

FATE OF AN ARTIFICIAL POND RECEIVING DRAINAGE  
FROM A RECLAIMED COAL REFUSE AND SLURRY AREA<sup>1</sup>

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**Abstract.**--A pond was created as part of a reclamation effort at an abandoned coal mine near Staunton, IL. The pond was designed to help control runoff and to provide wildlife habitat. The benthic macroinvertebrates were analyzed as part of the site reclamation evaluation. Macroinvertebrates were collected from the newly created pond, a retention pond that received gob pile drainage, and a farm pond that served as a control. Reclamation activities began in 1976; samples were collected from the ponds in 1977, 1978, and 1987. Results from 1977 and 1978 indicated that the newly created pond was developing into a productive ecosystem. During those years, the benthos was dominated by dipterans, especially chironomids. By 1987 the pH of the new pond had declined to below 2.5 and no invertebrates were found in the new pond or the retention pond. Phytoplankton was found in the new pond, but species richness and abundance were severely limited. Efforts to create viable aquatic habitats in slurry areas of abandoned coal mine sites may be subject to failure unless remedial actions, such as neutralization, are conducted on a regular basis.

INTRODUCTION

In the past, the methods and sites for disposal of coal-mine refuse were usually determined by convenience and economics. Coarse refuse (gob) was usually dumped near the preparation plant, which often created large, steep-sided piles. Effluent (slurry) from the coal washers was pumped into a nearby impoundment where solids were allowed to settle out. Many abandoned

(pre-regulation era) refuse-disposal sites still present serious environmental, economic, and aesthetic problems. Conceivably, it could take hundreds of years for natural restoration of these acidic waste sites, during which time the surrounding environment would be adversely affected (Jastrow et al. 1984).

The U.S. Department of Energy, through the former Land Reclamation Program at Argonne National Laboratory, and two Illinois agencies -- the Abandoned Mined Land Reclamation Council and the Institute of Natural Resources -- developed a cooperative project to address the problems associated with reclaiming one of Illinois' abandoned deep mine refuse sites. Final land use for the area was to be a recreational area, wildlife habitat, and ecological education area.

As part of the reclamation activities, a 0.5-ha pond was created in the slurry area. This pond was designed to retain sediment and to develop into a productive aquatic community that could support fish and wildlife populations. The pond was constructed with deep (> 2 m) and shallow areas to provide a diversity of aquatic

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conditions that could support fish, benthic invertebrates, emergent vegetation, and a variety of wildlife. Two years following reclamation, the pond had shown signs of developing towards a productive community (Vinikour 1981). However, no monitoring or major site remedial actions occurred after that time. Given that ten years have past since initial site reclamation, it was deemed of value to assess the site and evaluate whether it currently is providing suitable invertebrate, fish, and wildlife habitat. This paper reports on the condition of the pond regarding its ecological value as a small pond habitat.

#### STUDY SITE AND RECLAMATION ACTIVITIES

The site selected for the reclamation demonstration project was the abandoned Consolidated Coal Company's Mine No. 14 near Staunton in Macoupin County, IL. The total site included 13.8 ha, of which 9.3 ha had been affected by past mining operations and required reclamation. This included a 25-m-high gob pile that covered about 2 ha and a 4.5-ha slurry impoundment area. The dam for the slurry area was breached in the early 1940s, resulting in acid and sediment runoff from the site being transported about 0.8 km down a small stream to Cahokia Creek.

Reclamation activities began in September 1976, and the major effort was concluded by April 1977. The gob pile was extensively recontoured to reduce it to about one-fifth its original height. The slurry area was also recontoured, which included the excavation of a retention pond. Neutralizing/stabilizing agents were applied at a rate of 168 t/ha  $\text{CaCO}_3$  equivalent and incorporated to a minimum depth of 15 cm into the recontoured refuse material. A 30 cm deep layer of soil cover material was then placed over the site. To this cover material, an application of 11.2 t/ha of agricultural limestone and 135 kg/ha each of nitrogen, phosphorus, and potassium was incorporated to a minimum depth of 10 cm (Vinikour 1981). The area was then seeded with a variety of grass and legume species (see LaGory et al. elsewhere in these proceedings).

#### MATERIALS AND METHODS

In June 1976, before any reclamation activities, a qualitative survey was made of the macroinvertebrates in standing bodies of water in the unreclaimed slurry area. Only a cursory search of the slurry area was conducted, and the observed aquatic or semiaquatic specimens were collected by hand.

During 1977, 1978, and 1987, benthic macroinvertebrates were collected from the three on-site ponds (fig. 1). The control pond was a small farm pond that was unaffected by the refuse or the reclamation

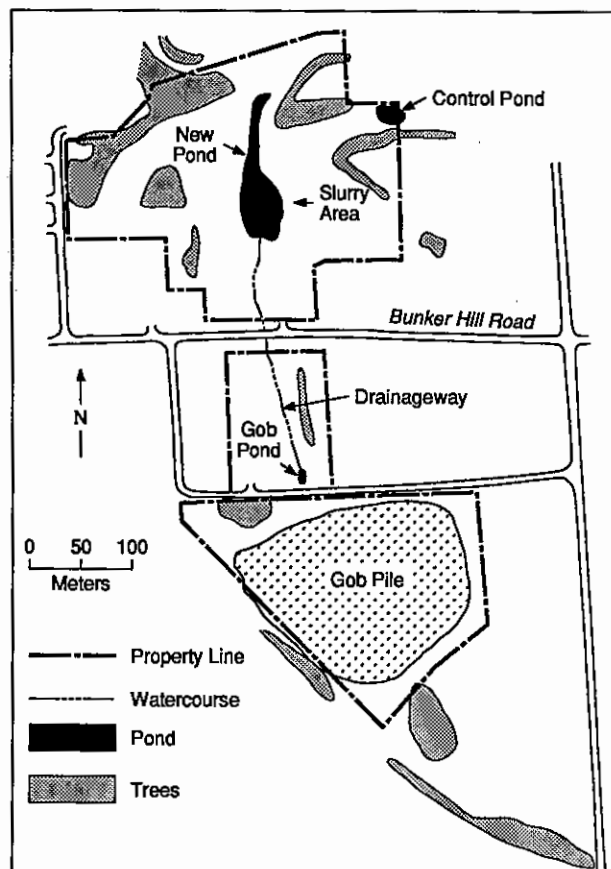


Figure 1.--Staunton reclamation site.

work. It served as a control for benthic community comparisons with the new pond. It was assumed that the control pond would indicate the potential community that could develop in the new pond. The gob pile retention pond was sampled because, even after reclamation, its water quality typified acid mine drainage conditions. Knowledge of the invertebrates that inhabited this pond would indicate those organisms capable of inhabiting water degraded by acid mine drainage. By comparing the organisms in the three ponds, it could be determined whether only tolerant organisms were colonizing the new pond or whether more sensitive species were becoming established.

Pond benthic samples were taken with a Ponar grab in 1977 and with an Ekman grab in 1978 and 1987. Each device collected from a  $0.023\text{-m}^2$  area of pond bottom per sample. Most sampling was done along the shoreline in depths of 0.3 to 1.0 m. Collected samples were washed through a #30-mesh sieve with the unsieved portion, including organisms, preserved in 70% ethyl alcohol. Routine sample sorting and taxonomic identifications were conducted in the laboratory (Vinikour 1981). Shannon-Weaver diversity values (logarithmic base 2) were calculated following procedures in Brower and Zar (1977).

Phytoplankton samples were obtained from the new pond and control pond in 1987

by taking near surface water samples. Lugol's solution was added to the samples as a preservative. Algae were identified to the lowest taxonomic level possible using microscopic examination. Ciliated protozoans were also enumerated.

## RESULTS AND DISCUSSION

The survey of the unreclaimed slurry area revealed that few aquatic species inhabited the standing water bodies. The only true aquatic species found was the water strider, *Gerris* sp. (Hemiptera: Gerridae). The only other species encountered was the variegated mud-loving beetle *Lanternarius brunneus* (Coleoptera: Heteroceridae). This semiaquatic beetle was collected from its galleries surrounding many of the water bodies in the slurry area. Species of this beetle family have not been previously reported to inhabit coal slurry and/or such extreme chemical conditions (e.g., pH < 4.0, acidity > 4,400 mg/L) (Vinikour 1979).

In the 1977 and 1978 samples, dipterans were the only organisms collected from the gob pond, the most abundant organisms in the new pond, and numerically dominant on all but one sampling occasion in the control pond. Chironomidae was the most prevalent family of Diptera. Eighteen chironomid taxa were collected from the ponds, with the major taxa being *Chironomus plumosus*, *Procladius* sp., and *Tanytus punctipennis*. *Chironomus plumosus* was the only species collected in abundance from the gob pond and was often the dominant species collected from the new pond. This was expected, considering degraded water quality in the gob pond (e.g., pH was < 4.5, alkalinity was 0.0 mg/L, and acidity ranged from 72 to > 29,500 mg/L) and the poor-to-fair water quality of the new pond (e.g., pH ranged from 4.0 to 8.4, alkalinity from 0.0 to 46.0 mg/L, and acidity from 0.0 to 28.0 mg/L). Harp and Campbell (1962) observed *C. plumosus* to be the only chironomid species in water with a pH of < 6.0. Other dipterans regularly collected were species of Ceratopogonidae and Chaoboridae.

In the 1977 and 1978 samples from the control pond, the fingernail clam *Musculium partumeium* and the snail *Physa gyrina* were commonly collected. They were absent (clams) or rare (snails) in the new pond because of inadequate water quality, substrate limitations, and/or physical constraints in colonizing the pond. The aquatic worm *Limnodrilus hoffmeisteri* was also common in the control pond, but absent in the new pond. Several dragonfly (Odonata), mayfly (Ephemeroptera), and beetle (Coleoptera) species were frequently collected, but in low numbers, from both the new and control ponds. These three insect orders contain species that are highly tolerant to extremes of water quality and/or are so highly mobile that they may enter or leave a body of water at will (Roback 1974). The mayfly genera present

in the new pond (*Caenis*, *Callibaetis*, and *Hexagenia*) are also more resistant to pollution (Edmunds et al. 1976). The limited benthic community composition of the new pond during the 1977 and 1978 period resembled that reported from several of the acid strip-mine lakes found in Grundy County, IL (Master 1979). Severely degraded water quality, indicative of acid mine drainage, in the gob pond limited its benthic fauna to low densities of *C. plumosus* and to sporadic occurrences of a few other tolerant dipteran larvae (e.g., the crane fly *Erioptera*).

Benthic densities in 1977 and 1978 were generally greater in the control pond than in the other ponds, and the lowest densities always occurred in the gob pond. Also, diversity values were always highest in the control pond, while the gob pond usually had the lowest values (e.g., median diversity values were 2.8 in the control pond and 1.9 in the new pond; while values in the gob pond were < 1.0 on all occasions). The higher benthic diversities in the control pond were probably due to its better water quality, developed macrophyte assemblage, and abundance of allochthonous leaf litter. Living plant matter (excluding cattails) and detrital plant matter were sparse in the other ponds. Macrophytes and leaf litter provide diverse habitat and food resources for macroinvertebrates, allowing development of a fauna that encompasses a variety of functional feeding and habit groups (Cummins 1978). Although an abundant stand of cattails (*Typha latifolia*) was present in the new pond, and although some insects (e.g., *Chironomus*, mosquitoes, and beetles) thrive near cattails, this plant often prevents other macrophytes from growing in shallow areas (Lackey 1939). However, cattails are conducive to the presence of muskrats, which were observed in the new pond in 1978.

In theory, grading and covering coal refuse material should decrease pyrite oxidation rates, reduce acid formation rates, and improve water quality of site discharges. For this to be successful, prevention of erosion is important to (1) reduce exposure of refuse and subsequent development of acidic runoff, and (2) reduce water percolation and oxygen diffusion into the underlying refuse, thereby reducing pyrite oxidation and acid leachate formation (Jastrow et al. 1984). However, water percolation and oxygen diffusion into the waste material may occur even if soil cover is sufficient to control erosion. Water quality samples taken in 1979 and 1980 indicated that the new pond was beginning to acidify (i.e., pH < 4.2). It was thus expected that the new pond would maintain a low diversity and contain mostly species that are tolerant of acid mine drainage conditions (Vinikour 1981).

During the 1987 site survey, a number of acid seeps were observed throughout the site and somewhat severe erosion was evident along the main drainage leading from

the gob pile to the new pond. The 1987 pond survey revealed that water quality and community composition of the new pond had deteriorated further. Water quality, as typified by a pH < 2.5 in the new pond, indicated a condition of severe acid mine drainage. The abundant stand of cattails that was thriving within the pond in 1978 had completely died off, with only encrusted stems remaining. Only a sparse population of living cattails occurred along the banks of the pond. A dense stand of reed phragmites (*Phragmites maximus*) occurred along a low lying area surrounding and north of the new pond drainage weir; but was not found around the perimeter of the new pond.

No benthic macroinvertebrates were collected in the Ekman grab samples and no neustonic species were observed in the pond during the several days of the 1987 site survey. Benthic samples did contain a few partial exoskeletons of corixids and head capsules of the midge *Chironomus plumosus*. Both of these organisms are common to less acidic waters and indicate that water quality conditions had been biotically-limiting for some period of time. *Chironomus plumosus* is often the only species reported in strip mine lakes with a pH < 6.0. It can be found in lakes with a pH < 3.0, but apparently does not complete its life cycle under such conditions. Also, it was only found under these severe low pH conditions when leaf detritus was present (Harp and Campbell 1962). No leaf detritus was observed in the new pond in 1987. Two generations of *Chironomus plumosus* normally occur each year, with emergence in mid-May and late July or August (Hilsenhoff 1967). Thus, if *Chironomus plumosus* was still extant in the new pond, larvae would have been expected to have been collected in early July. No remains of other macroinvertebrates that were collected in 1977 and 1978 were found (e.g., mayflies), indicating that these species had probably not inhabited the pond for a number of years. As the pH of the pond was < 4.2 in 1980, it can be assumed that the pond contained a very limited benthic community over the past eight years. Similarly, no benthic macroinvertebrates were collected from the gob pond. The pH of the gob pond was 3.2 in 1987, indicating that drainage from the gob pile has continued to be very acidic regardless of reclamation efforts.

Benthic species composition and diversity of the control pond were quite depressed in 1987. The only benthic species collected were *Musculium partumieum*, *Physa gyrina*, *Limnodrilus hoffmeisteri*, *Polypedilum*, *Ablabesmyia*, and *Palpomyia*; benthic macroinvertebrate diversity was 0.1. The high pH of the pond (7.8), coupled with the presence of the acid-intolerant molluscs (*Musculium* and *Physa*) and an abundance of amphibians in all stages of development, indicate that this suppression was due to factors other than acid mine drainage conditions. For example, the bottom of the pond was composed of an organic muck with little of the

leaf litter and other coarse detrital matter that was abundant in 1977 and 1978. Also, submerged macrophytes were completely absent in 1987. The surface of the pond was entirely covered with duckweed. Such conditions have been reported to limit the occurrence of mosquito larvae (Angerilli and Beirne 1980), and may be largely responsible for the paucity of chironomids observed in 1987.

Phytoplankton collected in 1987 from the control and new ponds are listed in table 1. The samples indicate that the new pond is extremely depauperate. None of the species typically found in waters of low productivity were present (e.g., chrysophycean flagellates, diatoms, or desmids). Also, no visible sestonic organic matter was found in the new pond. Primary productivity due to suspended algae is essentially zero in the new pond. In comparison, the phytoplankton of the control pond was rich and diverse. The abundance of euglenophycean flagellates and ciliates indicate that the control pond may be organically enriched, although the high abundance of blue-green algae indicates that the organic enrichment is not necessarily accompanied by nitrate enrichment. The control pond does lack some algal types usually present in warm, productive, shallow ponds (e.g., *Scenedesmus*, chrysophycean flagellates, and centric diatoms) (Stull, pers. comm. 1987).

## CONCLUSIONS

The new pond did not support a viable aquatic community ten years after reclamation activities were completed. The only benefit that the pond provides to terrestrial wildlife is related to the development of willows and other woody species around the perimeter of the pond. Slight-to-moderate acid mine drainage conditions were evident in the new pond after the initial two years following site reclamation. This condition was primarily responsible for the limited diversity and density of macroinvertebrates in the pond at that time (Vinikour 1981). Vinikour (1981) concluded that persistence of water quality conditions noted in 1979 (e.g., pH < 4.0) would limit the biota of the new pond to those species that can tolerate acid mine drainage conditions. Conditions since 1979 have continued to deteriorate to the point where the pH in the pond was less than 2.5, with no macroinvertebrates collected from the pond. Not even neustonic species such as water striders or water boatman were observed in the pond.

The new pond has functioned as a settling basin for sediment eroded from the site. This is viewed as a major benefit to the nearby receiving stream Cahokia Creek. Acid mine drainage discharge and sedimentation (including coal fines) to the stream have been kept in check without the need for any onsite mitigative measures for the past ten years. However, the lack of on-

Table 1.--Phytoplankton and ciliate protozoans of the new pond and control pond collected on July 7, 1987.

Taxa or Type	Abundance (number/ml) <sup>1</sup>	
	New Pond	Control Pond
<i>Anabaena</i> sp.	--	P
<i>Merismopedia trolleri</i>	--	5,000
<i>Microcystis incerta</i>	--	4,000,000
coccoid blue-green algae	1,000	80,000
lunate blue-green alga	--	P
<i>Euglena acus</i>	--	P
<i>Euglena oxyuris</i>	--	200
<i>Phacus acuminatus</i>	--	100
<i>Phacus helikoides</i>	--	200
<i>Phacus triqueter</i>	--	300
<i>Trachelomonas dybowskii</i>	--	300
<i>Coscinodiscus lacustris</i>	--	P
<i>Achnanthes</i> sp.	--	P
<i>Fragilaria</i> sp.	--	P
<i>Navicula</i> sp.	--	P
<i>Nitzschia</i> sp.	--	P
pinnate diatom, < 10 microns long	--	3,000
flagellates, < 4 microns long	1,000	30,000
ciliates	--	2,000

<sup>1</sup>P = present, but in too few numbers to accurately determine an abundance value, -- = not observed.

site mitigative measures have prevented the new pond from developing into a productive ecosystem. Creation of a viable pond, or any other type of wetland, in a reclaimed slurry area is difficult to accomplish, especially if remedial actions are not regularly employed. Leedy (1981) stated that waters with a pH of 4.5 or lower would require repeated applications of lime to maintain a desired pH of 6.0 or greater, with additional lime needed whenever the pH falls below this level. Without such efforts, surface runoff from acid seeps and lateral movement of acidic water through the buried slurry wastes would lead to the eventual degradation of water quality, as was observed in the new pond. It is recommended that reclamation planning efforts include methods to ensure good water quality in wetland areas that are to be developed in abandoned slurry areas for more than the first few years. This must include the inclusion of periodic site evaluations and, if necessary, remedial actions.

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