Biomonitoring to Assess the Relative Impact of Large-Scale Livestock Production on Stream Water Quality

Thomas L. O'Connor, H2O'C, Limited, Columbia, Missouri

A major issue related to the recent development and operation of large-scale livestock production facilities is the impact of animal waste disposal practices on stream water quality. This impact should be considered within the framework of other farming and rural waste disposal activities.

Impact of Agricultural Chemicals

Streams in rural farming areas surrounding livestock production facilities have long been impacted by the application of agricultural chemicals (fertilizers, herbicides) applied to maximize production of grains, beans and corn. As a result, for decades, Midwestern streams have typically exhibited comparatively high ammonium and nitrate ion concentrations.

Runoff into streams and reservoirs from fertilized farmland, particularly following heavy rains, has contributed to oxygen depletion, fish kills, intensified algal growths and, in some cases, nitrate concentrations exceeding drinking water standards. The impact of this long-term practice on the *macroinvertebrate populations* of receiving waters has not previously been extensively surveyed.

Most recently, potable water quality concerns have focused on runoff containing atrazine, the widely used preemergent herbicide for corn. Since atrazine in drinking water is limited by USEPA to an annual maximum contaminant level (MCL) of 3 micrograms per liter, impacted drinking water utility managers seeking to control treatment costs have reacted strongly, calling for reduced and, in some cases, an outright ban on the use of regulated contaminants. While secondary to human health concerns, the impact of preemergent herbicides on stream biota has not been comprehensively assessed.

Against this background, the lagooning and land disposal of large quantities of livestock waste has created an additional source of nutrient which may be capable of altering the benthic ecology of receiving streams.

Biomonitoring of Stream Macroinvertebrates

Aquatic scientists have long worked toward the development of methods for enumerating and characterizing the diverse populations of macroinvertebrates inhabiting streams. However, only recently have well-defined, standardized biomonitoring procedures been formulated in an effort to assess significant annual changes in the established stream populations. These efforts have been spurred by the intense debate over the long-term impacts of livestock waste management practice on stream ecology.

The procedures for assessing changes in stream macroinvertebrate populations are laborious and scientifically complex. A valid sampling program requires that a range of samples be taken from a variety of ecological niches both upstream and downstream of the drainage region to be monitored. This is required to determine whether the distribution of aquatic invertebrates, classified over a broad range of 'clean water' to 'polluted water' species, has become altered by passage through sections of streams receiving drainage from livestock production facilities.

Because *biomonitoring* is intended to assess long-term impacts on the stream community, as opposed to short-term events, such as fish kills, assessments must take place over years. To ensure the relative comparability of data from year-to-year, intensive annual sampling programs are replicated within a narrow time frame. Optimum sampling periods may be in the early spring or autumn.

Obviously, variations in macroinvertebrate abundance and diversity occur naturally from year-to-year depending on temperature, rainfall, runoff and other environmental factors unrelated to agricultural practice or animal waste disposal. As a result, it is necessary to conduct biomonitoring programs over a sufficient number of years to overcome the bias introduced by atypical environmental factors.

Sample Collection Procedure

Several commonly found habitats in shallow (wadeable) freshwater streams must be sampled in a systematic and consistent fashion.

Stream substrate samples (gravel, silt, sand, clay, sticks, organic debris) are to be collected in virtually any region which provides habitat for aquatic organisms. These may include:

flowing water	(coarse and fine bottom substrates from riffles and runs),
non-flowing water	(substrates from backwaters, nearshore, and areas exhibiting bottom accumulations of coarse organic matter),
vegetated areas	(surfaces of submergent or emergent aquatic vegetation),
leaf packs	(seasonal accumulations of leaves attached to snags or rocks),
snags	(logs, masses of periphyton or moss on logs),
root mats	(undercut banks and submerged roots from terrestrial vegetation)

Substrate samples are collected with the help of an *aquatic kick-net*, a fine-mesh bag capable of collecting the aquatic organisms displaced from their habitat when the bottom substrate is disturbed by a kicking action to a depth of about 6 to 10 inches.

Similarly, the attached materials from large debris, such as sticks, leaves, snags and roots are washed, rinsed or brushed into a fine mesh bag or kick net.

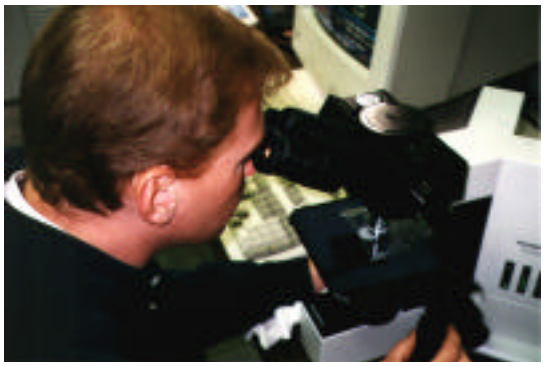


Overall, the object of the sampling program is to obtain a representative variety of the aquatic organisms present in the commonly-encountered stream habitats so that they can be classified and identified. For the habitat assessment, it is most important to determine the relative numbers of each species present.

Once collected in the nets, the aquatic organisms are flushed or rinsed into sample bottles where a preservative is added for transport to the laboratory. In the laboratory, the samples are transferred to a fine stainless steel sieve where large debris is carefully scrubbed free of organisms and removed.

Identification of Organisms

A stereo microscope is used to separate (pick) the organisms from the remaining debris. Organisms are initially separated into ‘slide mountable’ (Chironomidae and Oligochaeta) and ‘non slide mountable’. The picking of the organisms is laborious and time-consuming, but must be done carefully and consistently if the estimates of the relative abundance of the taxa present are to be valid.

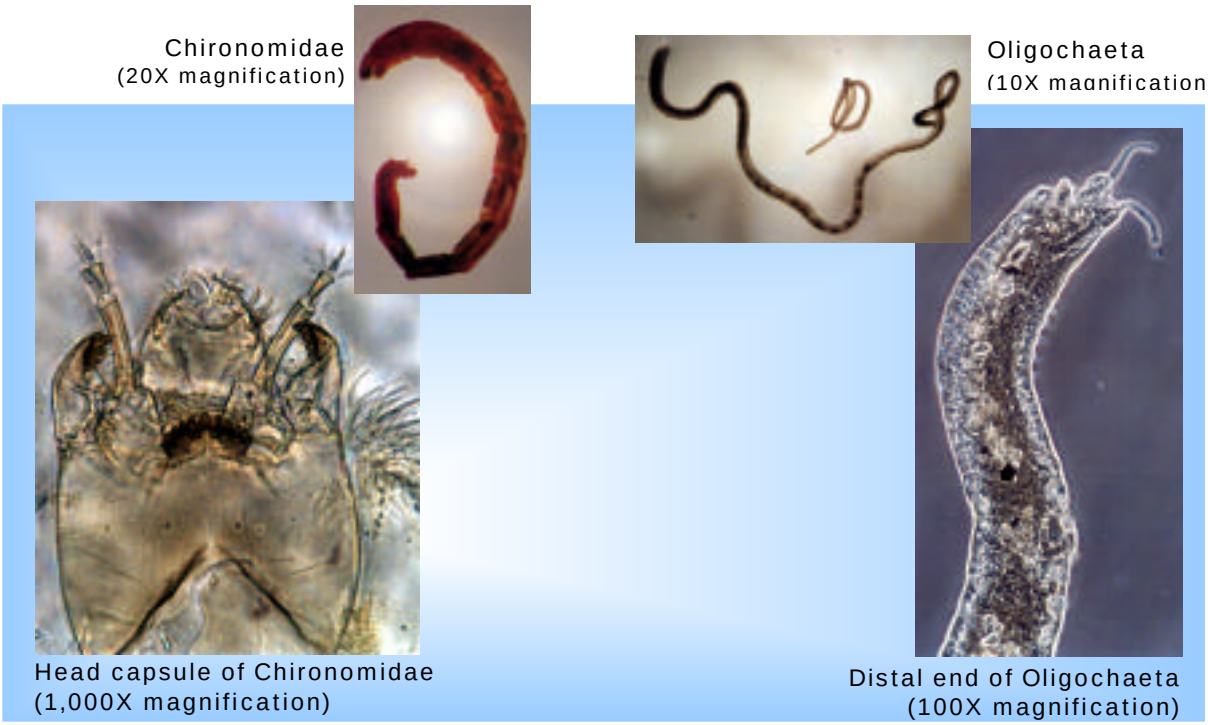


Identification of the organisms are then done to the lowest possible taxonomic level. This is commonly 'genus' or 'species'. For scientific quality assurance, a labeled taxonomic reference collection is created where representative organisms are permanently preserved for future examination and validation. The 'non-mountable organisms' are placed in a sample vial filled with ethyl alcohol along with two internal labels indicating

(1) the waterway, county, map coordinates, collection date, habitat, name of analyst and
(2) taxonomic identification.

Alternately, Chironomidae and Oligochaeta are permanently mounted on microscope slides for identification, labeling and archiving.

This *macroinvertebrate reference collection* may then be archived in the collection of the state regulatory agency.



Macroinvertebrate Data Evaluation

A variety of numerical 'metrics' (indices) may be calculated using the data from each macroinvertebrate habitat assessment. These metrics facilitate scientific comparisons between different habitat locales and allow the tracking of annual changes in the structure of the macroinvertebrate community.

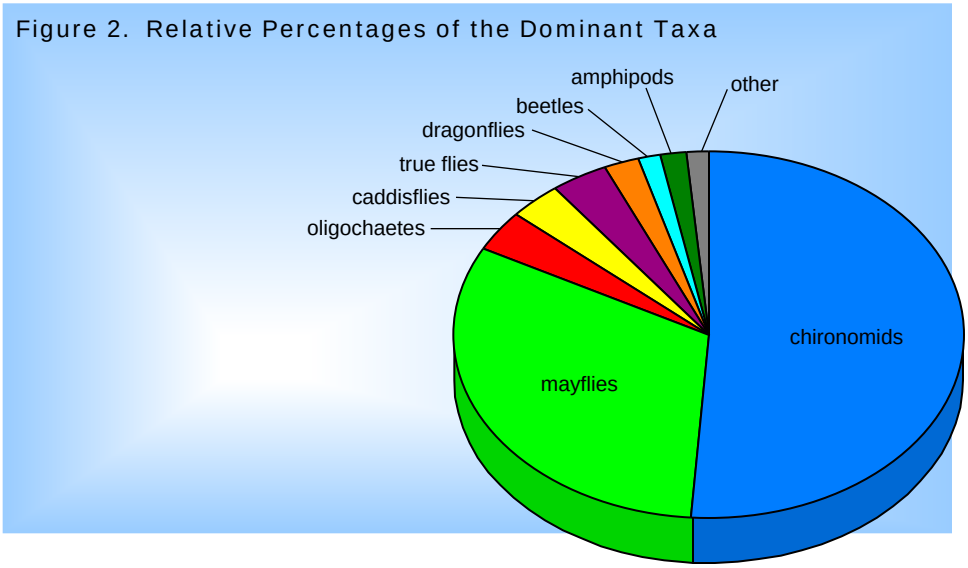
One example of a primary metric is *'taxa richness'*. Since the health of a stream's biological community is indicated by its diversity, the total number of taxa observed may increase with consistently improving water quality. However, taxa richness is only a single indicator. A more comprehensive score of biological condition can be obtained by using all of the available metrics based on multiple habitats and regions in the same stream.

While fish deaths have long been used as short-term indicators of excessive discharges of wastes or transient toxic spills, annual habitat assessment of the community of macroinvertebrates should provide greater insight into *long-term* adverse effects of human activities on a stream's biological community.

The progressive accumulation of stream habitat data on macroinvertebrates species and diversity, using evolving scientific approaches, are intended to help move the public debate over stream pollution from the political to the scientific forum.

An example of the results obtained from an assessment of a Midwestern stream is given in Figure 1. These results are among the earliest from an on-going, five-year study of biological changes in streams coursing through a region of intensive animal feeding operations.

Figure 2. Relative Percentages of the Dominant Taxa



It is envisioned that changes in the regional farming and livestock waste management practices will be reflected in the macroinvertebrate composition in surrounding streams. Improvements in the metrics of these streams would indicate the restoration of the streams abilities to support a diverse, and healthy, biological community.

Additional information on the procedures used in stream habitat assessment can be obtained by contacting the author at 1-877-22-WATER or TOM@H2OC.COM