

WM2010 Conference, March 7-11, 2010, Phoenix, AZ

**How Nuclear Waste Management Professionals Can Better Communicate
the “Essentials of Hazardous Materials Management”
to the General Public - 10066**

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ABSTRACT

As Nuclear Waste Management Professionals, our track record of communicating fundamental technical, scientific and engineering concepts of our profession related to the “essentials of hazardous materials management” can be improved. Potentially harmful materials can be found almost everywhere in our “Brave New World”. The General Public too often takes for granted, and has become complacent with regard to the chemical and physical properties of the materials, which we come in contact with every day. Properly managed, these beneficial materials help provide the quality of life that our society has come to expect. However improperly managed, these materials can become extremely hazardous. The inability to properly limit public exposure to harmful hazardous materials has resulted in highly publicized environmental disasters such as Love Canal, Times Beach, Three Mile Island, and the Exxon Valdez Oil Spill.

NEED FOR BETTER COMMUNICATION WITH THE GENERAL PUBLIC

The General Public really doesn’t understand the fundamental differences between exposure and contamination. How the inverse square law relates to radiation exposure and how the logarithmic concept of pH applies to mixed radioactive waste remains a mystery to the General Public. Drawing upon multiple experiences from over a quarter of a century of teaching numerous professional short courses, executive seminars, undergraduate and graduate school courses, technical conference presentations, and public meetings the poster presenter will provide additional unique insights and teaching techniques on how to better communicate the “essentials of hazardous materials management” to the general public.

For example, we are exposed to sunlight almost every day from a radioactive source (the sun). Contamination can be visualized using the analogy of adding a chocolate swirl or topping to plain vanilla ice cream. For my wife, adding a chocolate swirl or topping is the only way to enjoy plain old vanilla ice cream. I personally view chocolate swirl and other toppings as undesirable contaminants that detract from the delicate and subtle essence of unadulterated natural vanilla flavor in my ice cream.

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When I teach the inverse square law to non-nuclear waste management professionals, I pretend that I am “Grover” from the readily recognized television show, Sesame Street. I place a chair in front of the classroom, which I identify as the radiation source. Using a “Grover-style voice”, I move both near and far from the chair or “radiation source”. I also draw a circle on the blackboard and quickly identify the area surrounding the source at the center of the circle as being directly proportional to the square of the radius. Then, I write the inverse square equation on the blackboard while hammering home the concept that radiation intensity increases and decreases inversely with how near or far “Grover” is from the radiation source.

Unless you are a chemist, the general public doesn't have a clue regarding the real meaning of pH (negative power of 10 concentration of the hydronium ion in solution). Many years ago, I attended a public hearing regarding what pH should be allowed in a discharge permit by an industrial facility into the waters of the United States. The lawyers from both sides kept going back and forth regarding how much pH should they give the industrial facility. Finally after too much nauseating back and forth arguments the Judge slammed down his gavel and declared that he wasn't going to give the industrial facility any pH allowance. According to the Judge, the required pH would have to be zero!

My typical teaching approach is to relate pH to several common items encountered in normal household use. The pH of commercial distilled white vinegar purchased at the grocery store, containing 5% acetic acid, is 2.4. The pH of Coca Cola ® products ranges from 2.5 to 4.2. The pH of distilled water is 7.0. The pH of saliva is 7.4. The pH of household ammonia is 11.6. To make sure that the class understands the fundamental logarithmic concept of pH, I ask them to help me solve a generic pH problem. Given that we have just spilled one gallon of pH 2 liquid, approximately how many gallons of water would have to be added to dilute the spilled acidic liquid in order to raise the total pH to 3? I then quickly tell the class that it would take about 9 gallons. Then I ask the question, how many more gallons would be needed to dilute the spilled acidic liquid in order to raise the total pH to 4? Sometimes, very astute students realizing that there is a logarithmic relationship answer that it would take about 90 gallons to raise the total pH to 4. In rapid succession, I then ask about how many additional gallons would be needed to raise the total pH to 5, then 6 and then 7?

Potentially harmful materials can be found virtually everywhere within our “Brave New World”. We are often very dependent on the unique beneficial chemical and physical properties of these materials, which we come in contact with every day. Properly managed, these beneficial materials can help provide the quality of life our society has come to expect. Improperly managed, the waste from these materials can become very hazardous.

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Some of the products used in our home, garage, workshop, yard and garden can be considered hazardous. These products may be corrosive, explosive, flammable, a skin or eye irritant, toxic or radioactive. Examples of these products include: paint and decorating supplies, solvents and cleaning products, herbicides and pesticides, lawn care products such as fertilizer, and automotive products. When these household products are discarded, they may become hazardous waste; or what we should identify as "household hazardous waste." The average American household generates about 20 pounds of household hazardous waste each year.

DEFINITION OF HAZARDOUS MATERIALS

A **hazardous material** is any item or agent (biological, chemical, physical) that has the potential to cause harm to humans, animals, or the environment, either acting alone or through interaction with other factors. Hazardous materials are defined and regulated in the United States primarily by laws and regulations administered by the U.S. Environmental Protection Agency (EPA), the U.S. Occupational Safety and Health Administration (OSHA), the U.S. Department of Transportation (DOT), and the U.S. Nuclear Regulatory Commission (NRC). Each governmental agency has its own independent definition of what is a "hazardous material." OSHA's definition includes any substance or chemical which is a "health hazard" or "physical hazard," including: chemicals which are carcinogens, toxic agents, irritants, corrosives, sensitizers; agents which act on the hematopoietic system; agents which damage the lungs, skin, eyes, or mucous membranes; chemicals which are combustible, explosive, flammable, oxidizers, pyrophorics, unstable-reactive or water-reactive; and chemicals which in the course of normal handling, use, or storage may produce or release dusts, gases, fumes, vapors, mists or smoke which may have any of the previously mentioned characteristics. (Full definitions can be found at 29 Code of Federal Regulations (CFR) 1910.1200.)

EPA incorporates the OSHA definition, and adds any item or chemical which can cause harm to people, plants, or animals when released by spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping or disposing into the environment. Note: 40 CFR 355 contains a list of over 350 hazardous and extremely hazardous substances. DOT defines a hazardous material as any item or chemical which, when being transported or moved, is a risk to public safety or the environment, and is regulated as such under the: Hazardous Materials Regulations (49 CFR 100-180); International Maritime Dangerous Goods Code; Dangerous Goods Regulations of the International Air Transport Association; Technical Instructions of the International Civil Aviation Organization; U.S. Air Force Joint Manual, Preparing Hazardous Materials for Military Air Shipments. The NRC regulates items or chemicals which are "special nuclear source" or by-product materials or radioactive substances. (See 10 CFR 20).

BRIEF HISTORY OF HAZARDOUS MATERIALS MANAGEMENT

Ever since antiquity, the impacts of hazardous materials have been both fortuitous and catastrophic. The ability to create and manage fire was probably the one of the first fortuitous applications by our ancestors of hazardous materials management. When properly managed, fire provides beneficial warmth and improved quality of food. Totally out of control, fire can result in catastrophic devastation to personal property, human health, and the environment.

Pharmacology is the study of how chemicals interact with living organisms to produce a change in function. If these chemicals have beneficial medicinal properties, they are considered pharmaceuticals. Toxicology is the study of the adverse effects of chemicals on living organisms. It is the study of symptoms, mechanisms, treatments and detection of poisons. The chief criterion regarding the toxicity of a chemical is the amount of exposure to the substance. According to Paracelsus, a famous Swiss physician, chemist, and alchemist, who lived in the 16th century, all substances are potentially toxic. An obvious rhetorical question to ask is, “What experimental evidence did Paracelsus have to come to his conclusion that all substances are potentially toxic”? The highly probable answer is that his scientific conclusion was derived from multiple “dose versus response” experiments on himself. Paracelsus, the original hazardous materials manager, is today regarded as one of the fathers of modern medicine & toxicology.

GOOD CHEMICALS & BAD CHEMICALS (WEEDS & FLOWERS)

Multiple times during the past quarter century, I have been invited to make environmental presentations regarding both good chemicals and bad chemicals to local garden clubs and nature societies. The primary theme of my lectures have been that when chemicals are properly used they behave well (become good chemicals). When people don't read the manufacturer's instructions or material safety data sheets for these same chemicals, they misbehave (become bad chemicals).

While waiting for some of the other garden club speakers to finish their presentation, I had a “Day of Epiphany” experience. The theme of one of the other speakers on this particular day was there was no such thing as weeds. At first I just didn't understand what they were talking about. Then I suddenly realized they were trying to communicate that weeds were just flowers in the wrong garden. Later when it was my turn to speak, I jumped up and proclaimed my newly discovered knowledge that there was no such thing as bad chemicals (weeds). They were really good chemicals (flowers) in the wrong garden. This concept was somewhat hard to accept by some of the hardcore garden club members who were totally opposed to the use of any chemicals in their gardens, including chemical fertilizer and pesticides. Undaunted, I then started lecturing on the dangers of dihydrogen monoxide. I proclaimed that dihydrogen monoxide was one of the primary ingredients in polluted water. It is found in mother's milk and is a ubiquitous chemical found within our polar ice caps. This part of my lecture brought a smile to some of the more enlightened faces in the audience. I then made a paradigm shift in my lecture when I explained that dihydrogen monoxide was just another name for H₂O or water.

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I then tried to un-ruffle a few feathers amongst the garden and nature lovers in the audience by stating that dihydrogen monoxide was one of the primary ingredients in fruits and vegetables, in our human bodies and of course is an ingredient in liquid bread (beer).

Regarding weeds and flowers, my wife believes that dandelions are definitely weeds. Thus, on weekends one of my tasks is to remove unwanted weeds (including dandelions) from our yard. On the other hand, my neighbor thinks that dandelions are definitely flowers. He collects dandelions to make wine, jelly and dandelion flavored beer. He also adds dandelion greens to his salads and as an ingredient on top of pizza. Given the current status of dandelion weeds and dandelion flowers in my neighborhood, I have recently started to dig up dandelion weeds in my yard and then just discretely throw them over the fence into my neighbor's yard.

IS THERE BETTER LIVING THROUGH CHEMISTRY?

Polychlorinated biphenyls commonly known as PCBs are man-made chemicals that had never previously existed in nature. When first manufactured in 1929, the entire family of PCB chemicals, they were quickly acclaimed as an industrial breakthrough (good chemicals). Without examining the environmental impact of PCBs, this was viewed as an example of better living achieved through modern chemistry. These chlorinated oils have a low degree of reactivity. They are not flammable, have very high electrical resistance, good insulating properties, and are very stable even when exposed to heat and pressure.

All in all, they seemed at the time to be the perfect oil for use in dielectric fluids, and as insulators for transformers and capacitors. Not only were PCBs hailed for their role in preventing fires and explosions, they were actually required by fire codes. Uses for PCBs quickly expanded to include hydraulic fluids, casting wax, carbonless carbon paper, compressors, heat transfer systems, plasticizers, pigments, adhesives, liquid cooled electric motors and fluorescent light ballasts.

PCBs were used for the following industrial purposes: hydraulic fluids; casting wax; carbonless carbon paper; compressors; heat transfer systems; plasticizers; pigments; adhesives; liquid cooled electric motors; fluorescent light ballasts. There is little wonder that this group of chemicals was so readily accepted. One of the qualities that make PCBs so desirable is one of the characteristics that make PCBs so hazardous to the environment. The high thermal and chemical resistance of PCBs means that they do not readily break down when exposed to heat or chemical treatment. This is a very desirable trait for lubricants.

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However, since PCBs do not break down they remain in the environment and continue to build up as more are introduced into the environment. Worms consume organic matter contaminated with PCBs, and small fishes eat the worms. Small fish are then eaten by larger fish, and perhaps the large fish are eaten by an eagle. Worms may only live for a short time, but eagles live for a long time. They continue to eat lots of large fish that ate lots of small fish that ate lots of contaminated worms. Over a lifetime, the PCB concentration in the fatty tissue of the eagle would continue to increase as it ate more and more contaminated fish. This accumulation of a chemical in animals at the top of the food chain is known as bioaccumulation. If the chemical happens to be toxic, the consequences become obvious.

NEED FOR QUALIFIED HAZARDOUS MATERIALS MANAGERS

At any point in the life-cycle of hazardous materials, qualified professionals are needed to be proactively involved, from initial process planning and development of new products; through manufacture, distribution and use; to disposal, cleanup and remediation. The life-cycle concept is sometimes expressed as from cradle to grave or womb to tomb. The inability to properly limit public exposure to hazardous materials has resulted in highly publicized environmental disasters such as Love Canal, Times Beach, Three Mile Island, and the Exxon Valdez Oil Spill. Excessive publicity of these disasters has resulted in a legacy of command-and-control environmental, health, and safety regulations. Members of technical & scientific professional organizations are hereby challenged to improve our communication with the general public. We must learn from our history of hazardous materials communication disasters. Otherwise, we and our public-at-large stewardship are all condemned to repeat our collective history. Our society looks towards professionally trained individuals who understand the “essentials of hazardous materials management” to help avoid nuclear waste, mixed waste, and environmental management disasters.