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New challenges in environmental chemistry

Wilson F. Jardim

Instituto de Química, Universidade Estadual de Campinas, UNICAMP, Caixa Postal 6154, 13081-970, Campinas, São Paulo, Brazil

Abstract: The major goal of this paper is to point out the frontiers of environmental chemistry and the new paradigms for the next decade, with especial focus to Latin America countries. To better address the issue, three different scenarios were selected: (a) major changes in laboratory routine and research activities; (b) extra-laboratory tendencies; and (c) legal, political and social aspects. In the first case, there is an enormous need for implementing protocols centered on quality assurance, especially when dealing with ultra-trace analysis. The use of certified materials and standards should be enforced in the near future, as well as the implementation of intra and inter laboratory calibration programs. Sampling is another point that will demand a great amount of attention. Field analysis, including *in situ* monitoring, is a fast growing area in environmental chemistry, and certainly will demand expertise in various issues, including miniaturization of instrumentation, remote and continuous monitoring and bioassays, providing information that certainly will subsidize the evaluation of existing quality criteria for water and air.

Introduction

According to the special report published last year in ES&T (ref. 1), research priorities for the 21st century include the following issues:

- **Economics and risk assessment**
- **Environmental monitoring and ecology**
- **Chemicals in the environment**
- **The energy system**
- **Industrial ecology**
- **Population growth**

It is understood that these are research areas that will demand increased attention over the next two decades. Some of the issues pointed out in the document are global, and will affect not only the US, but our planet as a whole.

However, due to the present stage of technological and socioeconomic development observed in Latin America, some of these issues are far from being a real threat when compared to others, which can be considered more risky on a short time basis. For instance, providing potable water and better sanitation is a chronic problem in the vast majority of developing countries, their lack is responsible for taking millions of lives each year. This is only one example illustrating that, despite the fact that some global issues are important, in some aspects local or regional ones are the ones that will demand rapid action. Selecting and solving these acute problems is a challenge that Latin American chemists will have to face in the near future, and perhaps the logical way to tackle the problem is first to provide a good diagnostic of the situation, followed by a mature discussion of how to achieve a better quality of life combined with vigorous industrial activity, yet keeping most of the natural wealth (such as biodiversity) in a good balance for future generations.

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It is important to bear in mind that in the endeavor to achieve better quality of life, in Latin America, chemists will play an important role in this task. Considering that chemists normally interact in several areas of knowledge, the idea is to present in this paper some of the key aspects that will demand direct and effective efforts from us to better use our science in the benefit of every human being.

The quest for better education and social gains

Chemistry is a branch of science that has been striving worldwide to overcome a problem of rejection among secondary students. Among the reasons that contributed to this problem, one could point out that in many Latin American countries, a substantial fraction of chemistry teachers at secondary school have not graduated in chemistry. The other important aspect is that education as a whole is normally not ranked as a priority within governmental targets.

In this realistic educational chaos, environmental chemistry is perhaps the branch of chemistry that has more links to the daily life aspects than any other subject. In this case, it has to stand as the main vector to rescue chemistry as a natural, multidisciplinary and interdisciplinary science. Unfortunately, again, the number of professionals with a holistic (one could dare to say a modern) view of chemistry is still very low, thus perpetuating the idea of an egocentric science devoted to solving its own problems and divorced from the real world.

Finally, chemists have always been very timid when it comes to the point of analyzing the social gains and benefits that Chemistry has provided directly or indirectly to society as a whole. This problem is even more crucial in Latin America, and has to come to an end through long term educational programs which aims to break this vicious cycle.

Quality as the modifying agent

Despite the fact that Quality Assurance Programs (QAP) are routine in the vast majority of chemistry laboratories outside the universities, it still faces many barriers before being assimilated within university teaching and research laboratories, specially in Latin America. This scenario has to be changed in a short time, not only because there is an increasing demand in the market for chemists with this type of professional background, but mainly because the university cannot ignore this global tendency.

Indeed, quality has to be faced as a modifying agent because in the ultimate analysis, it is the major carrier to bring all chemical laboratories, independent of their nationality, to the same level of comparison and credibility. Since quality never comes alone, one can expect the following areas to follow the same trend of increasing demand and needs:

- **routine use of certified samples**
- **laboratory intercalibration programs**
- **increase in automated methods of analysis**
- **accreditation of laboratories**

Taking these detected tendencies and the associated demands based upon the present stage observed in most laboratories in Latin America, it is clear that the offers are well below of what is expected. In this case, Latin America faces an urgent need for improving the capability of making their own certified samples, for implementing effective intercalibration programs available to the vast majority of interested laboratories at fair costs, and to discuss suitable accreditation mechanisms and institutions.

The scenario outside laboratories:

When one looks at the future tendencies in environmental as well as in analytical chemistry, one should expect some changes not only in activities related to routine work performed within the

laboratory space, but also to field work. In this case, the following extra-laboratory activities are expected to demand a great deal of improvement in the near future, especially in Latin America, where field work has been discontinued in the last decade due to the high costs associated with it.

- **Sampling**
- ***In situ* monitoring**
- **Miniaturization of field instrumentation**

According to Keith (ref. 2), obtaining a reliable environmental sample is difficult, and sampling is often considered to be the weakest link in a well planned analytical strategy of analysis. To minimize sample contamination during transportation from field to laboratory, to avoid problems of integrity during preservation, and also to trigger corrective actions with no delay, *in situ* analysis has been growing mainly in areas related to environmental monitoring and compliance. This development is a partial reflection of the advancement observed in both electronics and the miniaturization of field instrumentation and chemical sensors. It is important to remember that one of the greatest benefits of this new analytical stage is the possibility of expanding the capability of data acquisition in real time.

Analytical instrumentation:

Following the global trend in instrumentation observed not only in chemistry, but also in the medical area, one could point out that analytical chemistry will experience a growing demand in the following areas:

Miniaturization: mainly because it makes feasible a wide range of field sampling and analysis at relatively low cost.

Continuous monitoring: as already mentioned, continuos monitoring is expected to be compulsory at most discharge sites to check compliance.

Hyphenated techniques: some hyphenated techniques such as GC/MS are already well established in environmental analytical chemistry. Others, such as HPLC/MS are just about to overcome technical details to become a routine very shortly.

Infrared (near and mid) and Raman spectroscopy: Near (and to a lesser extent Mid) infrared spectroscopy is one of the booming techniques of this decade. Due to its non-destructive nature associated with fast response time, this is one of the most promising analytical techniques in environmental chemistry. Also, because of the fast development observed in lasers, Raman spectroscopy has been revitalized in the last 5 years. With the help of chemometrics, these techniques will be responsible for a great deal of environmental analysis in the near future.

Immunoassays: high specificity of immunoassays, and the possibility of using some of them in the field are the two major aspects that collaborate for the future success of this method.

Toxicity tests (speciation): chemists will have to face the challenge to support biologists in the search for more representative organisms in toxicity tests, at the same time developing ways to determine only the concentration of the toxic species within the total concentration of the stressing agent.

Environmental modeling: understanding the fate of chemicals in the environment is the key factor to test environmental models to predict impacts and to implement corrective actions over a short time span.

Environmental issues to be looked at:

Finally, in a more broad sense, when we look at the state of art of environmental chemistry and the way of life of the so called modern society, one can forsee that some extremely important environmental issues will arise in the next century, and we have to be prepared to discuss them on a mature and scientific ground.

Legal aspects: in terms to better subsidize technical aspects related to future legislation, but also to revise the present ones, with especial emphasis on quality criteria and environmental exposure.
Chemometrics: as a powerful mathematical and statistical support to interpret complex analytical data, as in many NIR and RAMAN spectra.
Endocrine disrupters: recent studies have pointed out that high levels of natural and synthetic hormones found in municipal wastewaters may be responsible for endocrine disruption in fish. Up to date, very little is known about possible endocrine disrupters to men and the consequences upon chronical exposure (ref. 3).
Industrial ecology: or, in other words, combining the ecological approach to production line and consumption habits with the objective of reducing environmental impacts. Basically, it is the combination of cleaner chemical processes guided by rational use of resources.

Final remarks:

Perhaps the major point of this talk was to emphasize the importance of Chemistry in the improvement of life quality in our planet in the past, and specially in the future. The points discussed above will demand a new way of thinking of all chemists, especially in Latin America, where some other specific problems have arisen recently. Globalization and protectionism programs (such as ISO 9000 and 14000) are forcing Latin America to reorganize some scientific bases. It is a matter of survival, and the best way to compete is to strengthen cooperation among chemists worldwide.

As far as Latin America is concerned, it is imperative that we define our local and regional environmental priorities. In doing so, we will be able to detect the real threats to our environment, with special attention to our two majors sources of wealth: natural resources and biodiversity. These are the major points to be considered in the conception of a realistic and unique developmental model that can be applied to Latin American countries, taking into consideration the generations to come.

References

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