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COMMENTARY

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Water and Life in the International Year of Chemistry

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ABSTRACT: This commentary talks about the worldwide health impact of lack of access to potable water. Household water treatment and storage (HWTS) is described as one approach to improving potable water accessibility in which students and educators can make a contribution to alleviate the problem of lack of access. The author suggests that, as chemists, educators can contribute to the success of HWTS by engaging students in water quality measurements placed at the service of the HWTS approach. In addition, this commentary highlights the pedagogical benefits of such an engagement.

KEYWORDS: First-Year Undergraduate/General, Second-Year Undergraduate, Upper-Division Undergraduate, Analytical Chemistry, Environmental Chemistry, Hands-On Learning/Manipulatives, Water/Water Chemistry

This year we are celebrating the International Year of Chemistry (IYC). The global yearlong celebration, which is being coordinated by IUPAC and UNESCO, aims to highlight the achievements of chemistry and the countless ways in which chemistry makes lives better. Details about the objectives of IYC and the multiple activities that will mark the celebration have been provided elsewhere in this *Journal*.[1−4] Water will be one of the themes of the global celebration. My task here is to tell you a little about one way in which we can involve our students in doing a type of water chemistry that can improve the lives of others and their own lives.

HOW WATER FEATURES IN THE INTERNATIONAL YEAR OF CHEMISTRY

The ACS, as one might expect, is playing a prominent role in the IYC 2011. The activities and resources designed to engage students and the general public are structured around four quarterly themes. The year begins with a quarter on "Water in the Environment", two quarters, one on "Alternative Energy" and one on "Materials", follow and the year ends with a quarter dedicated to "Health".

In addition, IUPAC is sponsoring "Water: A Chemical Solution",[5] a worldwide experiment in which millions of students from over 100 countries are expected to participate. The experiment includes four activities focusing on water quality and water treatment: Acidity—pH of the Planet; Salinity—Salty Waters; Water Treatment—Water: No Dirt, No Germs; and Distillation—Solar Still Challenge.[6] The title of the experiment, intentionally, carries a double meaning. It refers to "solutions" in the chemical sense of a solute dissolved in a solvent but it also means "solutions" in the sense of providing answers to the challenges of delivering safe water to people around the world. The theme of the global experiment and the ACS emphasis on the first and last quarters have something in common, as lack of access to potable water is one of the most important health concerns in developing countries. To that story, and to the modest efforts in which I have participated in an attempt to provide "solutions", we now turn.

WATER QUALITY AND WHY IT MATTERS

The ACS theme for the first quarter of the IYC is Water in the Environment. In a broad sense, the theme highlights the ecological importance of having healthy bodies of water such as lakes and rivers, as well as groundwater resources. This is an important story we have been increasingly exposed to over the past few years. Students in K−12 schools, colleges, and universities are quite aware of the environmental importance and impact of water. In addition, in recent years, the measurement of water quality indicators has been incorporated into instructional labs from elementary schools to colleges all over the country. More could be done and the IYC aims to do just that, but this is an area in which progress has been made. What I would like to do is direct your attention in a different direction.

Consider the following for a moment: Each year, an estimated 2.5 billion cases of diarrhea among children under 5 years of age are reported worldwide. The overall incidence has remained relatively stable over the last two decades. The mortality rate, however, has improved considerably from an estimated 5 million deaths a year 20 years ago to approximately 1.5 million today. That is good news. Nonetheless, at approximately 20%, diarrhea remains the second most common cause of child death worldwide. About 80% of those deaths occur in Africa and South Asia. In spite of the progress, diarrhea continues to kill about 200 children per hour. It is estimated that 88% of diarrhea deaths are due to inadequate sanitation, poor hygiene, and lack of access to potable water. When the worldwide experiment, Water: A Chemical Solution, talks about the challenge of delivering safe water to countless people around the world, this is the staggering challenge that is referring to: delivering water to the billions of people who do not have access to potable water and suffer terribly as a result. That is why water quality matters. The lives of people depend on it. Not the quality of life—life itself.[7]

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Figure 1. Families take home their new household water treatment filters. Instruction in using the filters safely was offered and filters were distributed in San Juan de Dios, Quintana Roo, Mexico, in January 2011.

HOW TO ADVANCE ACCESS TO POTABLE WATER

Reducing the incidence of water-related diseases depends not only on having access to a potable water source (water quality) but also personal and environmental sanitation is fundamental and, as a result, the quantity of water one has access to is also a factor. For that reason, worldwide efforts that have led to improvement in recent years have emphasized the importance of an integral approach that pays attention to both water quality and hygiene promotion. At this point you may be wondering how we, as educators and chemists, can contribute to a reduction of the incidence of water-related diseases. Given the magnitude of the challenge, one might think that the solution can only come from building municipal water treatment plants to provide people with the water they need. That is, no doubt, part of the solution, yet it is unrealistic to think that approach will be sufficient. Alternative approaches are needed, in the short term, to supplement whatever large-scale efforts are being made. That opens the door for ways to address this problem to which we can contribute as chemist and educators. I am referring to what is now known as household water treatment and storage (HWTS). The name and acronym come from the recognition that this approach has received in recent years from international agencies such as the World Health Organization (WHO) and UNICEF (United Nations Children's Fund). WHO now has an HWTS Network dedicated to the promotion of this approach.[8]

Using HWTS as an Approach to Providing Potable Water

HWTS is simply a way in which, at the household level, people can treat water to make it potable. In addition, storage is important because if the water is stored improperly it can become recontaminated. HWTS is an approach that literally concentrates on one family at a time, which is labor intensive because it requires behavioral changes on the part of the beneficiaries as every family becomes responsible for the water that family consumes (Figure 1). Sometimes this approach includes a device to filter water at the household level. In other cases, the appropriate HWTS method may be disinfecting the water with a chemical solution followed by safe storage of the disinfected water. The approach varies depending on resources, the community of people involved, and environmental factors affecting the water supply. Nonetheless, the effectiveness of HWTS is now widely recognized. A report[9] by WHO and UNICEF recently summarized the impact of HWTS plainly (p 28): "Simple techniques for treating water at home and storing it in safe containers could save a huge number of lives each year."

Figure 2. Sampling water from a municipal source in San Juan de Dios, Quintana Roo, Mexico, in January 2011. A student will analyze the sampled water for the presence of basic chemical and microbiological water quality indicators.

What Can We as Chemical Educators Do?

So what can we do as chemical educators? It very much depends on which level one teaches; nevertheless, the opportunities are endless. If one is in elementary and middle schools, the health consequences of not having access to potable water and sanitation can be emphasized. The magnitude of this problem is staggering and I suspect, maybe wrongly, that a large number of our students simply assume that, like them, most people around the world have adequate access to potable water. Opportunities abound for teaching how to measure basic chemical and microbiological water quality indicators in the context of the problems that lack of water access creates.

For high schools and particularly for colleges and universities, there are opportunities for participation in making chemical and microbiological measurements of water quality in places where people are suffering the consequences of lack of access to potable water. A great deal of importance is attached these days to "internationalization" and "service learning" in higher education. Here is an ideal situation to combine these areas. Water quality problems can often be encountered in most underdeveloped countries as soon as one leaves urban areas and, at times, within them. Students could do water quality measurements in rural communities or, better yet, they could find communities in which a household water purification device is in use and assess how it is performing. Our colleges and universities are emphasizing the importance of "citizenship" and community service. Sometimes that service is directed preferentially to the less fortunate. All over the country students are urged to participate in "alternative spring breaks" and to travel to underdeveloped countries to have direct contact with other peoples and cultures. A lot of this is already being done. I am just advocating for a way to put science at the service of the disadvantaged.

Humanitarians working in underdeveloped countries usually have to deal with water in one way or another as they realize that improving the health of those they are serving is not primarily a matter of improving access to medical care, although that is important, especially to treat a sick person's acute symptoms. Addressing the root causes of many serious illnesses requires improvements in public health measures involving water and sanitation, among others; health gains will come fundamentally from these water-related efforts. Among those serving abroad, however, most lack the resources to do water quality measurements. For that reason, there is a great deal of need for water quality measurements in the field (Figure 2). We can involve our students, literally all over the world, in this effort. It is not that

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Figure 3. Teaching community members about safe practices for household water treatment and storage prior to distributing filters in Bonao, Dominican Republic, in October 2007.

difficult and it is not that expensive. The basic parameters of water quality can be done in the field with equipment that is easily available.

Let me be clear, this is the *Journal of Chemical Education*, not the *Journal of Public Health*. Involving our students in these kinds of activities could be of immense value to communities, but the argument I am making has essentially a pedagogical justification. I am recommending involvement in these activities not exclusively, or even primarily, as a way to benefit communities around the world (as important as that is) but because they can be of great benefit, in all sorts of ways, to our students. One can be naturally skeptical about the ability of high school and undergraduate students to make a significant dent on a problem of this magnitude. The argument I am making is not that they will, even though they may. My argument is that engagement with this problem is a very good way to promote interest in chemistry and to highlight the ways in which chemistry can improve people's lives. At times the lives improved are those of our students for reasons that have nothing to do with water. Students interested in public and global health can also learn the fundamentals of health impact assessment and hygiene promotion from participation in this kind of work.

■ MY MODEST PARTICIPATION IN THIS EFFORT

Primarily, I have been conducting water purification projects in rural communities in the Dominican Republic using the HWTS approach (Figure 3). In these projects, I distribute filters that residents of rural communities can use at home to purify their own water. A number of these so-called appropriate technology filters are used around the world. The model I have used has been modified over the years to respond to the challenges encountered in the field. Students participate in the assembly and distribution of filters as well as in the chemical and microbiological measurements necessary to determine the quality of the water produced by the filters. Trips to the Dominican Republic are not limited to students interested in water. They are open to the entire student body. The water work is combined with small construction projects and so forth. While I have not done so recently, in some years a few students have remained in the Dominican Republic for 6−8 weeks in the summer to measure the performance of the filters over time. On occasion, students from graduate programs in public health have worked alongside undergraduates in an effort to assess the health impact of the presence of the filters in a given community. For routine water quality measurements, the chemical parameters of interest are turbidity, residual chlorine, and pH. Microbiological measurements can be done using a variety of methods; chiefly, one is looking for the presence of indicator organisms that signal fecal contamination. All these parameters can be measured in the field with equipment designed for that purpose. For me, and for the students, this activity has been immensely rewarding and, in my view, its pedagogical value is hard to exaggerate. I highly recommend involving students in making water quality measurements in the field. If the results can be placed at the service of an approach that may improve the health of those that lack access to potable water, that is even better, but those opportunities may not be available to everyone. I thank the *Journal* for letting me tell you about the opportunities I have had.

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