United States
Environmental Protection
Agency

Chesapeake Bay
Program
Annapolis MD 21401

Research and Development

EPA-600/S3-83-036 Sept. 1983

EPA

Project Summary

Evaluation of Management Tools in the Occoquan Watershed

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From May, 1979 to May, 1981, nine water quality monitoring stations were operated in small catchments in the Occoquan Watershed of Northern Virginia. The study sites incorporated different land uses (pasture land, corn croplands, suburban developments, and forest) as well as contrasting management approaches (heavy versus light grazing, no-till versus minimum-till cropping, detention ponds). Water samples were routinely analyzed for total suspended solids, ammonia nitrogen, total Kjeldahl nitrogen, oxidized nitrogen, ortho-phosphorus, total soluble phosphorus and total phosphorus. Meteorological records were also kept during the study period, and collections of dryfall and precipitation were routinely analyzed.

Loading rates, calculated as kilograms per hectare per centimeter precipitation, indicated that the heavily grazed pasture site generally exhibited the highest pollutant concentrations. The forested site and lightly grazed pasture typically generated the least pollutant export. Significant differences were observed between the no-till and minimum-till croplands. The greatest differences were in the transport of soluble nutrient forms. Results of measurements at the stormwater pond were sometimes ambiguous, but evidence was found that proper maintenance of such a structure greatly improves its efficiency.

Measurements of atmospheric pollutant loadings indicated that the greater proportion generally came from wetfall. Annual loadings for various constituents were calculated. The existence of acid rain in the study area was confirmed repeatedly, and based upon indirect evidence, the source was hypothesized to be sulfur oxides.

This Project Summary was developed by EPA's Chesapeake Bay Program, Annapolis, MD, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

This study was designed to characterize nonpoint source pollution from various land-use areas within the Occoquan Watershed and to provide a basis for the comparison of selected management practices. The data base was also intended to be used in the calibration of a mathematical pollutant transport model. Actual data collection began on May 15, 1979, and continued through May 31, 1981.

Procedures/Methodology

Nine monitoring stations were established in small watersheds, primarily in agricultural areas. Drainage areas appropriate to the established criteria were selected with the assistance of the U.S. Cooperative Extension (CES), the U.S. Soil Conservation Service (SCS), and the Virginia Division of Forestry (VDF).

Site one was a heavily grazed pasture, as evidenced by visible erosion and loss of vegetative cover. The soils in this 12.7-ha drainage area are moderately well drained and relatively inefficient in producing runoff. Whereas the upper reaches of the drainage showed a four percent average slope and better cover vegetation, the lower drainage was

characterized by a six percent average slope and thin, poorly established vegetation.

Site two was a no-till corn field of 10.8 ha, which was located on the same farm as sites one, three, and four. Soils similar to those of site one were predominant, and a relatively uniform slope of 8.5 percent was evidenced over the drainage area. Drainage from this area entered the pond. After the first season of monitoring, the management practice at this location was changed to a minimum-till approach.

Site three was a small area of heavily grazed pasture immediately adjacent to the site two drainage area and upstream of a farm pond. The drainage area here was 4.5 ha, with a uniform slope of about 10 percent. The primary function of this station was to provide data on input to the farm pond.

Site four was located immediately below a farm pond and received runoff from sites two and three. Water flowed from the five-ha pond by means of a 10-cm diameter riser pipe. Pool height in the pond varied seasonally according to precipitation, and at times even the emergency spillway was overtopped. Total drainage area to this lower station was 20.8 ha.

Site five was a lightly grazed pasture of 7.6 ha. The average slope was 3.5 percent, and canopy heights of over 60 cm were observed late in the growing season. This site was paired with site one in an attempt to evaluate the effects of different management practices on pollutant loadings.

Site six was originally set up at a no-till corn cropland but had to be abandoned shortly thereafter because of a change in management practices and problems with landowner cooperation. No data from this site were recorded.

Site seven was a 27.6-ha drainage that collected runoff from a suburban townhouse development via a 183-cm (72-inch) corrugated metal pipe. The area was approximately 90 percent townhouse development and 10 percent open land. Flow from this drainage proceeded to a dry stormwater management pond.

Site eight provided a measure of the outflow from the stormwater management pond. Drainage to the pond included an area not measured at site seven, for a total drainage area of 35.7 ha. A perforated riser pipe provided for detention in the pond, with the effluent passing through a concrete conduit. Together, sites seven and eight provided the potential for compiling a pollutant transport mass balance for the stormwater pond. These two sites thus form a management pair.

Site nine contained 30.6 ha of hardwood forest. Because the area was relatively undisturbed, this site was selected to provide data to represent pre-development conditions. The average slope in the watershed was 9.4 percent. Good under-canopy vegetation and a thick layer of litter reduced runoff potential at this site.

Site ten contained 10.4 ha of corn, representing minimum-till management. The average slope here was about 3.4 percent. This site was paired with site two in order to compare effects of management practices on pollutant loadings.

Each monitoring station was instrumented to provide data on precipitation and runoff and to collect runoff samples during storm events. At one station, samples of atmospheric fallout were collected. Meteorological parameters -- including solar insolation, mean wind speed, net evaporation, temperature, and relative humidity -- were also measured at this station.

Most of the monitoring sites were fitted with a type-H flume for primary flow control. Continuous stage measurements were recorded using pressure transducer type flowmeters. In addition to this, each site also contained an automated sampler for the collection of discrete samples and a tipping bucket raingage, which recorded rainfall in increments of 0.25 mm (0.01 inches) of precipitation.

The focus of the analytical efforts was on nutrient forms. The following determinations were routinely made: total Kjeldahl nitrogen (TKN); soluble Kjeldahl nitrogen (SKN); ammonia nitrogen (NH_3-N); oxidized nitrogen (ox-N), or combined nitrate and nitrite nitrogen; total phosphorus (TP); total soluble phosphorus (TSP); and total suspended solids (TSS). Other analyses were also performed but with less frequency than those identified above. These included analyses for biochemical oxygen demand (BOD), chemical oxygen demand (COD), lead, zinc, pesticide and herbicide concentrations, and various soil parameters.

Results/Conclusions

During the study period (May 1979 through May 1981), a total of 245 storm events were monitored. The distribution of monitored events was uneven due to varying precipitation patterns and differing hydraulic efficiencies at each site.

Both median values for pollutant concentrations and loadings measured at the various sites were used for comparison. The use of whisker and box plots was incorporated to provide a better interpretation of the data distribution.

It was determined that the cropland sites (sites two and ten) produced relatively high nutrient concentrations in stormwater runoff. Pollutant loads were also found to be higher at site ten. The use of commercial fertilizers and animal manure on such lands obviously contributed to the observed nutrient levels.

As expected, the hardwood forest (site nine) and the lightly grazed site (site five) showed both the lowest pollutant concentrations and loads. The forest probably showed the lowest levels because of its abundant ground cover and canopy. At both sites, the general lack of soil disturbance within the catchments is probably basic to the low concentrations of pollutants.

The concentrations of TSS, TKN, and TP were generally higher at the heavily grazed pastureland (site one). This reflects the erodable nature of the soils in this catchment. As was the case with the cropland site (site ten) site one was found to have high median loadings. The lowest of these concentrations was at the lightly grazed pasture site (site five) and at the forested site (site nine).

Site seven, the suburban site, showed high levels of both pollutants and loadings. The median loading of total nitrogen at this site is as high as or higher than those levels at the cropland sites. This of course may reflect the use of fertilizers in the suburban environment. The loading rates for total phosphorus and total suspended solids show a similar pattern.

The data were variable among the parameters and from site to site. For example, site seven was sampled most often and showed relatively small variabilities. This may reflect the unchanging nature of the site; the cropland sites (two and ten), on the other hand, undergo more intermittent disturbances resulting in greater variabilities. Total suspended solids were highest at site seven and lowest at site two. Of these two sites, site seven may be indicative of a more constant input from impervious surfaces, whereas the agricultural catchmnets may undergo more intermittent disturbances resulting in greater variability.

Some water quality data were collected irregularly. These data included zinc and

lead concentrations, biochemical and chemical oxygen demand measurements, and pesticide analyses.

Lead was detected only in the suburban catchment and even then infrequently. Zinc appeared to be much more prevalent. The highest concentrations of total zinc were found at sites one and two, which were located on the same farm. Zinc was most consistently detected at the suburban site but was also found in all samples analyzed.

Median values of COD were nearly the same at all sites with the exception of heavily grazed pasture (site one), where values were much higher. The forest site exhibited the lowest COD concentrations. In general, the BOD values measured were low. This may be due in part to constituents in the runoff (e.g., heavy metals or pesticides), which could inhibit bacterial growth. Analysis of filtered and unfiltered samples indicated that more than half of the BOD measured was soluble. Analysis of inhibited and uninhibited samples indicated carbonaceous BOD represented 70 to 90 percent of the total.

During the course of this study two sets of samples were collected specifically for analysis of pesticides and herbicides. The initial results were of some concern because relatively high concentrations of polychlorinated biphenyls (PCBs) were reported.

A broader scan for pesticides and herbicides was carried out seven months later. PCB levels in these samples were noticeably lower. None of these samples was filtered, so that the variations observed in duplicate analyses might be due to differences in the suspended matter included in each individual sample.

Comparison of management practices indicated that the heavily grazed pasture consistently produced greater pollutant concentrations than the lightly grazed pasture. Statistical differences in pollutant concentrations were found in the TN, TSN, TKN, ox-N, TP, and TSS. The similarity of soils and hydraulic efficiencies at these two sites underscored the effect of management practices on pollutant transport.

In comparing the no-till and minimum-till cropland site, statistically significant differences in observed concentrations were indicated with TN, TSN, ox-N, OP, and TSP. These differences were related primarily to soluble nutrient forms. During the study, site two was converted from no-till management to a minimum-till approach. The data suggest that both pollutant concentrations and hydraulic efficiencies increased under minimum-till management.

Initial study of the farm pond indicated removal efficiencies for suspended solids and nutrients to be over 85 percent. However, allowance was not made for pond storage capacity in these estimates. After a survey was conducted to establish that capacity, an ensuing drought precluded additional estimates. Concentration data alone, however, indicated high removal efficiencies for TSS and TP (85 percent and 86 percent, respectively) and a relatively low removal efficiency of 34 percent for TN.

Although 27 paired storms were monitored at the suburban detention pond site, the results were often contradictory. Because a satisfactory water balance could not be routinely made between the monitoring stations used, it was impossible to compare pollutant loadings with adequate confidence.

Evidence regarding the cleaning of the stormwater pond suggests that removal of most pollutants was greater after the maintenance activity was completed.

Atmospheric loadings were measured using a wetfall/dryfall collector located in an agricultural setting. Annual pollutant loadings from wetfall were commonly found to exceed those from dryfall. More solids deposition resulted from dryfall--over 60 percent of the total load of 96.1 kg/ha/yr. Nutrient loadings were found to be 16.82 kg/ha/yr for TN and 0.651 kg/ha/yr for TP.

The pH of precipitation measured during this study was ordinarily in the range to warrant the use of the term acid rain. The range of pH values observed was from 3.2 to 6.1, with a median value of 3.8. Indirect evidence suggested that sulfates were the causative factor.

The small catchments studied were all within the Occoquan Watershed. Similar studies of larger basins within the watershed were simultaneously performed under the continuing mission of the Occoquan Watershed Monitoring Program. Comparison of these results indicated generally higher pollutant concentrations at the small catchments. Unit area loads, however, were generally higher at the stream sites, due to the greater hydraulic efficiencies of the larger basins.

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The complete report, entitled "Evaluation of Management Tools in the Occoquan Watershed," (Order No. PB 83-255 687; Cost: $19.00, subject to change) will be available only from:
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