DRINKING WATER TREATMENT: WHAT'S WORKING, WHAT'S ON THE HORIZON.

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INTRODUCTION

Growing concern about the environment hit North Americans where they lived back in the 1980's when drinking water quality became a major concern. Rumblings about contamination in something as basic as the water we drink turned into a roar in the U.S. when the federal government recognized the problem and issued amendments to the Safe Drinking Water Act (SDWA) in 1986. That was followed by the 'Surface Water Treatment Rule' (SWTR) in 1989.

Since then, regulations have driven the drinking water industry. They've propelled the development of new technologies, forced municipalities to upgrade their water quality standards, and maneuvered many communities into tough financial ,binds as they struggle to build expensive new treatment facilities to comply with government mandates.

But the good news in this mixed picture of mandates and money is that regulations have also spurred new research efforts in treating water to protect us from ,waterborne diseases carried by algae, viruses, and microorganisms such as Giardia lamblia.

The research is timely. Recent outbreaks of Cryptosporidium in Canada and ithe U.S..have forced an evaluation of current operating practices and highlighted the importance of top quality treatment operations to public health. The spotlight has been shining on changes to coagulation/flocculation, assessing plant performance for turbidity and particle removal, and on closer monitoring of filter backwash operations.

All of this has had a profound affect on the water industry on both sides of the border. While new technologies are constantly being developed to meet the new regulations, for most municipalities funding an expensive new infrastructure is a difficult challenge. That's why making the most of existing facilities is the most popular way of keeping compliance costs in line. And it's why the up and coming !technologies won't be replacing conventional methods anytime soon.

GOVERNMENT REGULATIONS

The Safe Drinking Water Act boosted the number of regulated and unregulated volatile organic, synthetic organic, and inorganic compounds to be considered for treatment to approximately 100, a number that will increase significantly in the next several years. Better analytical methods and more sensitive laboratory equipment have combined to identify even more previously undetectable volatile organic and other chemical compounds in water.

The Surface Water Treatment Rule was designed to go beyond simply measuring the presence or absence of coliform bacteria in drinking water. The rule applies not only to surface water supplies but also to ground water sources that contain insects and microorganisms or to those that show quick shifts in physical/chemical characteristics that correlate to climate or surface water conditions. This is defined as ground water under the influence (GWUDI) of surface water.

As analytical detection limits get lower, the next step is to develop the technology to remove the contaminants from surface and ground water. The challenge now is to examine conventional treatment and filtration technologies to see if they can meet the performance standards for the 21st century.

CONVENTIONAL WATER TREATMENT

Water purveyors have spent billions of dollars on flocculation, dual media filtration, and sedimentation, the conventional treatment processes which have served the water industry well for many years. But more stringent standards, financial constraints, and recent outbreaks of waterborne diseases in Canada and the U.S. have forced utilities to reevaluate the ' old way of doing things . New research has focused on reducing the concentration of by-products and filter turbidity formed during the disinfection process.

The water quality division disinfection committee of the American Water Works Association surveyed U.S. treatment plants in 1992 and found that most utilities continue to rely on chlorine gas or hypochlorite solutions as primary disinfectants, with some increase in the use of chlorine dioxide. A quarter of the utilities have moved the point of chlorination downstream.

New modifications include decreasing the prechlorination dosage, improving coagulation by decreasing pH, and adding ammonia, changes most often made in response to the Safe Drinking Water Act amendments. The survey found that changes to reduce the formation of trihalomethanes, have not been widely accepted. The main reason is that such treatment would require major infrastructure investments, such as granular activated carbon contactors or ozonation, whose cost is not justified by the benefits.

UP AND COMING WATER TECHNOLOGIES

New technologies tend to address concerns with synthetic and volatile organic material and disinfection by-products. The most promising include:

- membrane processes
- ozonation
- granular activated carbon
- advanced oxidation processes
- biological treatment.

A great deal of research is going into processes that use semipermeable membranes to separate impurities from water. Pressure pushes the water through the membrane, leaving the impurities, classified according to the sizes and types of particles, as a concentrate ultrafiltration, operated at low pressure, can only remove suspended and colloidal solids. nanofiltration can remove trihalomethane precursors at operating pressures of approximately 100 pounds per square inch. Reverse osmosis, which has been used for nearly 25 years to desalinate sea and brackish water, requires the highest operating pressures to remove contaminants in the tiny ionic size range as well as nearly all species of microbes.

It's not new, but ozonation is starting to be used more widely because of regulatory restrictions on byproducts and concentrations associated with chlorine treatments. Another factor is that chloramine is not recommended as a primary disinfectant against Giardia cysts or viruses. Ozone is also the most effective primary disinfectant against Cryptosporidium.

Granular activated carbon (GAC)is an effective way to remove organic contaminants such as taste and odor compounds that aren't affected by the coagulation and sedimentation processes. The EPA considers it to be the best available technology for these contaminants and the current wisdom says GAC will continue to be an effective way of treating water for domestic and industrial use for many years.

GAC works on the principle of adsorption of contaminants to carbon grains, whose large surface areas make them highly suitable for this job. The open spaces within the grains and the pore space between them filter particulate matter such as sediment, chemical precipitates, and some larger microorganisms.

Advanced Oxidation Processes are based on free radicals as the oxidizing species. Free radicals like hydroxyl (OH-) are produced when ozone or ultraviolet irradiation decomposes hydrogen. Adding hydroxide ions (high pH), hydrogen peroxide, or ultraviolet irradiation accelerates the ozone decomposition. This ozone and hydrogen peroxide process is easily adapted to existing water treatment plant designs and should be cost effective.

Treating drinking water biologically means using microorganisms to remove waterborne organics through aerobic processes. The process occurs on a granular medium, usually carbon particles, where large surfaces are available for a biofilm to develop. A biofilm is an organic layer of microorganisms which forms on the carbon. It removes organic compounds and other potential contaminants in finished water. An. extra benefit is a reduction in disinfectant requirements.

In western Europe most advanced water treatment plants use biologically activated carbon, which is a combination of ozonation followed by granular activated carbon. Ozonation breaks down large organics into smaller pieces to be oxidized by microorganisms in the granular medium's biofilm layer. This sophisticated process is beginning to get attention in North America.

CONVENTIONAL GROUND WATER TREATMENT

Granular activated carbon is a relative ly new way to remove organic contaminants from surface water, but it's also been recognized as useful in treating ground water for some time, and will continue to be.

Aeration, also called air stripping, has been designated as the best available technology for removing volatile organic compounds. it is, in fact, the most common way of stripping them from ground water. It works on the principle of mass transfer of volatile organic compounds from the aqueous to the vapor phase. As a general rule, highly volatile compounds with low water solubility respond best to this treatment, but aeration also removes iron, manganese, and unwanted gases from ground water.

The packed tower is the most common type of aerator used today. The tower is filled with hollow sphere packing, which looks like whiffle balls and has a high contact surface area. Water cascades from the top of the tower down through the packing, changing its shape and pattern as it goes and transferring volatile organic compounds from water to the air in the process. Air flow is forced up through the tower to help with the mass transfer process. Economics make it attractive to use aeration and GAC treatments together.

UP AND COMING GROUNDWATER TECHNOLOGIES

Many of the new water treatments being used by large-scale municipal water systems for surface water apply to groundwater too, including membrane air strip~ ping and polymeric resins.

Membrane air stripping, an emerging technology with the probability of wide application, is most effective at removing volatile organic compounds from water. it involves pumping water through microporous hollow polypropylene fibers while a counter flow of air passes along the fibers' exteriors.

Just as with aeration, this method works on the principle of mass transfer of contaminants from the aqueous to the vapor phase. Mass transfer rates are of a higher order of magnitude than aeration. One problem, though, is that pretreatment chemicals and pH can attack the microporous membrane. Once this is solved and capital funds are available, membrane air stripping will be a viable treatment alternative.

Although carbon is widely used to remove organic compounds from air and water systems, low-cost polymeric resins are lurking on the horizon to replace it. Why? Because of the high regeneration costs for carbon. Polymeric resins are cross-linked polymers whose adsorbent properties vary widely. The selection of the polymeric resin to be used varies according to the specific volatile organic compound to be treated.

One great attribute of polymeric resins is their desorption capacity. The desorption cycle combines a process that elevates temperature, reduces pressure, and purges gas flow to allow the desorbed volatile organic compounds to be recovered, recycled, or legally disposed of. Polymeric resins are an exciting technology which is now almost -exclusively used on small scale remediation projects with systems such as soil vapor extraction and treatment of off-gases from aerators. Details about the technology and its long term application are not yet available, but it holds promise for treating off-gases from large water systems in the future.

GETTING THE MOST FROM WHAT WE HAVE

The trend in the drinking water industry is to borrow management and treatment methods from its wastewater counterparts. The most popular is the CCP "Composite Correction Program" which offers a systematic, action-oriented approach that regulators, consultants, or utility workers can use to upgrade the performance of water treatment plants and achieve compliance using existing facilities. CCP focuses on incremental changes such as replacing manual with computer controls or re-calibrating chlorine concentration rather than investing in expensive new treatment plants.

These days the water industry, like water itself, is fluid. Regulations have sparked interest in new technologies for treating drinking water to make it safe for the public, but paying for them is the big challenge. Once the two are married and settle down, maybe then we can clean house of the filters and water bottles that clutter the kitchens of people skeptical about the quality of the water that swishes through their pipes.

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