislation has had on water quality.

The Susquehanna River Basin covers half the land area of Pennsylvania and portions of New York and Maryland (27,500 square miles) (SRBC 2001). The Susquehanna River is the largest tributary of the Chesapeake Bay and accounts for almost half (45.7%) of Pennsylvania's stream miles (SRBC 2001). Population and land use in this area have changed throughout the years. By 1999 it had 4.1 million residents and it consisted of more than 65 percent of forestlands (SRBC 1999).

The Susquehanna River Basin Commission has been the main public entity in charge of water quality in the region. Past research in different areas of the basin have shown an improvement in water quality. Metzgar (1977) stated that the majority of the Lower Susquehanna basin had a good water quality with high levels of dissolved oxygen. McGarrel (1997) stated that the water quality of several streams in the Juniata Watershed has improved dramatically since the late 1970s. Also, a study of nutrient concentrations in the Susquehanna River Basin from 1985 to 1996 indicated downward trends in concentrations of total nitrogen and phosphorous (Lindsey et al. 1998). In addition, a study covering the period 1974 to 1993 of the Susquehanna River Basin, reported that trends in total phosphorus were predominately downward in three of five stations (Edwards 1995). However, other studies have shown other problems. Metzgar stated that the West Branch of the Susquehanna Basin exhibits poor water quality, due especially to an acid mine drainage problem (Metzgar 1977) and in 1999 the Susquehanna River Basin Commission stated that acid mine drainage continued to be an issue in the area (SRBC 1999). In 1995 Edwards found an upward trend in total nitrogen and phosphorus (Edwards 1995).

The goal of this study is to further investigate the effect of legislation on water quality in The Susquehanna River Basin, by comparing data of five water quality parameters between the periods of 1972 to 1982 and 1983 to 1993. We tested the hypothesis that Nitrogen, Dissolved Oxygen, pH, Phosphorus and Aluminum levels did not differ between 1972-82 and 1983-1993.

STUDY AREA

We selected 4 stations within the Susquehanna River Basin from the US Geological Survey database (USGS 2001a). These stations have recorded water quality data for the years 1972 to 1993. The stations were: the Juniata River at Saxton, the Juniata River at Newport, Susquehanna River at Harrisburg and Young Woman's Creek near Renovo (Fig. 1).

The stations at Saxton and Newport are located in the Juniata River basin in south-central Pennsylvania. This basin drains about 3,400 square miles. It is characterized by a series of tightly folded parallel mountains and long narrow valleys. The basin is mostly composed by carbonate rock (Lindsey et al. 1998). Oak, hickory and maple cover most of the basin (JCWP 2000). The Susquehanna River station at Harrisburg is located in the Lower Susquehanna Watershed. The southern part of the basin contains most of the population and some of the most productive agricultural land in the Nation. This area is for the most part underlain by carbonate bedrock. The Young Woman's Creek area is characterized by high, flat-topped uplands dissected by steep-sided stream valleys. Young Woman's Creek is a southwest-flowing tributary of the West Branch of the Susquehanna River. Second and third growth oak-hickory and maple-beech-birch forest types cover the basin. Sandstone, conglomerates and shale compose its bedrock (USGS 2001b).

METHODS AND MATERIALS

We divided water quality data into two periods of time: 1972-1982 and 1983-1993. We selected 5 chemical water-quality parameters for each station. The parameters were total nitrogen (mg/L as N), dissolved oxygen (mg/L), phosphorus (mg/L as P), aluminum (μg/L as Al) and pH in standard units.

We checked our data for normality using the Anderson-Darling normality test, and ran a test for equal variances for each of the 5 chemical water quality parameters. We used the Wilcoxon signed rank test to compare total nitrogen. We used a paired design for dissolved oxygen, pH and phosphorus to account for variability among stations. We paired the means of the two periods of time (1972-82 and 1983-93) for each of the 4 stations and ran a paired t test. We used a two-sample t test for aluminum because the data for this parameter were available from only 1 of our 4 stations. We considered a test to be significant when $P \leq 0.05$.

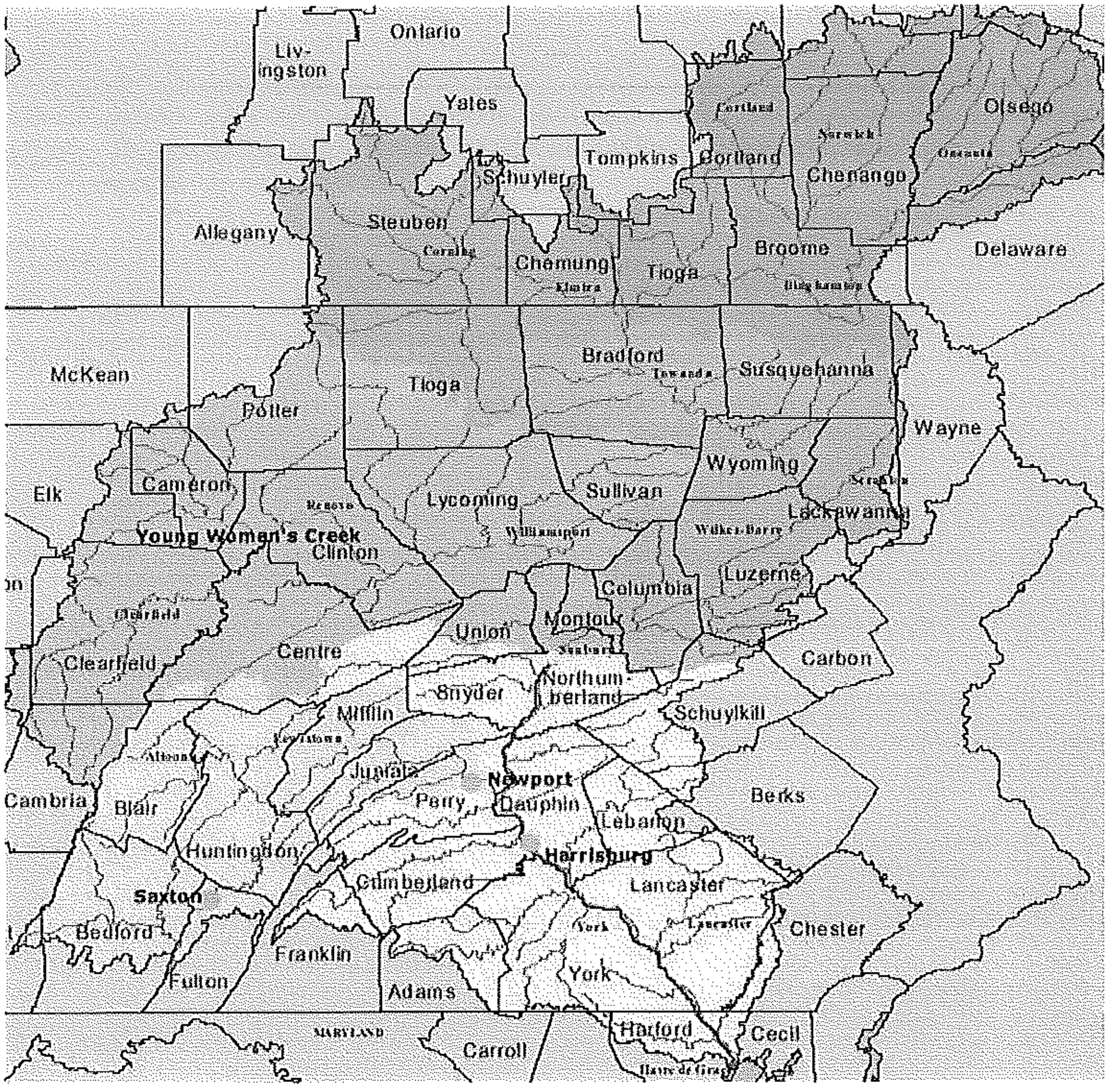

Figure 1. Map showing the stations of Newport, Saxton, Harrisburg and Young Woman's Creek at the Susquehanna River Basin.

RESULTS

We found mean total nitrogen to be significantly greater in 1983-93 (1.07) than in 1972-82 (0.71) (Fig. 2). We found mean dissolved oxygen to be significantly greater in 1983-93 (11.07) than in 1972-82 (11.16) (t = 4.50, df = 3, P = 0.021) (Fig. 3). Similarly, we found mean pH levels to be significantly greater in 1983-93 (7.54) than in 1972-82 (7.29) (t = 3.96, df = 3, P = 0.029) (Fig. 4). We found mean phosphorus concentration to be significantly greater in 1972-82 (0.072) than in 1983-93 (0.064) (t = 3.22 , df = 3, P = 0.048) (Fig. 5). Finally, we found mean aluminum concentration to be highly significantly greater in 1972-82 (1123.42) than in 1983-93 (29.64) (t = 3.76, df = 206, P < 0.001) (Fig. 6).

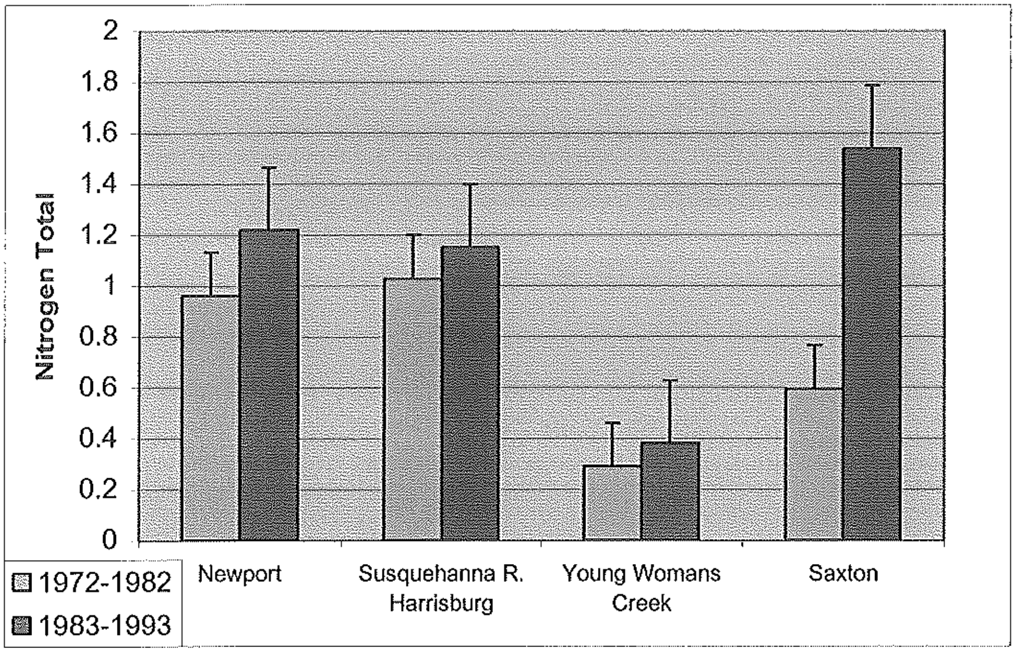

Figure 2. Total nitrogen mean (±SE) concentrations for the 1972/82 and 1983/93 time periods at each of the stations on the Susquehanna watershed.

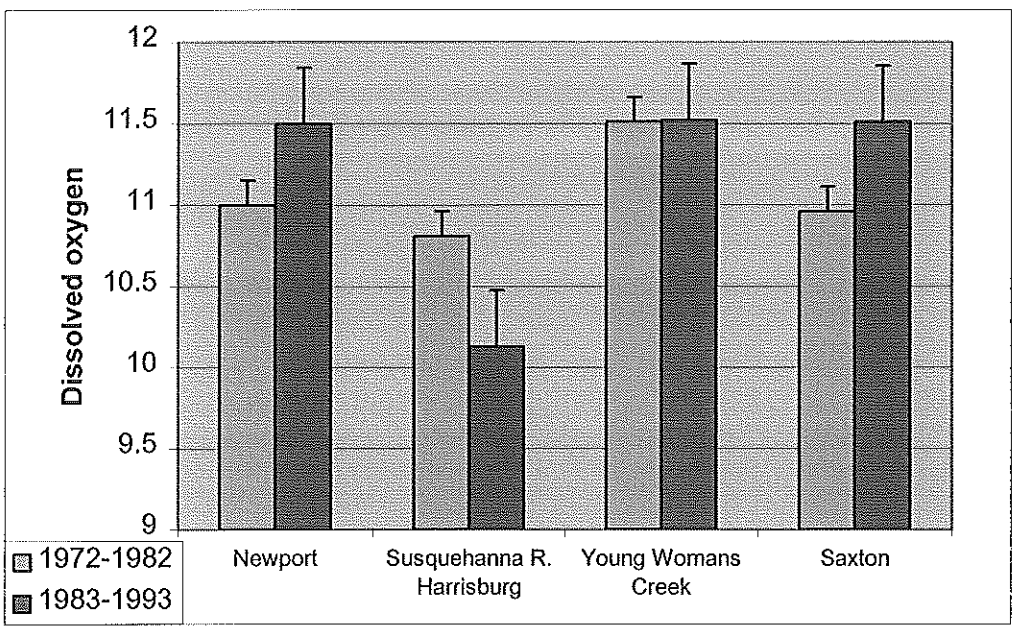

Figure 3. Mean dissolved oxygen concentrations (±SE) for the time periods 1972/82 and 1983/93 at each of the stations on the Susquehanna watershed.

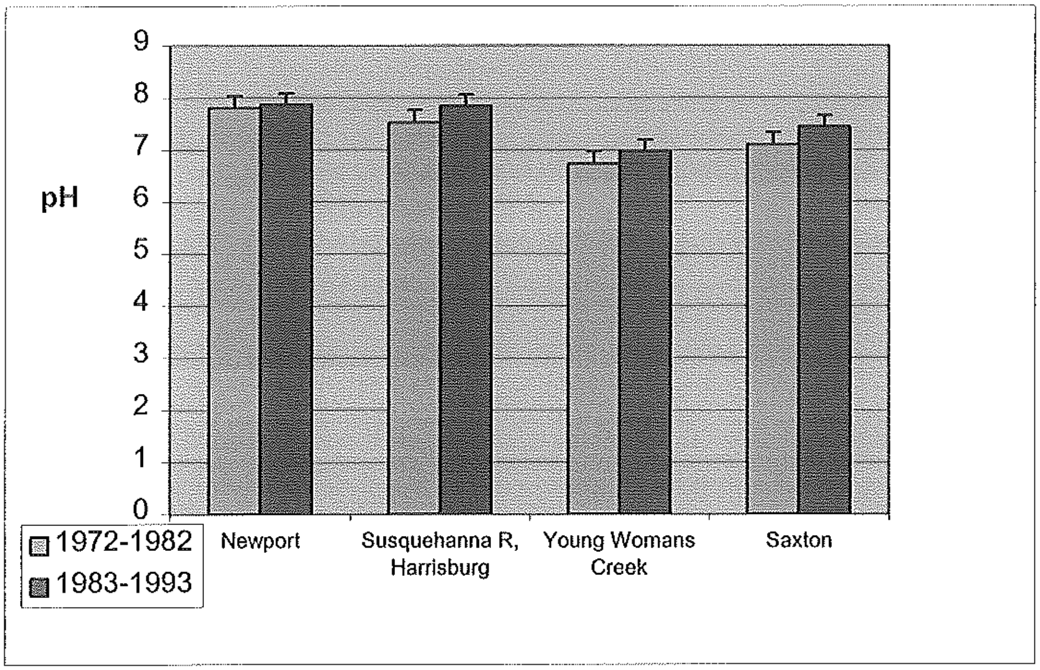

Figure 4. Mean pH (±SE) for the time periods 1972/82 and 1983/93 at each of the stations on the Susquehanna watershed.

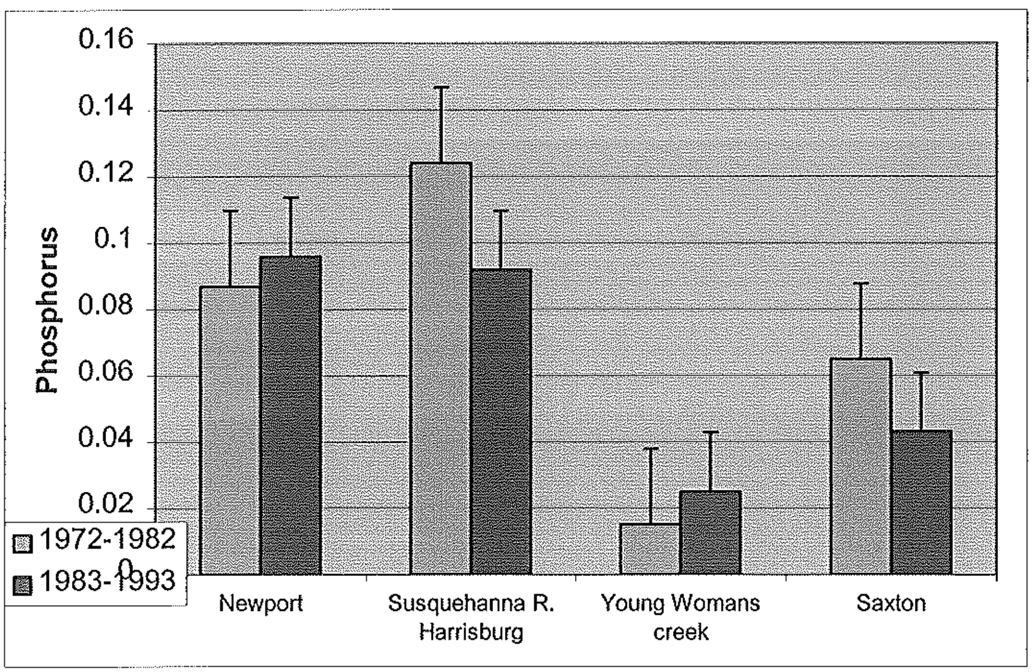

Figure 5. Mean phosphorus concentrations (±SE) for the time periods 1972/82 and 1983/93 at each of the stations on the Susquehanna watershed.

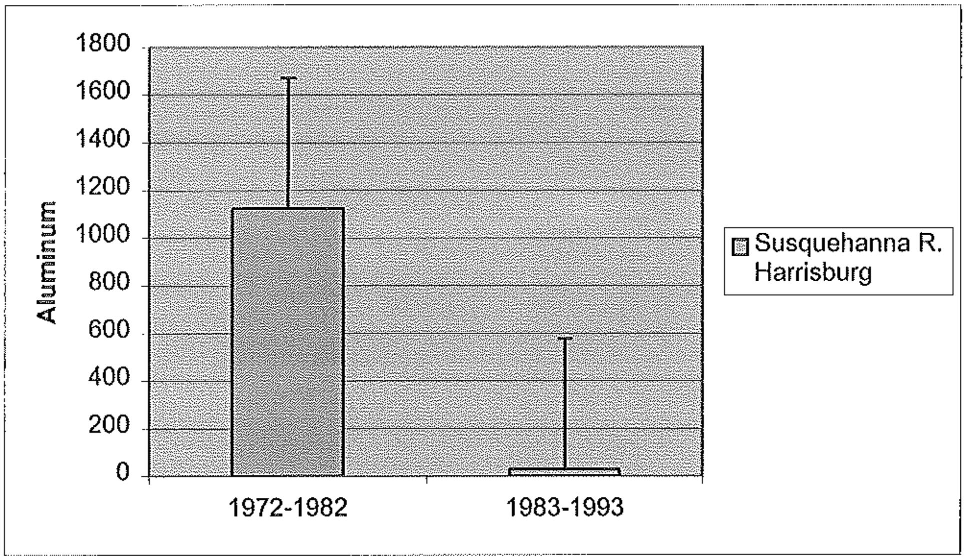

Figure 6. Means concentrations (±SE) of aluminum for the time periods 1972/82 and 1983/93 at the Harrisburg station.

DISCUSSION

Contrary to our expectation, we found a significant increase in nitrogen levels at all stations and an increase in phosphorus concentrations at two (Newport and Young Woman's Creek) of four stations. Our study does not show evidence to support the USGS statement that total nitrogen and phosphorus concentrations in the Susquehanna River decreased during the 1985-96 time period (Lindsey et al. 1998). The increasing concentrations of nitrogen and phosphorus may due to increasing runoff from farmland, especially manure, and to discharges from urban and rural developments, such as sewage. Ineffective legislation may also explain why we found increasing concentrations for both of these parameters.

Our dissolved oxygen levels for the 1983/1993 period increased at three stations and decreased at one. However, all oxygen levels stayed above 5 mg/L, the minimum for aquatic life (British Columbia 1998). The pH levels increased at all stations for the 1983/1993 period and stayed between the 4.5 and 9.5 levels required for aquatic life (British Columbia 1998). We did not find evidence to support previous studies at the West Branch of the Susquehanna River Basin that showed an acid mine drainage problem associated with low pH (Metzgar 1977 and SRBC Report 1999). Legislation might have contributed to maintaining dissolved oxygen and pH at levels required for aquatic life.

Our aluminum concentrations decreased dramatically during the 1983/93 period. This might be due to a positive effect of legislation. Legislation has targeted industry discharges and industrial effluents such as dye and paper manufacturing, which are common sources of aluminum.

A limitation of our study was a lack of data for adequate aluminum analysis. Our results do not give an accurate picture of aluminum concentrations throughout the Susquehanna watershed. Therefore, further research on this specific parameter should include more stations.

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