Environmental testing - science or commodity?

Environmental laboratories play a critical role in the support of environmental management programs. Critical decisions with costly consequences are often made on the basis of specific laboratory results. It is, therefore, vital to have a high level of confidence in the quality of the data.

Considerable changes have taken place in the environmental chemistry field over the past three decades. Public awareness of toxic chemicals in the environment has been greatly enhanced and, also, the importance of reliable test results.

At the same time, the private laboratory sector was growing rapidly, especially in the late 1980s, and, before long, a “commodity mentality” started to develop in the marketplace. We started to observe a significant emphasis on productivity, especially automation. In the United States and Canada, many mergers and acquisitions have been occurring; the lab business is becoming "big business". Prices have been falling because of the "push" towards productivity gains and cost saving measures.

Moreover, environmental testing contracts required by larger corporations, can often be handled by purchasing departments which can interfere with the important interaction between the laboratory service user and provider.

A concerted effort has been made by many in the field (from both private and public sectors) to educate industry, regulators, consultants and the public about the field of measurement science as it pertains to environmental monitoring.

Considering the importance of environmental monitoring results, the emphasis must be on the science. Productivity, of course, is also important and automation must be employed where appropriate.

The environmental testing field is not, however, as amenable to automation as are other types of laboratory operations such as medical, agricultural and geochemical, and yet these are often viewed as models for the environmental sector.

Environmental testing is a relatively new and highly complex field that is still undergoing considerable change. Intervention by experienced chemists is necessary throughout the testing process.

The position of the Canadian Council of Independent Laboratories (CCIL) is that environmental testing is not a commodity that should be purchased based on the lowest price. Following are some of the factors that set the environmental testing field apart from other more automated laboratory sectors.

Environmental testing is not routine

a) Methods are still evolving – General water and wastewater analyses for a number of standard parameters (nutrients, some metals, BOD, etc.) have been carried out since the 1930s and 1940s. However, most of the tests performed in environmental laboratories today, were initially developed in the late 1970s, especially those for low level organics in water and soil. The methods have been going through considerable technological advancements from the 1980s to the present.

US Environmental Protection Agency methodologies are the basis for many environmental test methods in use today. This agency has now recognized that it is not practical to have prescribed "standard" methods for most of these parameters and it has now officially recognized a performance-based method approach. In this way, a laboratory can refine a method on its own accord as long as specific performance standards (i.e., detection limit, specificity, precision and accuracy) are met. Under this mode of operation, diligent and thorough method validation by the laboratory is extremely critical.

For example, the oil and gas industry (both upstream and downstream) is regulated for a number of parameters and, in the case of hydrocarbon classes, different methods can produce drastically different results due to variations in extraction methodologies. Due to the vast differences between laboratories, the regulators in Canada established a benchmark method based on using a "Soxhlet extraction" which is a 16-hour technique involving heat and continuous extraction.

To increase productivity, laboratories may choose to develop an alternate method but must prove equivalence (within 15% of the benchmark method).

b) The samples are complex - Laboratories that are highly automated process large numbers of uniform sample types. For instance, in medical laboratories the large majority of samples are blood, serum and urine. Within each of these three categories, the sample "matrix" is virtually indistinguishable from sample to sample as the primary composition of bodily fluids does not change; the only variable is the concentration of trace

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constituents.

This is definitely not the case in environmental laboratories where the sample types range from fish livers to air sampler canisters, with concentrations of contaminants ranging from ppt (parts per trillion) or even lower, to percent levels. The consistency of samples, even within a single submission of one sample type (e.g., soils) is not uniform. Soils often range from very fine silt to coarse gravel, even from the same site.

Dealing with the consistency of the samples is a highly critical component of the testing process and can have a dramatic impact on the final result.

c) Analytical variability must be understood - The ultimate "product" from an environmental laboratory is a report containing a series of results. It is usually well understood that these results are associated with a range or "error - bar" but the degree of variability can in some cases be larger than the client expects, especially for some of the organic compounds. This can have a significant impact on how test results will be interpreted, especially if the reported result is near a particular regulatory limit or guideline.

Laboratories are now required under CCIL's national accreditation to report method uncertainty. CCIL scientists have taken a lead in developing the protocols for determining uncertainty. (See CCIL position paper at www.ccil.com).

d) Sensitivity of tests - constantly being "pushed" - In the late 1960s it was routine and acceptable to report a detection limit of 50 ppb (parts per billion) when analysing for lead in water. By the late 1970s the best detection limit routinely reported was 1 ppb. Today, the detection limit requested for environmental baseline monitoring can be as low as 0.01 to 0.05 ppb. This amounts to a 1,000 to 5,000 times increase in sensitivity over a 30-year period and the regulators are still considering the need for greater sensitivity for some parameters.

Laboratories are often producing data at levels below the ability of reviewers to understand or interpret. It must be realized that, the more sensitive the analysis, the easier it is to be measuring artifacts such as contamination introduced during sampling, storage and analysis. When projects require ultra-low level analysis it is vital to carry out additional and uniquely designed quality assurance (QA) and review these QA results before the data are reported.

e) Need for supplemental testing and consultation - "This 'xyz' result does not make sense." This is a frequent query that clients make to a laboratory but it does not necessarily mean there is an error in the analysis. The work and, of course, internal costs associated with this kind of query can be considerable. The resolution process requires that re-analysis be undertaken on a priority basis and can also require significant attention from senior personnel (including the client contact person, lab manager, lab supervisor, analyst and quality manager).

In some cases, further diagnostic work can completely change the interpretation of the results. As an example, one of our member laboratories was involved in a project whereby hydrocarbons were reported from using the standard method required by the government and the results were reported to the client. The hydrocarbon results were considerably higher than had been expected. So, it was requested that a further assessment be done by one of the senior chemists of that laboratory.

Upon further diagnostic testing, using alternative detection methods, it was shown that wood waste materials within the samples were being extracted and were registering positive values as hydrocarbons. This was an important, and cost saving, finding for the client.

Environmental laboratories face significant costs

It is also important for laboratory users to have an understanding of the significant costs that environmental laboratories face to be able to offer the broad range of services required.

a) Professional staff - CCIL member laboratories employ a number of senior scientific staff who are not involved in day to day analysis work, and who are thus not doing actual chargeable work. These staff members are needed to carry out important functions such as: training, instrument optimization, method development, research, consultation with clients, issue resolution, quality

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management, data management, and more.

b) Facility costs - An environmental laboratory is housed in an extremely complex facility that must address unique HVAC, cooling water delivery, piping of a variety of compressed gases, fume removal, separation of certain chemicals, cold storage of samples, significant power requirements, along with computer linkage, waste storage and more.

The typical replacement cost of laboratory space is in the range of $160.00 to $220.00 per square foot for most CCIL members. Thus the cost to build a 30,000 square foot building (or 3,000 square metres) would be in the range of 4.8 to 6.6 million dollars. This is much higher than for most types of service companies in the environmental industry.

c) Investment in technology - CCIL member firms must invest significant capital to acquire the most updated laboratory instrumentation as well as Laboratory Information Management Systems (LIMS). Table 1 provides a few examples of instruments routinely acquired by CCIL member laboratories.

Table 1 – Some representative costs of laboratory instrumentation.

Instrument	*Cost – (dollars)*	*Used For*
ICP/MS	*150 to 190K*	*low level metals*
GC/MS	*100 to 140K*	*organics*
LC/MS	*200K*	*organics*
IC	*50 to 75K*	*anions*
High Res – MS	*450 to 550K*	*dioxins**

ICP – Inductively Coupled Plasma Spectrophotometer, MS – Mass Spectrometer, GC – Gas Chromatograph,
LC – Liquid Chromatograph – Ion Chromatograph
** and other organic compounds requiring extra sensitive testing.*

d) Supplies - Supply costs represent at least 15% of a typical laboratory's overhead. Certain reagents and standards are extremely expensive. For example, some organic standards can cost over $1,000 per gram and have a very short shelf life.

In addition to supplies utilized in the laboratory, CCIL member laboratories provide a full array of sampling equipment, supplies and containers, as well as shipping supplies. Each cooler with bottles and sampling reagents can be upwards of $300.00 and often as many as 10 can be requested for a large project.

Laboratory Accreditation

All CCIL member laboratories are accredited by either CALA (Canadian Association for Laboratory Accreditation) or by the SCC (Standards Council of Canada). These two bodies in turn are officially recognized by ISO (International Organization of Standards). The accreditation process is a comprehensive undertaking involving highly detailed site audits along with the analysis of a broad range of proficiency samples.

To provide an estimate for a fairly

Table 2. Annual CCIL accreditation costs.

Laboratory	*ABC Labs Inc*
# of employees	*100*
Services offered	*Conventional parameters, metals, organics*
Samples	*Water, wastewater, soil, sediment, air, foods*
Cost – site audit	*$15.000*
Cost – proficiency program	*$35,000*
Cost – QA staff & benefits	*$80,000*
Cost – dedicated supplies	*$10,000*

typical lab site the annual accreditation costs are itemized in Table 2.

Purchasing laboratory services

Reliable environmental monitoring is a multi-step process that includes sampling and testing design, sample collection, sample analysis, data reporting and data evaluation. The CCIL recommendations for consideration in purchasing an environmental laboratory service are:

- *Qualifications of the staff* – many staff are involved in carrying out an environmental laboratory program and the buyer must be assured of their qualifications.
- *Relevant project experience* – it is important to ensure that the laboratory selected has sufficient experience with the type of project requested.
- *Relevant laboratory equipment and facilities* – if, for example, the intended project involves very low detection limits, the bidding labs must have the appropriate "clean rooms" and the necessary instrumentation such as Inductively Coupled Plasma Spectrophotometer/Mass Spectrometer (for metals) or high-resolution Mass Spectrometer (for organics).
- *Accreditation* – the laboratory must have the relevant accreditation. It is important that the buyer be supplied with the details of a laboratory's accreditation to make sure they are accredited for every test that could be requested in a particular project. As well, the laboratory must be able to show their systems with respect to sample management, data management and archiving.

Two envelope bid protocol

It is essential that we continually advocate a bidding process that ensures that the buyer is considering best overall value over the lowest bid. Indeed, CCIL recommends a two-envelope bid protocol so that the best proposal is selected without consideration of the bid price. Once the firm is selected, the price proposal is opened and the value of the contract is further negotiated.

This bid protocol is also recommended by the various engineering associations in Canada.

For more information, visit www.ccil.com