A current perspective on the chlorine debate

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Chlorine concerns extend outside pulp and paper industry.

Even as the pulp and paper industry debates the relative merits of elemental chlorine-free versus totally chlorine-free bleachind, the battle over chlorine use in other industries continues. A recent meeting of experts on the topic provided a broader perspective on how chlorine use is being viewed. it also hinted at further implications for the pulp and paper industry.

In an attempt to put rational science into the debate about chlorine and caustic chemicals, the Chemistry Section of the American Association for the Advancement of Science (AAAS) held a symposium in Atlanta, GA, during its week-long 1995 Annual Meeting and Science Innovation Exposition in February.

The full-day session, entitled "A World Without Chlorine," embraced a diverse panel of experts on the issue. The morning session, moderated by Robert Perry of the Department of Chemistry at the University of Utah, pitted Greenpeace against a trio of experts who questioned the validity of phasing out chlorine.

The Environmentalist: Joe Thornton is the research coordinator of Greenpeace's International Chlorine-Free Campaign and has testified before the U.S. House of Representatives, the U.S. Agency for International Joint Commission on the Great Lakes, the U.S. Agency for International Development, and the West African Environment Regional Pesticide Disposal Conference on the chlorine issue.

Thornton presented the case for a phaseout of chlorine in his paper, "Risk assessment for global chemical pollution? The case for a precautionary policy on chlorine chemistry." He came representing an international movement calling for a phaseout of chlorine. Armed with a massive amount of scientific data—he even provided supporting evidence from opponents of the ban— Thornton questioned the "good science," which demands that organochlorines be regulated on an individual basis using risk assessment, acceptable discharge limits, and pollution control technology.

"The default state of the risk paradigm is to allow chemical discharges; limits may be applied to individual substances based upon predictions of safe pollution levels," he stated. "Even dilute acceptable discharges slowly build up in the environment until they reach unacceptable levels," Thornton said. The model does not take into account social implications, he added, and it abandons ethics and values.

The prevention paradigm, in contrast, calls for continued reductions in the discharge of all anthropogenic substances into the environment in favor of cleaner production technologies, according to Thornton. It is based on the following principles:

- The capacity of the ecosystem to assimilate pollutants that are persistent in the environment, are toxic, or both, at very low doses is essentially zero.
- Chemicals do not act in isolation—it is the total pollution burden that may cause harm in any living system.
- Our ability to predict the effects of chemical mixtures upon complex, cybernetically organized living systems is very limited.
- Pollution control devices, which are active after pollutants have been generated, merely transfer wastes from one medium to another; only "front-end solutions" that address the production and use of harmful substances can prevent their eventual release into the environment.

Based on data that 177 different organochlorines have been found in the fat, blood, mother's milk, semen, and breath of the general population of the United States and Canada, Thornton warns that "we are confronting a persistent, global pollution burden that results in a universal exposure on a multigenerational time scale." Thornton proceeded to inform the group about the human and wildlife physiological impact resulting from exposure to organochlorines.

The chemical industry produces 40 million tons of chlorine annually, Thornton reported. Chlorine use is broken down by industry: plastics industry, 48%; pulp and paper industry, 15%; production of other chemicals, 15%; solvents, 10%; wastewater treatment, 4%; and *drinking water treatment and pharmaceutical uses, less than 1%*.

In regard to the pulp and paper industry, an audience participant asked Thornton for his solution for reducing caustic soda demand while cutting down on chlorine production. Thornton replied:

1. Reduce the use of caustic soda in process recycling and process improvements
2. Use alternative chemicals, alternative sources of the sodium ion, or alternative alkalies such as soda ash, lime, etc.
3. Produce caustic soda without producing chlorine.

He cited a number of plants in Wyoming that produce caustic soda from trona (sodium carbonate).

Thornton left the audience with reassurances that the precautionary approach would not be applied in isolation. He advocates an orderly phaseout, in which each particular use of chlorine is evaluated in terms of what benefits are provided, what alternatives are available, and how each fits into the continued and progressive reductions in the use of toxic chemicals.

The Chlorine Industry Representative: William Carroll—an executive on loan from Occidental to the Chlorine Chemical Council (CCC)—defended the continued use of the chemical in a speech entitled "Chlorine in the service of man." As an industry expert in areas of recycling, combustion chemistry, incineration, and chlorine chemistry, Carroll rejected the idea of a ban. He talked about the benefits of chlorine and the costs associated with eliminating the use of the 11th most abundant element in nature.

Carroll recounted society's and industry's dependence on chlorine chemistry. In one form or another, chlorine chemistry is used in 98% of water disinfection, 96% of crop protection chemicals, and 85% of pharmaceuticals. "Chlorine impacts 60% of all commercial chemistry and is used in manufacturing virtually every pound of plastic in one form or another . . .," he said.

Based on a report compiled by Charles River Associates for the CCC in 1990, Carroll unleashed the financial implications of eliminating chlorine in industrial processes. "Chlorine use saves over US$ 90 billion annually in the United States versus the replacements. It would require US$ 60 billion in capital to replace the uses of chlorine. The industries employ over a million workers... [they account for] US$ 57 billion of domestic investment in the industry and on a 1990 basis an annual trade balance of US$ 3 billion," he said.

"What would be a better use of US$ 90 billion than to reengineer products that we already have, most of which are very, very good, contrary to what Joe has told you, simply to get back to the place where you are today."

The majority of mills today use chlorine dioxide as a bleaching agent, Carroll said. Elemental chlorine interacting with lignin generates dioxin, so the paper industry substituted chlorine dioxide. This is a case where chlorine was a problem and a higher form of chlorine chemistry was the answer.

In various instances, research has also cleared chlorine as the agent responsible for health problems in specific animals, Carroll pointed out. At the National Water Research Institute in Canada, for example, researchers investigating the illness in fish downstream of paper mills found that it wasn't chlorine at all, but the concentration of rosin acids that was making fish sick. In closing, Carroll admitted "a responsibility to steward chlorine chemistry appropriately. We have been reducing our emissions of materials over the course of the last 20 years, but particularly over the last five, by 40% and it's an ongoing process ... It's a commitment that I'm making to you, as well, from the industry to the EPA."

The Academic: Donald Mackay is a Ph.D. in the Department of Chemical Engineering at the University of Toronto and a TAPPI member. In "A perspective on the environmental chemistry and management of chlorine," Mackay talked about environmental chemistry of chlorine and organochlorine compounds. He traced the evolution of the controversy, starting with the uncontrolled use of chlorine before 1960 because of the limited understanding of bioaccumulation and toxicity of the chemical. He proceeded to discuss the effect of hydrophobicity and its role in bioaccumulation.

He credits Rachel Carson's *Silent Spring* as the clarion call for environmental awareness in 1962. Today, because of the increased emphasis on health and well-being, people are experiencing frustration due to an awareness of "inadvertent exposure" and a leveling off of environmental quality. Mackay said, "The only justification for a ban is that it would break this regulatory gridlock, and that is really a sad reflection on the ability of organizations like Environment Canada and EPA to regulate. If this is the only way they can do it, they should really be ashamed of themselves."

Mackay then presented his personal perspective and suggested an alternative strategy for managing organochlorines. He is opposed to regulating the chlorine element. He supports the use of chlorine for potable water treatment and calls its use "probably the greatest single beneficial application of chemistry for human well-being in history." He questions the use of chlorine in wastewater treatment systems, since "any time you bring chlorine into contact with aromatic molecules of dubious unknown structure, you are inviting trouble."

The main focus of his research at the University of Toronto relating to chlorine is on measuring the properties of organochlorines. These properties dictate how they behave in the environment, how long they persist, whether or not they bioaccumulate, whether or not they evaporate. "We are just in the business of trying to understand the behavior of these chemicals and, in some respects, predict how they might behave in various lakes or rivers." He places his faith in control technology. "The strategy, I think, just has to be to search out the priority compounds or groups of compounds; understand their properties, their chemistry, and their toxicity; define regions of concern, for example, Lake Ontario or the State of Georgia or the United States; measure the ambient concentrations; and work out the amounts of chemicals in these places."

Mackay refers to this as the "mass balance approach," which is essentially an accounting of where the chemical comes from, where it goes, and what happens to it. Out of this comes information such as what concentration you would expect to see in water, in sediment, and in fish, and you can compare these concentrations with concentrations that you know are likely to cause effects.

"This process change (the switch from chlorine to chlorine dioxide) is an excellent example of enlightened industrial response to an environmental concern," Mackay believes.

The Field Biologist: William Cooper, a professor of zoology at Michigan State University, serves on the EPA's Science Advisory Board. From 1981–1987, he chaired the Department of Zoology at MSU and served two terms on the National Research Council Board on Environmental Studies and Toxicology. He has directed the relative risk assessment program for the State of Michigan. Cooper is recognized as an expert in chlorine issues. His talk was entitled "The Michigan Governor's report on chlorine."

Cooper views the chlorine issue through the eyes of a field biologist. He walks away from the assumptions and models and looks at real data. He defines "sound science" in a very empirical sense. He challenges other scientists, "Do you really know what your science means?" People need to understand the relationships between *exposure* and *concentration* and *risk*. In terms of chlorine chemistry, "Is the risk real or is the risk perceived? And the big difference is exposure," he says.

If you're going to apply an ecological risk assessment to nonhumans, you should use a population study, Cooper argues. Based on his field work in monitoring eagle populations in Michigan, Cooper took issue with the statement that the Great Lakes is one of the major places that "demonstrate wildlife impacts" of chlorinated compounds over the last 20 years. He pointed to his population study of baby eaglets and how, during a period where accumulative organochlorine or persistent chlorinated compounds were building up, the eaglet population under study did not indicate reproductive failure, which would be the estrogenic effects resulting from exposure to the compounds.

The majority of persistent toxins—mercury, PCBs, dioxin, benzofurans—which are entering the Great Lakes now are airborne, according to Cooper. "The biggest impacts right now are habitat destruction, introduction of exotic species and nonpoint-source runoff—most of it is sediments, it isn't toxic chemicals."

No one took a vote or would venture a prediction as to the outcome of the chlorine debates. Three out of four see the elemental-free chlorine mill as a practical, and economical, and environmentally freindly compromise. TJ

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Chlorine dioxide suggested as preferred chlorine

As the debate rages on, the North American pulp and paper industry is gradually accepting the challenge of green technology. And, chlorine dioxide is becoming the substitute of choice. Projections provided by Josephine Cooper vice president of Environment and Regulatory Affairs of the American Forest & Paper Association (AF&PA) for year-end 1996 boost the use of chlorine dioxide and hydrogen peroxide by more than 60% and the use of oxygen by 90%.

According to Doug Pryke, executive director of the Alliance for Environmental Technology (AET), April 1995 figures showed ECF (elemental chlorine-free) pulp, bleached with chlorine dioxide, dominating the world markets. Since 1990, ECF bleached pulp production has grown by 700%. By the end of 1995, ECF pulp manufacture will exceed 28.5 million metric tons per year, for a market share surpassing 40%. "In all major pulp producing regions of the world, ECF demand is rising rapidly," Pryke said.

In Canada, ECF pulp production totals 6.6 million metric tons, while in the United States, ECF pulp will reach 8.6 million metric tons/year in 1995.

"ECF is not only pollution prevention," said Pryke. "As the market figures demonstrate, ECF is also a cost-effective way to manufacture the highest quality paper products," he said.

Jim Fisher, president of International Business Management Associates in Princeton Junction, NJ, following a discussion about alternative bleaching technologies and costs versus benefits, put it this way:

"I don't think it's practical in an economic sense to operate in a totally chlorine-free environment. An elemental chlorine-free environment is doable, from technical, economic, and practical considerations. Ozone and hydrogen peroxides have their place, and I think it becomes a purely economic choice at this point.

"Some of the sort of emotional issues surrounding the replacement of chlorine are starting to settle down, and more scientific or rational thought processes are being brought to bear. It would appear that the reasonable people might even have a chance to express their opinions."

I. North American bleached pulp production—growth in elemental chlorine-free (ECF) bleaching equals 1200% for the period 1990–1995 (© 1995 AET).