RECOMMENDATIONS TO CITIZEN GROUPS FOR CHEMICAL MONITORING OF STREAMS AND RIVERS

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Abstract. Recommendations are made for modifying the methods used by citizen groups that follow the Georgia Adopt-A-Stream Program (GAAS) protocols for chemical monitoring of streams. These suggestions include estimating or measuring discharge, modifying some of the analytical methods, and following simple quality control procedures. These recommendations are made with the goal of having data obtained by volunteer groups become more acceptable to the regulatory and professional community. In addition to the water quality parameters described by GAAS, it is recommended that five day biochemical oxygen demand (BOD_5), fecal coliform, total solids, and turbidity be added to the list of measured parameters. This expanded list will permit calculation of a water quality index used by the Global Rivers Environmental Education Network . Such an index provides an assessment of the condition of a stream that is easily understood by the public and is consistent with how GAAS uses data obtained from micro invertebrate assemblages.

INTRODUCTION

One of the main problems when citizen groups undertake water quality measurements of streams is the general lack of acceptance of their data by the regulatory and professional community. This is in part due to the fact that some volunteer groups may not be utilizing some of the newer analytical instrumentation and methods that are currently available. Additionally, some groups do not describe or fail to follow some simple quality control protocols.

In this article, we recommend modifying some of the basic methods described by the Georgia Adopt-A-Stream Program (GAAS, 1997) that are commonly used by citizen groups conducting chemical monitoring of streams and rivers. These suggestions are derived from a review of practices currently advocated by this program along with recommendations by EPA for monitoring by volunteer groups (EPA, 1997), by the Global Rivers Environmental Education Network (GREEN) (Mitchell and Stapp, 1996), and from our experience teaching water quality courses for a number of years at the University of Georgia. These recommendations are seen as applicable to groups conducting both yearly 'spot' sampling and more intensive monitoring of selected streams and rivers.

ASSESSMENT OF DISCHARGE

It is important to determine the discharge of a river at the time of sampling or when water quality parameters are measured. Numerous studies indicate that concentrations of most chemical constituents vary with discharge (e.g., Drever, 1997). Some, like nutrient elements (nitrate and phosphate) and turbidity, increase during storm runoff, whereas others, such as specific conductance and alkalinity decrease due to dilution.

There are several approaches that can be used to ascertain discharge. At some locations, these data are available from the U.S. Geological Survey website at: http://waterdata.usgs.gov/nwis/ . For most streams and rivers, such data are not available. However, an assessment of the relative discharge of an unmonitored stream might be made from data from a nearby stream that is being monitored if the two watersheds are hydrologically equivalent. To be hydrologically equivalent, the two watersheds should be approximately the same size, experience the same amount of rainfall at the same time, and have a similar land use. Thus, for example, if a monitored watershed experiences low discharge, then it can probably be assumed that streams in a nearby watershed are also experiencing the same low flow conditions. One has to be more careful, however, in equating streams in two nearby watersheds during high flow conditions. Two equivalent watersheds might exhibit similar responses during a winter rainfall event, since such events commonly affect a wide area, whereas this may not be true in summer. Summer rainfall events tend to be more localized. Thus a stream draining one watershed might have a high discharge and an adjacent stream in another watershed might not.

In instances where detailed information is needed, then it is best to measure discharge at all unmonitored sites at the time of sampling. Simple methods for doing this are outlined by EPA (1997).

SAMPLING PROTOCOLS

Sampling of streams and rivers must be done with caution and protocols outlined with each type of analysis should be followed. In general, temperature and pH measurements must be done in the field. For dissolved oxygen, most methods of analysis require that measurements be done in the field. However, we describe a way of obtaining reliable data by collecting samples in the field and doing the analysis in a laboratory. This same approach can be used for measuring most other water quality parameters. Samples are commonly collected in glass (commonly for organics) or plastic containers (commonly for inorganics), but they must be thoroughly cleaned and acid rinsed prior to collection. Alternatively, pre-steralized, disposable Whirl-pak® bags prove useful (EPA, 1997). These avoid problems with possible contamination, which for some chemical constituents (e.g., phosphate), can be a problem.

BASIC WATER QUALITY PARAMETERS

Temperature

It is critical that a number of measurements be made at the time of sampling and that these measurements be properly linked to site specific features such as the amount of overhead tree coverage, turbidity, rate of movement, stream depth, etc. The GREEN program recommends that average temperatures be recorded over a 1 mile reach of a river to detect thermal pollution sources. Reliable temperatures can be measured by a number of field instruments besides thermometers, such as conductivity, pH and dissolved oxygen meters. It is important to check the accuracy of these instruments. The simplest way to do this is to record the temperature of a water-ice mixture.

pH

This must be done in the field. Reliable semiquantitative measurements can be made using pH sensitive indicator paper or by a color comparison method. A pH meter provides greater sensitivity but requires prior calibration with one or more freshly prepared buffers.

Dissolved Oxygen

This is usually done in the field. The dissolved oxygen (DO) concentration can be quite variable within a stream. EPA (1997) recommends that several measurements be made at a site. Proper sampling is critical to avoid contamination with atmospheric oxygen. GAAS, EPA, and GREEN all recommend using a drop-type Winkler titration procedure (e.g., Lamotte DO kit) or, when possible, a DO meter (EPA, 1997). We find that students often have difficulty obtaining reliable results using a drop-type titration kit. DO meters are expensive and oftentimes difficult to maintain. We recommend, where feasible, that volunteer groups utilize the Hach colorimetric method of analysis using AccuVac® vials (see Hach, 1998). These vials, which contain preweighed chemical reagents under vacuum, permit sampling at any location within the stream by breaking the tip of the vial under water. When properly sealed in the field, these vials can then be safely stored for several hours prior to analysis.

Nutrients (Nitrate and Phosphate)

GAAS, EPA, and GREEN recommend using a color comparison kit for doing these analyses. We recommend, if at all possible, that volunteer groups use a portable, battery operated field colorimeter or spectrophotometer. These instruments are relatively inexpensive (many cost less than $1,000) and are in common use in universities and other research centers. Modern instruments provide more precise and accurate data and many come from the manufacturer already calibrated such that data output is given directly in mg/L. We find these calibrations to be generally reliable, but all instruments require periodic checking with standards. Hach sells AccuVac® vials for both phosphate and nitrate analysis using their instruments. Water samples can be collected in the field and brought to a laboratory for analysis. Paper indicator strips can be used in the field for rapid, semi-quantitative determination of both nitrate and phosphate.

Alkalinity

This analysis is best done in the field, but samples can be collected and stored for later analysis. GAAS recommends using a drop-type titration procedure, whereas EPA suggests using digital titration. GREEN does not recommend measuring alkalinity. We recommend, if at all possible, that digital titrators be used since they provide greater precision. Since it is difficult to obtain reliable data, it is best that samples be collected in the field and brought to a laboratory where experienced personnel can do the titration. When doing these analyses, it is important that both standards and duplicates be run on as many samples as possible. It is best if both P(phenolphthalein) and T(total) alkalinity be measured since the results can be used to assess the concentrations of hydroxide, bicarbonate, and carbonate in the sample. Paper indicator strips can be used in the field for rapid, semi-quantitative determination of alkalinity.

Turbidity

GAAS suggests that settleable solids, measured using an Inhoff cone, along with determination of clarity using a Secchi disk, serves as a proxy for turbidity. GREEN recommends using the latter method or a turbidity meter. We recommend, if at all possible, that turbidity be measured directly using a turbidity meter. This approach is also endorsed by EPA. While Secchi disks provide a reasonable assessment of turbidity, they can only be used in deep, slow moving streams and lakes. Although many modern turbidity meters come already calibrated, it is important that they be checked with freshly prepared formazin standards.

Other Parameters

Both EPA and GREEN recommend that water samples be measured for total solids, five day biochemical oxygen demand (BOD_5), and fecal coliform. We feel that the latter two types of analysis should not be done by volunteer groups without access to specially equipped laboratories. One of the major limitations for obtaining reliable data is that incubation requires exacting temperature control. Nevertheless, it is important that these analyses be done, if at all possible, since these three water quality parameters are very important.

Total solids represent both the total dissolved substances (TDS) in a sample (normally that portion of a sample that passes through a 0.45μ filter) as well as the suspended solids. Determination is made by drying a premeasured volume of sample and weighing the solid residue. Such measurements require weighing to a high degree of precision, usually to tenths of a mg, and thus require sensitive analytical balances that are only available in laboratories. However, an estimate of TDS can be made using a conductivity meter. Such meters are readily available, easy to use, and reliable, but do require periodic calibration. The amount of suspended solids in a sample is closely approximated by turbidity (Hach, 1998).

Other chemical constituents of possible interest, including ammonia, hardness, iron, and copper, can be measured semiquantitatively using special indicator paper strips. These indicator strips are inexpensive, easy to use, and convenient. If warranted, these constituents can be measured with greater accuracy and precision using AccuVac® vials with a colorimeter (for ammonia, iron, copper) or by digital titration (for hardness).

QUALITY CONTROL (QC) ISSUES

It is essential that proper QC protocols be followed. EPA (1997) details a number of methods that can be used by volunteer organizations. We recommend at a minimum that duplicates be collected in the field and measured for at least 10% of the samples. It is also important that blanks be measured when doing all analysis. For DO analysis, some samples should be cross checked in the field using the Winkler titration method or with a DO meter. When samples are brought back to the laboratory for analysis, additional replicates can be analyzed along with calibration standards. It is also important that some (about 5% if possible) of the samples at the time of analysis be spiked with a known amount of a standard, permitting calculation of percent recovery (Miller and Wenner, 2001). All QC data should be reported along with the data obtained from the study samples.

RECOMMENDATIONS FOR CALCULATING A WATER QUALITY INDEX

The assembly of many water quality parameters by themselves often conveys little meaningful information to the public. However, collectively they can be used to calculate a water quality index which provides a classification system in which streams and rivers can be rated as excellent, good, medium, bad, and very bad. Such an index, however, requires measurement of more parameters then those advocated by GAAS.

It is thus recommended, where possible, that fecal coliform, BOD_5, turbidity, and total solids be added to the list of measurements suggested by GAAS. These data can then be used to calculate a water quality index such as the one proposed by the National Sanitation Foundation (Mitchell and Stapp, 1996). Such an index is derived from a numerical scoring of nine water quality measurements, with each parameter assigned different weighting factors. With this particular index, DO and fecal coliform values are assigned the greatest weight. The final numerical value derived from measurement of these nine water quality parameters permits an assessment of the overall quality of the water body in terms (very good, good, bad, etc.) that are easily understood by the public. Additionally, the use of this or another water quality index provides a way of conveying the kind of information currently recommended by GAAS for macro invertebrate assemblages.

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