"Interesting Questions"

(opinion paper)

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Many items which are accepted as fact in the swimming pool and spa industry are, in actuality, either working hypotheses presented as fact or are downright myth. Fortunately, this is not the case for most of the information we rely on, but every once in a while we trip over something that is not correct. Many purported facts are presented without experimental, or even anecdotal evidence for their support. Often, when researching a bibliographic citation that apparently supports a statement of fact, one finds that the citation leads only to a prior statement of the supposed fact, presented without evidentiary foundation.

This article, along with others to follow, as readers have occasion to point out similar items, is not intended for those satisfied with dogmatic recitations of unsupported fact in industry publications. Rather, it intended to invite thoughtful, documentable response to some puzzling contradictions or oversights in the industry.

This initial offering is presented for your enjoyment by Ben Powell, and responses will be accepted in the form of letters to the editor, short technical notes, or, if appropriate, research papers.

pH Ranges

Almost everyone in the pool and spa industry seems to accept (know) that pH levels outside the 7.2 – 7.6 (or 7.2 – 7.8, depending on whom one consults...) range are irritating. Yet, I personally have swum, without goggles, in pools with pH's as low as 6.6 and as high as 8.4 without ill effect. The pools we service normally range from 7.6 to 8.2, and our customers usually report *reductions* in eye discomfort once we assume responsibility for the pool. My provisional conclusion has been that pH alone has little impact on eye discomfort, at least in some range such as 6.8 to 8.2. Although pH obviously has an effect on chloramine formation, sanitizer consumption, corrosivity/scaling of the surface and equipment, etc., which also govern the ranges in which pH should be maintained, why do we as an industry accept and promote the eye irritation idea without apparent support?

Sodium Bicarbonate and Total Alkalinity

Standard doctrine in the pool and spa industry seems to be that it is appropriate to use sodium bicarbonate to maintain total alkalinity in **heated** and **aerated** spas, while still maintaining the pH in the proper range. However, it seems as though this is theoretically futile. Carbonate chemistry seems to suggest that while the pH is maintained below 8.4, a portion of the carbonates will be present as H_2CO_3. Further, it seems accepted that as long as carbonic acid is present, un–hydrolyzed carbon dioxide gas will also normally be present. Aeration of this water will then strip the carbon dioxide gas, resulting in an increase in pH. As the pH is subsequently balanced with acid, alkalinity is consumed. So more sodium bicarbonate is added, and more CO_2 is aerated off, and more acid is needed, and more alkalinity is consumed... Where and when does this vicious cycle end? What would be a more efficient (yet cost effective) way of maintaining water when aeration and heating promote CO_2 loss? Or is the maintenance of the pH in the normal ranges in such conditions unrealistic?

Chloramines

Hypochlorous acid is commonly proposed as the most powerfully sanitizing species of chlorine present in pools, and much effort is expended in maximizing it. However, there is data suggesting that monochloram-

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ine may equal, or even surpass, hypochlorous acid as a sanitizer when the pathogens are present as, or in, a biofilm. Practically speaking, this seems to be the basis of success for the ammonium sulfate–based "chlorine enhancers". What are the implications of this in commercial pools, where pathogens are commonly introduced, not as free–floating individual organisms, but in "globs and bumps", i.e., various mucus secretions and fecal particles?

Types of Pathogens

While on the subject of fecal particles, is there data showing CT values for pool–like systems where there is a release of fecal material in the water, as opposed to individually suspended pathogens? (Unfortunately our experience is that the issue of fecal material in the pool is more common than most swimmers would like to believe.) All CT values we have reviewed were derived from experiments measuring the sanitizer/oxidizer against a dispersed, relatively evenly distributed contaminant in the sample. Fecal material, however, is typically deposited in the pool in "lumps" which affect the time required for complete sanitization. Commonly used standards for disinfection do not seem to take into account the reality of the swimming pool/spa environment. Is there a practical way of assessing sanitizers in a manner which would allow us to see how they perform under realistic conditions?

Dehumidification

It appears that indoor pool dehumidification systems operate with an embedded control priority that controls *maximum* humidity, and *minimum* water and air temperatures. A typical result is a failure to control air *wet–bulb* temperature. Some systems even indirectly sacrifice wet–bulb air temperature in order to raise pool water temperature. It seems that the significant comfort factor for pool users is wet–bulb temperature, almost without regard to dry–bulb temperature. Is the present method the best way to go about dehumidification?

Copper/silver Ion Studies

With few exceptions (such as Dr. Gerba's of the University of Arizona), studies on the efficacy of copper/silver ionization systems that are used in the industry were done for applications other than the pool environment. This is true of many aspects of the swimming pool/spa industry. The problem with adopting studies done for other industries is that conditions and sanitizer requirements in other environments (for example, the one–pass treatment of drinking water) are not always comparable to the swimming pool/spa environment. Are there other studies specific to the pool/spa industry that could better be referenced, or is there supporting documentation showing that non–industry studies are applicable to our needs?

Oxidation Reduction Potential (ORP)

There is a movement in the swimming pool/spa industry toward proposing that ORP voltages be used in place of chlorine or other sanitizer levels as the indicator of adequate sanitation. Is the correlation of particular ORP levels to inactivation of certain pathogens *causal* or only *coincidental*?

Old Water

We have repeatedly observed, on heavily used indoor pools, reductions of measured ORP values when the pH and halogen levels (with no CYA) have remained constant. The ORP seems to drop simply because the water "ages". Is there literature examining what seems to be happening under these (aging water) conditions? Incidentally, we have found no significant correlation between TDS values between 500 and 6000 ppm (inferred from electrical measurements), and ORP measurements resulting from a particular pH/chlorine level.

Algaecides

There are six common algaecides commonly available in the pool industry today: chlorine, bromine, monochloramine, linear quats (multiple types), polymer quats, and copper/silver. We frequently see announcements of "new" algaecides which seem merely to be repackaged versions of the above, or combinations thereof. With the removal of some products from our arsenal (such as simazine) we are faced at times with inadequate "tools" for the job. Are there other, different products available?

Chlorine Levels

Swimming pools standards for chlorine levels have called for a maximum level of 3 ppm total chlorine. That standard seemed to be based on University of Wisconsin studies dating back 3 to 4 decades ago, which did not take into consideration climatic differences or differences in prevalent organisms in regions of the United States. Also, studies regarding the actual effect of these low levels of chlorine on humans seem to be lacking. Recently the industry has moved toward accepting an increase in the acceptable ceiling from 3 to 5 ppm. However, this increase seems to be an arbitrary increase based on the reality that the 3 ppm level is inadequate and arbitrary. No new or old studies have been cited to support the change, or to

support why the ceiling shouldn't be raised even higher. We commonly see pools and spas at 15 to 20 ppm chlorine, where staff are not receiving complaints of discomfort. What should the upper limit be, and on what scientific/medical data is/should this upper limit be based?

Carbon Dioxide

Carbon dioxide is being widely used to lower pH in indoor pools. However, indoor carbon dioxide levels are a major consideration in most analyses of IAQ (Indoor Air Quality). Has the potential impact of CO_2–based pH control systems on indoor air been examined?

Saturation Chemistry

It is becoming more and more evident that the various versions of saturation indexes being used in the industry are actually not reliable indicators of whether a pool will etch or scale. Published studies dating to the 1970s have pointed out the fallibility of using the Langelier Saturation Index (as "modified" for the pool industry) to predict etching and/or scaling, yet saturation chemistry is still actively promoted. One obvious factor in saturation chemistry in swimming pools that was not figured into Langelier's Index (because it was not appropriate for his application) is the presence and dynamics of dissolved gasses in an open body of water. The use of a fallible Index is becoming a concern as municipalities are beginning to assign blame in plaster/pool chemistry problems wholly or partially on the "balance" of the water as defined by the Langelier Index. What work is being done, or could be done, to account for the influence, for example, of CO_2 on calcium solubility, and the dynamic exchange of dissolved CO_2 in pools with atmospheric CO_2? Could saturation index applications be made useful by reasoned, scientific analysis of what elements are lacking in existing indexes and how they could be added?

About the Author

Ben Powell is the president of WaterCare, Inc., a firm providing water quality management services to commercial pools. Mr. Powell is, among other things, a licensed plumbing contractor, an avid simmer and scuba diver, a Red Cross lifeguard, and an NSPI CPO instructor. He was graduated from the University of Tennessee at Chattanooga with a degree in Engineering Management.