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Instrumentation Need in Environmental Monitoring

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特別寄稿

Guest Forum

Instrumentation Needs in Environmental Monitoring

Recently, I visited the capital city of a Latin American country and met some of the staff of the Ministry of Environment, one of the first to be established on the American continent. Less than a year ago, as a result of elections, a new government came to power and, as in many other countries, most of the senior management in this Ministry was replaced. Although, usually quite disturbing to the organization, such changes also offer a good opportunity for a program review and overhaul.

This was exactly what was happening in the Ministry I visited. The senior managers were taking stock of what has been accomplished to date and, especially, what the current issues were. They were also working on establishing priorities and reexamining the existing programs in light of the philosophy, approach, and goals of the new government. In other words, the senior management of this Ministry was reexamining everything, forced partly by a tough economic situation and a reduced operational budget. In the final instance, decisions had to be made on the allocation of very limited resources to a series of activities, all seemingly very important. The approach chosen in this particular case was to select from a long list of important activities the ones that contributed directly to the basic objectives and functions of the Ministry of the Environment.

Although the specifics change from country to country, the basic objective of a Ministry of the Environment is to "Protect and conserve the environmental quality of the country while contributing to the improvement in the quality of life for its population". This is usually accomplished through a basic set of activities consisting of, for example, the preparation of environmental legislation and regulations, their enforcement, monitoring of environmental quality, management of environmental impact assessment process, preparation for and attending to environmental emergencies, and supporting environmentally related research, environmental education and public awareness efforts.

Monitoring, in my opinion, is a legitimate activity for government environmental agencies. The dictionary defines monitoring as a systematic observation or measurement of a given process, activity or characteristic, usually over a long period of time. An environmental monitoring program can have different purposes:

- Define the spatial and temporal variabilities of water, air, ... quality and the major factors affecting them, e.g., geology, l and use, climate, and industrial and municipal sources
- Establish suitability of water or soil for various uses
- Support development of legislation, standards and regulations
- Determine compliance with standards and regulations
- Determine the contributions of the point and non-point pollution sources
- Determine long term trends

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Currently, Dr. Demayo advises the governments of several Latin American countries on how to strengthen their environmental protection and conservation programs.

Before joining The World Bank, Dr. Demayo spent over 27 years working for the Canadian Department of the Environment as well as for several international organizations active in the environmental field.

In his career, Dr. Demayo carried out research in analytical methods and the environmental kinetics of some organic compounds, developed computer applications for analytical laboratories, recommended ambient water quality guidelines, and worked in the environmental data analysis, presentation and interpretation.

- Improve the understanding of the processes, e.g., transport, chemical and biological, taking place in the environment and their effects on the ecosystem, including the human life
- Determine the effectiveness of pollution control measures
- Report on the state of the environment
- Support of the economic and social planning
- Support environmental impact assessment

This is a long list. Because each objective listed here has its own data collection requirements, e.g., what is being measured, where, what frequency, sampling and measurement methodology, it is difficult to do justice to several objectives within a single monitoring program. Unfortunately, more often than not, this is exactly what happens, i.e., data collected for a particular goal are used for purposes for which was not intended and for which might not be suitable. This is understandable. Faced with rapidly shifting objectives and reduced budgets, like in the country I visited, the managers are looking for ways to cut the operational costs of their organization. In the specific case of environmental monitoring, they are looking for methods/systems that would provide reliable data for a variety of objectives, in a cost-effective and efficient manner. The scientific and technological advances in the last several years provides partial solutions to this challenge.

Traditionally, monitoring consisted of sampling, physico-chemical and/or biological analysis, and data analysis and interpretation. In the 1950s and 60s when the concerns about the environmental quality started to grow rapidly, monitoring emphasized the measurement of basic physico-chemical variables. In water quality monitoring, for example, the variables that were being measured were conductivity, colour, turbidity, hardness, alkalinity, and eventually dissolved oxygen and carbon dioxide. Although important in terms of water chemistry, these variables said little about the effects on human and aquatic life of other substances, present in water at much lower concentrations, but with very significant effects on the ecosystem integrity. It is also true that with the field and laboratory instrumentation available 30 years, say, measuring very low concentrations, e.g., parts per billion, was very difficult if not impossible.

Currently, the environmental monitoring is focusing more and more on measuring those variables that really count in terms of their effects on environmental quality, with the toxic substances being the major concern. Unfortunately, although today's laboratory instrumentation allows us to analyze for a very large number substances, the cost of environmental analysis is high. When the costs of sampling, data storage and interpretation are added, the result is an expensive program that few governments can afford. When the cost factor is coupled with the technical difficulties of sampling, analyzing, and interpreting the data, it is not difficult to understand why

reliable environmental data are hard to obtain.

How can the costs be reduced and at the same time obtain high quality, reliable data for decision making? One way is to optimize the design of the monitoring programs. Another, complementary approach, is to have fewer, but better equipped laboratories rather than many, small, poorly equipped ones. Typically, in such a laboratory the instruments will be in use 16 to 24 hours/day, and the professional staff will have the critical mass that will allow for meaningful consultations and professional development. When distances are large and response time is important, many government organizations are opting for portable equipment and mobile laboratories equipped with such instruments like gas chromatographs and atomic absorption that allow on site measurements for many of the substances of interest. An added advantage of this approach is the fact that the measurements are made soon after the sample collection or "in situ" thus removing some of the uncertainty in the data resulting from sample preservation, transportation, and/or storage before laboratory analysis. A further additional advantage of the mobile laboratories and portable instrumentation approach is its higher visibility for the agency doing the monitoring. This, in turn, should translate in better public awareness and support of the government/agency efforts in environmental protection.

What else is needed? Perhaps of the several basic functions of an environmental ministry, the enforcement of legislation is the one that receives lots of attention. Low cost sensors that can detect (qualitatively) a variety of toxic substances in the waste streams of various industries above preset thresholds would be ideal for monitoring compliance with regulations and would significantly contribute to improvements in environmental quality (in addition to making money for their developer!). Even better, would be sensors that measure quantitatively the same substances in the waste streams. The next logical step would be to have sensors that measure the toxic substances in the receiving environment, where the concentrations are of orders of magnitude lower. It is my belief that today's technology allows such developments. Why such sensors have been slow in becoming a reality is a mystery to me. Perhaps, some of the readers can answer this question. Even better, perhaps some of the readers have already advanced a great deal on this road. All of us would be thrilled to hear such news!

「環境モニタリングにおける計測機器の必要性」

このほど南米大陸初の環境庁を訪ずれたが，スタッフは1年前とはすっかり入れかわっていた．彼等は，厳しい経済環境の下で，政府の環境政策の見直しや限られた予算をどのように振り分けるかについて精力的に活動していた．

環境行政の基本的な目的は,「自国の環境の質を保護・保存すると同時に，住民の生活の質の向上をはかる」ことにある．この目的の達成のために，法規制の策定・実施，環境の質の監視，影響の評価,さらには,大衆への啓蒙活動などを行っている．

環境のモニタリングには次のような目的がある．

①水質や大気に影響を及ぼす主要な要素，たとえば，地質，土地利用，気候，産業汚染源などの短期的・長期的な変動の把握．

②法律，標準，規制などを策定し，それらへの適合性の判定．

③環境汚染源の把握と，その抑制効果を判定．

④交通，化学的・生物学的プロセスが生態系に及ぼす影響への理解．

⑤経済的・社会的計画と環境アセスメントの支援．

これらの目的を達成するためには，モニタリング・データの蓄積と適切な活用が必要となる．実際は，方針の変更や予算削減などにより少なからず困難を伴うが，近年の科学技術の発展がその解消に役立っている．

従来，環境水質のモニタリング項目としては，導電率，色，濁度合，硬度，pH，溶存酸素などの物理・化学量であり，人体や水圏生物への影響は，ほとんど何もわからなかった．生態系の維持には他の微量物質が重要な影響を及ぼしている．

現在，環境モニタリングの焦点は，環境の質への影響要因，とくに，有害物質に移りつつある．既存の実験室用の分析機器を使えば分析は可能ではあるが，コストがかかり過ぎ，この費用を捻出できる政府はきわめて限られてしまう．また，信頼性の高いデータを得るためには，高度な技術が必要となる．

コストを削減し，質が高く，信頼性の高い環境計測方法はないのだろうか？

一つはモニタリング・プログラムの最適化で，もう一つは，数は少ないが質の高い設備の整った実験室を整備することだろう．時には，専門のスタッフが，24時間常時監視の機器を備え，移動式実験室や携帯用の機器を持って現場にでかける．これが，大衆の意識高揚につながり，政府機関の努力支援にもなっていく．

この他，廃棄物中の有害物質を定性的・定量的に検出して，規制値との適合性を監視することも重要だ．廃棄物の物流にローコストなセンサを導入できれば，有害物質の濃度は数桁低くできるだろう．今日の技術レベルからすると，このようなセンサの開発は可能だと思う．

本誌の読者の中には，この方面の研究を進めている方がおられるはずだ．吉報を期待している．

（文責　編集部）