WISCONSIN MEDICAL JOURNAL

Occupational and Industrial Health at the Wisconsin State Laboratory of Hygiene

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ABSTRACT

Occupational hazards have been known for centuries, but the creation of facilities capable of carrying out the testing necessary to assess these risks is a comparatively recent development. The Wisconsin State Laboratory of Hygiene (WSLH) created the Wisconsin Occupational Health Laboratory (WOHL) in 1937 to address this need. Since then, WOHL's range of analytical capacity has grown to include an impressive array of assays, including volatile organic compounds, asbestos, silica, environmental lead, bioaerosols, and elemental carbon. WOHL has been a leader in emerging occupational health threats, and has been the primary testing facility for the United State's Occupational Safety and Health Administration's (OSHA) consultation program since 1977. Through it all, WOHL has remained a fee-for-service branch of the WSLH and has not used Wisconsin taxpayer funds to support its day-to-day operations.

HISTORY OF THE WISCONSIN OCCUPATIONAL HEALTH LABORATORY

The field of occupational health and medicine is generally accepted to have begun with the publication of Bernardino Ramazzini's *De Morbis Artificum Diatraba* (Diseases of Workers) in 1713.[1] In his treatise, Ramazzini outlined dozens of occupations and their hazards and suggested some preventive measures that might be taken, such as covering faces to avoid breathing dusts generated by work practices. Benjamin McCready published the first work on occupational diseases in the United States in 1837.[2] The American Industrial Hygiene Association (AIHA) was organized in 1939. The Occupational Safety and Health Act of 1970 established two large federal organizations: the United States Department of Labor's Occupational Safety and Health Administration (OSHA) and the Centers for Disease Control and Prevention's National Institute for Occupational Safety and Health (NIOSH). Both were created to improve workplace conditions in a vast array of professions. It is estimated that occupational injuries and illnesses cost US businesses between $170 billion and $255 billion annually.[3]

The Wisconsin State Laboratory of Hygiene (WSLH) recognized the need for adequate facilities to analyze samples related to the health and safety of workers over 6 decades ago with the founding of the its Occupational Health Laboratory in 1937. That laboratory was renamed the Wisconsin Occupational Health Laboratory (WOHL) and quickly became one of the leading laboratories in the country for the analysis of workplace hazards. Since 1977, WOHL has been the primary testing facility for OSHA consultation programs. WOHL is accredited by the American Industrial Hygiene Association for all aspects of industrial hygiene chemical analysis and was one of the first laboratories in the country to be accredited for Environmental Lead and for Environmental Microbiology. There are 3 certified industrial hygienists on a staff of 40 with nearly 500 cumulative years of industrial hygiene chemistry experience. The staff works in close partnership with field industrial hygienists, both in government and in the private sector, to reduce exposures to hazardous materials encountered in the workplace.

WOHL AND OSHA

The WOHL serves as the national laboratory for 43 of the states and territories participating in the US Department of Labor OSHA's small business consultation program. The program, funded by OSHA and administrated by the individual states, provides free safety and health on-site consultation visits at the invitation of the employer. Employers are obligated to correct serious hazards identified, but no fines or citations are as-

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sociated with the program. In Wisconsin, the industrial hygiene program is located in the Bureau of Occupational Health at the Wisconsin Division of Public Health (WDPH), and the safety program is conducted through the Department of Commerce. WOHL performed 134,339 tests on 18,703 samples for this program in the fiscal year ending June 30, 2003. The great majority of these are air samples collected in the breathing zones of workers. The laboratory calculates the air concentrations of OSHA-regulated chemicals to which the worker is exposed, for purposes of comparing these exposures to the Permissible Exposure Limits (PEL) established by OSHA.

Because this program services such diverse workplaces as radiator repair shops, lawn care specialists, dry cleaners, foundries, semi-conductor manufacturers, beauty salons, and pharmaceutical firms, among others, WOHL is capable of performing a spectrum of analyses matched by few other industrial hygiene laboratories nationwide. WOHL has the necessary equipment and expertise to analyze for metals, solvents, pesticides, PCBs, crystalline silica, isocyanates, asbestos, pharmaceuticals, toxic gases, molds, polynuclear aromatic hydrocarbons, various carcinogens, and many other materials used or generated by industry.

WOHL has been a member of the OSHA family for more than 25 years and is proud to have been a part of OSHA's success. Occupational illnesses are preventable, and laboratory analysis is essential to determining whether working conditions are likely to result in deleterious health effects. OSHA estimates that it has saved over 75,000 lives and prevented millions of injuries and illnesses. Since 1970, occupational fatalities have been cut in half, and on-the-job injuries and illnesses have been reduced by 40%.[4] The state of Wisconsin benefits from having this state-of-the art facility available to assist the Division of Public Health in meeting its objectives for "Healthiest Wisconsin 2010," which lists reducing occupational health hazards as 1 of the 11 health priorities for the state.[5]

INDUSTRIAL HYGIENE SERVICES

From its earliest days, the WOHL has provided services to the WDPH, the Department of Natural Resources, the University of Wisconsin Safety Department, and many other state agencies. When appropriations for OSHA testing were first received during the late 1970s, state funding to the WSLH for industrial hygiene was diverted to other programs. In the early 1980s, a decision was made to develop a capacity for industrial hygiene analysis independent of the OSHA contract. In fiscal year 2003, WOHL analyzed 114,285 analytes on 46,100 samples on a fee-for-service basis for clients outside the OSHA consultation program. WOHL's clients, in addition to numerous state and federal agencies, include industrial hygiene consulting firms, insurance companies, private citizens, small and large industries, and even other laboratories—about 20% of WOHL's non-OSHA workload represents subcontracts from commercial laboratories. This level of reference testing is attributable to the fact that WOHL provides a broader spectrum of analyses than is offered by most industrial hygiene laboratories.

One example of the specialized testing that WOHL performs is crystalline silica analysis using an x-ray powder diffractometer. Nationally, there are 850 AIHA-accredited industrial hygiene laboratories but less than 10% of them perform analysis of crystalline silica. This is a particularly difficult analysis because it entails looking at the crystalline structure of silicon dioxide to determine if it is present as alpha-quartz, cristobalite, or tridymite. These are the only forms of silicon dioxide that are known to cause silicosis, a debilitating lung disease. Although the dangers of crystalline silica have been well understood for many decades, significant overexposures continue to exist in industries such as foundries where sand (quartz) is used for making molds, road construction, sandblasting, and concrete work. OSHA estimates that 2 million workers are exposed to crystalline silica and 300 die annually.[6]

As a result of the OSHA consultation program and this fee-for-service work, Wisconsin has a full-service state-of-the-art industrial hygiene laboratory available to deal with industrial accidents, public health events, and terrorist attacks, without investing any state tax dollars.

ASBESTOS

For more than 30 years, the WOHL has tested air, bulk, and drinking water samples for the presence of asbestos fibers. Included as an amendment to the 1970 Clean Air Act, analysis of airborne asbestos began in the mid-1970s. Analysis of bulk building materials began shortly thereafter with the creation of the OSHA consultation program.

Initially, analysis of asbestos samples represented a small portion of WOHL's workload. This changed in the late 1980s with the passage of the Asbestos Hazard Emergency Response Act (AHERA), more commonly known as the "Asbestos-in-Schools" law. Under this federal act, public and private elementary, middle, and high schools were required to assess the level of as-

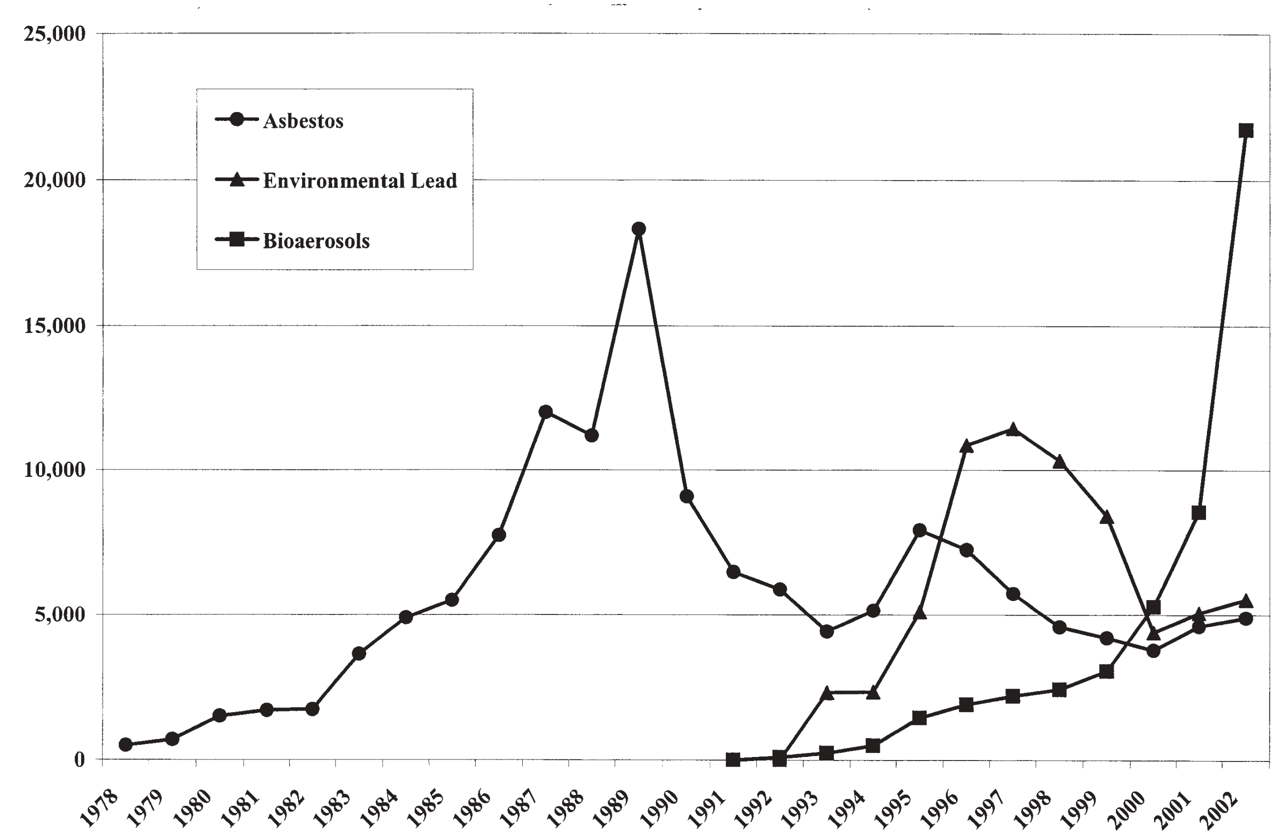

Figure 1. Asbestos, environmental lead, and bioaerosol samples analyzed by WOHL per year (1978-2002).

bestos-containing materials used in their buildings. This resulted in a landslide of samples, and the laboratory's asbestos program expanded to meet this public health challenge (Figure 1).

As the asbestos market continued to mature through the mid to late 1990s, testing drinking water samples for asbestos by transmission electron microscopy and detecting asbestos in settled dust gained emphasis. As more and more schools came in to compliance with AHERA, the need for asbestos testing gradually declined. Today, WOHL continues to serve the citizens of Wisconsin as well as nationwide participants in the OSHA consultation program.

INDOOR AIR QUALITY

As the energy crisis of the 1970s drove the construction industry to build "tighter" buildings, concerns began to develop about the levels of pollutants in these energy-efficient structures. The term "sick building syndrome" was coined to describe situations in which building occupants experience acute health and comfort effects that appeared to be linked to time spent in a building.[7] As a result of this phenomenon, up to 30% of WOHL's workload, beginning in the late 1980s, shifted from traditional industrial hygiene to Indoor Air Quality (IAQ) analysis. Many of the actual analytes remained the same, but the airborne levels of interest were much lower. Whereas most OSHA PELs are in the parts-per-million (PPM) or even hundreds of PPM levels, IAQ investigations require measurements down to parts-per-billion (PPB).

The WOHL provides a complete array of analyses to support IAQ investigations. The most requested analyses are formaldehyde that is emitted from particle board, carpets and other fabrics; solvents from cleaning products and office equipment emissions; various components of diesel exhaust including elemental carbon, aldehydes, oxides of nitrogen, volatile organic compounds (VOCs), and polyaromatic hydrocarbons; molds; carbon dioxide as a surrogate measure of inadequate ventilation; nicotine and ethenyl pyridine as markers of environmental tobacco smoke; and residue from improperly applied pesticide products.

Although extremely sensitive techniques, such as Thermal Desorption Gas Chromatography-Mass Spectrometry, exist for measuring IAQ contaminants at PPB levels, the interpretation of these measurements can be problematic. There are no universally accepted standards for acceptable concentrations of chemicals in indoor air settings. Most experts agree that it is improper to use the OSHA PELs for assessing exposures in a home because the exposures are longer than 8 hours and affect more vulnerable populations such as the very young and very old. However, setting an acceptable exposure level for a single chemical or assessing the possible cumulative effects of many chemicals is not likely to happen soon. More research is needed on the effects of these low-level and cumulative exposures.

ENVIRONMENTAL LEAD

Exposure to excessive levels of lead can increase blood pressure and cause digestive problems, kidney damage, and nerve disorders in adults, and brain and nervous system damage, learning and hearing problems, and stunted growth in children. The dangers of lead have been known for thousands of years. Around 370 BC, the Greek "Father of Medicine" Hippocrates identified lead poisoning in miners and metallurgists. Unfortunately, lead remains a serious problem today, with as many as 900,000 children between the ages of 1 and 5 carrying dangerously high blood-lead levels.[8] In fact, recent evidence suggests that any amount of lead in the body, no matter how slight, negatively affects intelligence in children.[9]

One of the primary sources of lead in the environment is paint. Although the US Consumer Product Safety Commission banned the sale of paint containing more than 0.06% lead for use in consumer products in 1978, lead-based paint remains a health hazard, particularly in older homes. The 1992 Residential Lead-Based Paint Hazard Reduction Act cited 0.5% as the level at which lead in paint should be considered potentially dangerous and helped draw public attention to lead paint hazards. WOHL began seeing a sharp rise in environmental lead samples about this time, with the sample-load peaking at around 1000 samples per month in 1997 (Figure 1). The increased interest in laboratories capable of environmental lead analysis prompted the American Industrial Hygiene Association (AIHA) to create an environmental lead accreditation program in 1995, and WOHL was one of the first laboratories in the nation to earn accreditation for air, dust, paint, and soil matrices.

Lead is also a major concern in industry, where lead exposures can occur for welders, firing range users, crystal artisans, battery manufacturers, and workers in many other fields. To illustrate the degree of concern industrial hygienists have for occupational lead exposures, consider that 56% of the samples reported by WOHL from May 2002 to May 2003 for airborne metal analysis included lead results. Of those, 7.3% contained lead at or above the OSHA PEL.

MOLDS/BIOAEROSOLS

Bioaerosols are viable or non-viable microorganisms, fragments of these organisms, toxins, and secondary metabolites released as airborne particles. Bioaerosols are ubiquitous in nature. Bioaerosols include fungi, bacteria (including *Legionella*, thermophylic actinomycetes, and *Mycobacterium* species), and viruses.

In 1924, a correlation was documented between the onset of asthma and the presence of fungal spores in outdoor air. The prevalence of fungi in the atmosphere and demonstrated positive skin-test reactivity to antigens were then reported.[10] Over the past decade, there has been an increased awareness among clinicians and the general public that sensitivity to mold is a significant cause of allergic diseases. These diseases include allergic asthma, allergic rhinitis, allergic fungal sinusitis, bronchopulmonary mycoses, and hypersensitivity pneumonitis.[11] In 1994, the CDC reported on an outbreak of infant idiopathic pulmonary hemorrhage in Cleveland due to the presence of *Stachybotrys chartarum* and the potential of mycotoxin exposure.[12] In 2000, the CDC published a retraction due to insufficient evidence between associating *S. chartarum* and infant idiopathic pulmonary hemorrage.[13] These articles increased concern regarding health effects due to the presence of microorganisms in the indoor environment.

In 1986, the WOHL began testing for the presence of mold in the indoor environment. In 1997, WOHL was 1 of 6 laboratories in the United States initially accredited by the AIHA in Environmental Microbiology. WOHL, along with the WDPH, studied the presence of mold in a group of pre-fabricated homes in northern Wisconsin.[14] The WOHL Bioaerosol Unit has been involved in analyzing for microbes in metal-working fluids from manufacturing plants. WOHL also works with the WDPH when outbreaks of *Legionella* occur. Beginning in the 1990s, WOHL observed an increased interest regarding biological agents in indoor air quality in homes, schools, and the occupational environment (Figure 1).

In the future, the WOHL Bioaerosol program plans to develop methodologies for faster analysis of samples collected from buildings with indoor air quality problems due to microbial agents. Polymerase Chain Reaction techniques can be used to rapidly detect fungi and bacteria and potentially reduce the analysis time from days to hours. WOHL is currently developing methods to detect microbial metabolites, including endotoxins, mycotoxins, and microbial volatile organic compounds.

LOOKING FORWARD

For more than 65 years, the WOHL has been a partner in Wisconsin's public health initiatives related to the prevention of silicosis, asbestosis, lead poisoning, cancers, and other harmful effects of chemicals encountered in our workplaces and homes. Although major improvements in the control of exposures to these contaminants have been made, there will be a continuing need to monitor for these and other new chemicals that are constantly being introduced into the workplace. Figure 1 tracks the number of samples analyzed by WOHL for asbestos, lead, and molds. As each of these became headline news, WOHL was able to rapidly expand its capacity in the area of interest and then, after the private-sector laboratory capacity had developed to handle the testing needs, to re-deploy resources to prepare for the next public health emergency. As of mid-2003, the mold workload had peaked and was declining due to the rapid increase in the number of private-sector laboratories accredited for environmental microbiology.

An emerging role for WOHL is that of a frontline player in the effort to protect Wisconsin's citizens from the threat of chemical terrorism. In many ways, this role is no different than that assumed by WOHL in the past in response to accidental spills or unexplained illnesses such as the hospitalization of 11 participants in a hockey tournament in Beaver Dam in 1992.[15] The players were treated for acute respiratory and central nervous system symptoms. With the help of WOHL analysis, Wisconsin Division of Public Health epidemiologists were able to attribute the illnesses to nitrogen dioxide and carbon monoxide exposure from an out-of-tune Zamboni ice-resurfacing machine. The WSLH is establishing a dedicated staff of scientists to deal with chemical terrorism, and WOHL's expertise in analyzing airborne exposures to chemicals will be called upon in the event of a real or perceived airborne chemical attack.

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