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The LABYRINTH

Indiana State Department of Health Laboratories Newsletter

"What's in Your Well Water?"

By Mary Robinson, MS

The phone rings at the desk of the Environmental Water Microbiology Lab Supervisor's desk, the caller is a homeowner who recently purchased the house of their dreams in a quiet rural location, which came with a private well. The logical questions heard most often are "What should I test the water for to be sure it is safe to drink?" and "How/when do I clean/disinfect the well?"

Before embarking on answers, a basic review of well structure and function is in order. The three common types of private drinking water wells are dug, driven, and drilled wells. Dug wells are holes dug by shovel/backhoe and lined with a material such as concrete to prevent collapse; the opening is often covered with a metal lid. Dug wells are typically 10 to 30 feet deep and are at high risk for contamination, one caller saw tadpoles in his dug well when he removed the cover! Driven wells are constructed by driving a small-diameter pipe into shallow water-bearing sand or gravel. A screened well point is attached to the bottom of the casing before driving. These wells are relatively simple and tap only shallow water and are considered a medium-high risk for contamination. Drilled wells are typically 100 to 400 feet depth and can be 1,000+ feet deep. Drilled wells are constructed with a metal or plastic pipe and have a sealed casing which protects the well water from sources of contamination and provides a lower risk of contamination. No well can be assumed to be free of the risk for contamination. An animated description of drilled well function can be found at: http://www.in.gov/dnr/water/5230.htm.

Now to address the caller's first question, "What should I test the water for to ensure it is safe to drink?"

The EPA recommends testing a well for pesticides, organic chemicals, and heavy metals before a well is used for the first time. At a minimum, the EPA recommends to test the well annually for nitrate and coliform bacteria to detect contamination problems early. The presence of coliform bacteria is a potential indicator of possible contamination from human or animal wastes. Total coliform positive samples are tested for *E. coli*, a more specific indicator of fecal contamination which may cause illness. Nitrate sources of concern in well water are fertilizers, animal manure, and leaking septic waste systems. High levels of nitrate in well water present a health concern and can also indicate the presence of other contaminants, such as bacteria and pesticides. Drinking large amounts of water containing nitrates poses a serious threat to infants, either from drinking directly or when used to prepare formula. In addition, you may test the well

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Our Mission:

The Indiana State Department of Health Laboratories partners with other public health agencies to provide timely and accurate information needed for surveillance and outbreak investigations to protect and improve Hoosier health.

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more frequently if a problem is suspected based on; an aesthetic change in the water quality, if a structural issue occurs such as the cap breaking, and following environmental events such as earthquakes, floods, etc.

The EPA provides the chart below to help define some common water quality problems and testing options. The EPA concludes the last five problems listed may not be considered immediate health concerns but can affect water quality or indicate a problem with the well, and may have a long term effect on the well.

Conditions or Nearby Activities:	Test for:
Recurring gastro-intestinal illness	Coliform bacteria
Household plumbing contains lead	pH, lead, copper
Radon in indoor air or region is radon rich	Radon
Corrosion of pipes, plumbing	Corrosion, pH, lead
Nearby areas of intensive agriculture	Nitrate, pesticides, coliform bacteria
Coal or other mining operations nearby	Metals, pH, corrosion
Gas drilling operations nearby	Chloride, sodium, barium, strontium
Dump, junkyard, landfill, factory, gas station or dry-cleaning operation nearby	Volatile organic compounds, total dissolved solids, pH, sulfate, chloride, metals
Odor of gasoline or fuel oil, and nearby gas station or buried fuel tanks	Volatile organic compounds
Objectionable taste or smell	Hydrogen sulfide, corrosion, metals
Stained plumbing fixtures, laundry	Iron, copper, manganese
Salty taste and seawater, or a heavily salted roadway nearby	Chloride, total dissolved solids, sodium
Scaly residues, soaps don't lather	Hardness
Rapid wear of water treatment equipment	pH, corrosion
Water softener needed to treat hardness	Manganese, iron
Water appears cloudy, frothy or colored	Color, detergents

Laboratories performing drinking water tests should be state certified. The list of Indiana certified drinking water laboratories can be found at http://www.in.gov/isdh/24859.htm. Water sample test results should include contaminate concentration(s) if found and if the level exceeds a drinking water health standard. The List of Drinking Water Contaminants and their Maximum Contaminant Levels (MCL) provides the National Primary Drinking Water Regulations (NPDWR) public health goals for drinking water. If the sample test results exceed a drinking water standard, you can contact the EPA Safe Drinking Water Hotline at 1-800-426-4791, the ISDH Environmental Public Health Division, or county health department for assistance.

To address the caller's second question "When/how do I clean/disinfect my well?" A well owner may consider cleaning the well if the water becomes turbid, the well delivery capacity decreases, the water develops a new odor/taste problem, or the water does not meet testing requirements. The presence of a bacterial biofilm, an increase in detritus feeding anaerobic bacteria causing bad odors/taste, and chemical build up (encrustation) may lead to the need to clean the well.

Chlorination is typically the initial method of choice when bacterial contamination is an issue. A general description of well chlorination follows, a detailed procedure can be found on the IDEM website at http://www.in.gov/idem/files/welldisinfection.pdf.

First, follow all safety precautions!

- Bypass the water softener and other water treatment equipment (important as high levels of chlorine in the softener/purification system can ruin it).
- Remove the well cap/cover to add the hypochlorite granules or laundry bleach. Add the recommended amount of chlorine as determined by the depth and diameter the well. Laundry bleach works the best as the chlorine is already in a liquid form so it mixes readily with the water in the well.
- Mix and circulate the chlorine using a garden hose, run the water back into the well, flushing the sides of the casing as directed
- Fill several five-gallon pails with the chlorinated water. Turn off the hose and pour the pails of water into the well as fast as possible. Adding the additional chlorinated water raises the water level in the well and forces the chlorine into the faucets.
- Remove faucet screens (aerators) and turn on each water faucet (including outside faucets) individually and run until you smell the chlorine. Don't forget to flush the toilets!
- Turn off the water and let the system sit at least overnight, 24 hours is often recommended. Try not to use any water during this time; one caller's wife accidently bleached his clothes during well chlorination.
- Purge the well by running water from one or more outside faucets until the chlorine can't be smelled any more, this could take several hours. Callers have reported chlorine smell may linger for days, even weeks. The water should be run onto a driveway or ditch.
- Return the water softener back into service and manually regenerate it. Clean/ disinfect and reinstall the screens and aerators in your faucets.
- Finally, test the water. There are varying prescribed time intervals for testing. The CDC recommends testing 7-10 days after chlorination, 2-4 weeks later and again 3-4 months later to check for coliform regrowth.

Well cleaning processes using more caustic chemicals, pressurized air/water, or sonic waves may also be employed to clean the well. If the well is very old, these methods may do more harm than good, a new well or a point of use purification system may be a better answer to water quality issues. A professional well service should be consulted when assessing the well condition.

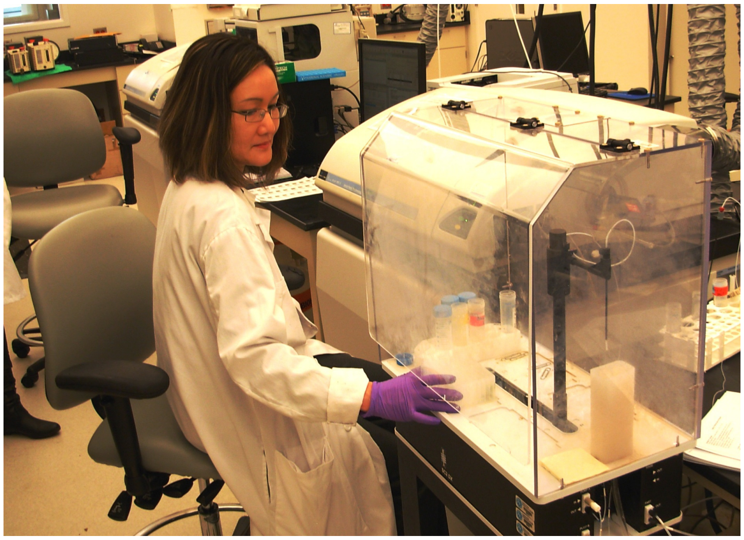
To ensure the well continues to be "safe" for use:

- Have it tested annually
- Keep the ground around the well head sloped away from the well
- Periodically inspect exposed parts of the well and correct problems
- Avoid using pesticides, fuels and other pollutants near the well

Private well information resources:
https://www.epa.gov/privatewells
http://www.cdc.gov/healthywater/drinking/private/wells/testing.html
http://www.wellowner.org/

Testing Blitzes for Schools with Elevated Lead Levels

by Jyl Madlem, MS, MT(AMT), Mary Ann Hagerman, MS, and Judith Lovchik, PhD, D(ABMM)



Taylor Dao performs a test on blood to check the lead levels.

News from Flint, Michigan's lead contamination problem has prompted communities throughout the nation to pay closer attention to the safety of their water. When customers of a public water supply in a rural Indiana community just north of Indianapolis received notice of a lead level alert resulting from regular EPA monitoring, the community school decided to test its water for lead. When tests by two private laboratories revealed lead levels considerably higher than the 15 parts per billion (ppb) action level, the Indiana State Department of Health (ISDH) was asked to retest. The ISDH Laboratory test results also showed excessive lead in various portions of the school's water system, including a water fountain in a kindergarten hallway. Community concern prompted the ISDH to then offer blood lead testing for all students and staff of the entire school system, as well as water testing for the residents of the town. The blood lead testing occurred during a "testing blitz" on a single day at both the elementary and middle/high school.

Jyl Madlem, Laboratory Program Advisor, had previously offered community trainings for blood lead testing throughout the state, so she was deployed to the local health department to give a full-day training to public health nurses and volunteers to properly collect blood lead specimens using capillary technique and filter paper cards. Additional volunteers were trained to use the ISDH LimsNet web portal for data entry of the specimens. Three days later, she and the trainees arrived at the schools early in the morning and set up two large rooms of testing stations, one for elementary students and staff and one for middle and high school students.

That day, 633 students, faculty and staff were tested. All specimens were analyzed at the ISDH Laboratory, and results were returned to the local health department within one week. Results of screening tests showed five students and one staff member to have blood lead results above 5 µg/dL. However, confirmatory test results for most were below 5 µg/dL.

A week later, an Indianapolis school had its water tested; the ISDH Laboratory retested and confirmed high lead levels in some of the samples. Again, a testing blitz was offered to the students and staff, this time assisted by the ISDH Public Health Emergency Preparedness and Response Division. Using lessons learned from the first clinic, plans were made and shared with school administrators. This testing event screened 159 students, faculty and staff in a single day. All specimens were analyzed at the ISDH Laboratory and returned to the school within two days, and none had levels above 5 µg/dL.

Another Indianapolis school, which serves a special needs population, asked the ISDH to test its water. None of these samples exceeded the action limit of 15 ppb.

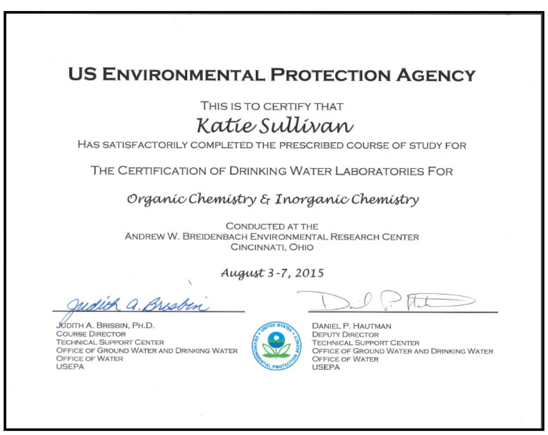
Two inductively coupled plasma mass spectrometry (ICP/MS) instruments provided by the LRN-C (Laboratory Response Network) made the quick testing of both drinking water and blood lead samples possible. For these events, the lab analyzed more than 100 drinking water samples for lead and almost 800 blood lead specimens, which was four times the normal testing volume for that time period.

While contaminated water is usually a minor contributor to elevated blood lead levels, ISDH is using current community concern to bring attention to the real risks for lead poisoning in Indiana. Sixty-three percent of Indiana's housing stock was built before 1978, with lead-based paint and aging plumbing. Our efforts for 2016 are aimed at increased testing of children at risk.

Hundreds of blood spot cards drying out. A total of 633 students, faculty, and staff were tested for blood lead levels.

The Inner-Workings of a Drinking Water Compliance Certification Officer

By Katie Sullivan



US ENVIRONMENTAL PROTECTION AGENCY

THIS IS TO CERTIFY THAT

Katie Sullivan

HAS SATISFACTORILY COMPLETED THE PRESCRIBED COURSE OF STUDY FOR

THE CERTIFICATION OF DRINKING WATER LABORATORIES FOR

Organic Chemistry & Inorganic Chemistry

CONDUCTED AT THE
ANDREW W. BREIDENBACH ENVIRONMENTAL RESEARCH CENTER
CINCINNATI, OHIO

August 3-7, 2015

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Indiana is considered a Primacy State under the *National Primary Drinking Water Regulations* (NPDWR); known by its fans as Title 40 of the Code of Federal Regulations parts 141 & 142. Primacy means Indiana has drinking water regulations at least as stringent as the NPDWR and has a drinking water laboratory certification program (1). In the simplest terms, my job as a drinking water compliance certification officer is to ensure that labs other than the ISDH lab are held to the same standards and follow the same protocols as the ISDH lab would. The image of a certification officer as an on-site auditor is what we are most known for. Today we prefer the term "assessor" to "auditor" and "site visit" to "audit." This change in terms is meant to reflect our true goal as a resource for laboratories. The role of a certification officer is to review data, assess the laboratory, and provide technical assistance to laboratories when needed.

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Inner Workings of a Drinking Water Compliance Certification Officer (continued from page 5)

The goal of the laboratory certification process is designed to help labs produce the best quality drinking water data and not to simply catch labs that have dropped the ball. In order for a laboratory to become certified to analyze drinking water compliance samples in Indiana or when an existing laboratory wants to bring on a new analytical test method, a formal request must be submitted in writing, which is typically done by the lab manager. Upon review of the request, the certification officer will then request specific data items, including, but not limited to: a copy of their SOP(s) for the procedure(s), a copy of the lab's quality manual, their most recent Proficiency Test results(PTs), their current Method Detection Limits (MDL) study, and a brief description of the qualifications of the primary personnel (2).

This is the part of the job that nobody finds glamorous. I read a lot of SOPs, quality manuals, and other technical documents. I review them to ensure that the analytical methods that they reference are on the list of analytical methods currently accepted by the EPA. Then I do a side-by-side comparison between the SOPS and the methods to make sure everything that is required, is included for method compliance. In addition, I review the laboratory's quality manual to make sure it addresses all required points. For PTs and MDL studies, I'm looking to see if they are current, done as required, and that the raw data contains all the essential information. Personnel qualifications are reviewed to make sure they are adequate for the job requirements. Once all of the documentation is in order, I schedule an on-site visit.

During the on-site visit, I verify they have adequate facilities for the analysis of samples, as well as for the health and safety of the personnel. It is important to verify that the lab really does have the equipment and supplies that they state they use in their SOP(s) and that it is being properly stored and maintained. I review calibration logbooks, maintenance records, temperature monitoring, etc. Every situation is different, but generally, I'm looking for bound books or electronic logs that can't be tampered with. I want to see dates, times, initials and corrective actions (if there was an issue). The next phase of an on-site visit is usually to ask the personnel a few questions about their sample handling procedures and ascertain that they're doing what is in the SOP. I want to hear and see that the analysts are doing what the SOP says and they have access to resources should any questions arise relating to the methods and procedures they are following.

I also want to know if they have any questions or concerns that I can address, which leads me to the next task of being a drinking water chemistry certification officer: being a technical resource. Being a technical resource for laboratories is one of the responsibilities of this job that is often overlooked by laboratories. I took the certification officer exam last August and I have only been assessing labs since September. I have not had very many instances where I have been called on to answer technical questions but I have had a few. I've been asked: Can bottles used for nitrate sampling be washed and re-used? (They can.) I've been asked: Are .pdf scan files of chains-of-custody an acceptable form of archiving? (They are.) The broadest one so far: What is a Quality Manual? (That was a long answer.)

At large facilities, I may hold formal opening and closing meetings with managers and technical directors. This is to review any discrepancies or issues that may have arisen during the on-site visit. At smaller facilities, this many may not be necessary because the same people who run the tests may also be the management and technical director. This is not uncommon. Large labs with high tech equipment don't necessarily produce any more accurate data than a small lab with paper logbooks. My role as the certification officer is to review that data, assess that the laboratory has adequate personnel and equipment, and provide technical assistance to laboratories if needed.

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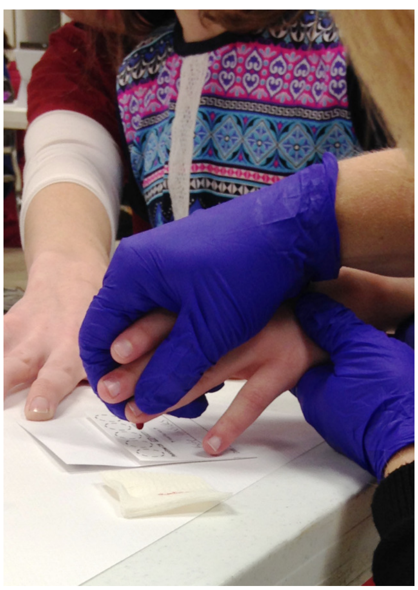
Opportunistic Infections in Persons with Elevated Blood Lead Levels

By Haleigh Kampman and Erica Vecchio, MS



A blood test being prepared.

Flint, Michigan gained national attention in 2014 after citizens reported abnormal water color, odor, and taste. Eighteen months after residents had begun expressing concern about water quality, a Flint doctor discovered extremely high blood lead levels in children. An investigation ensued. The conclusion: lead was leaching into the water from pipes that were built in the early 1900s and were devoid of corrosion control. To make matters worse, this situation had persisted for nearly a year in spite of public complaints (1).

Flint had transferred its main water source from Lake Huron, supplied by the city of Detroit which coated its pipes with orthophosphate, to the Flint River, supplied by water treatment plants that used no corrosion control measure, to save the city money (1). A nation-wide spotlight on the association between drinking water and lead has resulted in renewed interest in this topic; and with good reason. Excessive levels of lead in children's blood can lead to develop- mental problems, including slowed growth, impaired intelligence, and behavioral issues (1, 3).

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Opportunistic Infections (continued from page 7)

On a molecular level, heavy metal exposure in animals has been shown to depress the function of the immune system. Lead activates the inflammatory response, increasing the number of immune cells circulating in the body and releasing antibodies (i.e., IgG) (2). With all of these changes to the immune system, microbiologists at the ISDH Laboratories were interested in better understanding what effect elevated blood lead could have on infections. Are certain infections more common when people have elevated blood lead levels?

We reviewed several scientific articles on the topic. One of the most comprehensive articles on this topic was published in a 2016 study by two researchers, Krueger and Wade. In this article, the researchers examined National Health and Nutrition Examination Survey (NHANES) data to answer the question: Are certain infections more common when people have elevated blood lead levels? Surprisingly, their analysis demonstrated a strong correlation between high blood lead levels and seropositivity for *Helicobacter pylori, Toxoplasma gondii,* and Hepatitis B Virus (3).

Helicobacter pylori

Globally, approximately two-thirds of the population is infected with *H. pylori* (3). This bacterium commonly lines the stomach or the upper part of the small intestine and is generally harmless. On occasion, however, the bacteria can attack the lining of the stomach, allowing the acid to tear away at the stomach and cause peptic ulcers, chronic gastritis, or gastric cancer (3, 4).

The NHANES study analyzed *H. pylori* seropositivity rates for 5,994 non-smoking participants above three years of age from the years 1999 to 2000. The study determined that seropositivity in these individuals was highly dependent upon factors like age, race, income, birth origin, health condition, and crowded housing (3). In addition, a positive association was found between those infected with *H. pylori* and high blood lead levels and the strongest association was found in children. Children are generally more susceptible to heavy metal exposure because their tissues retain higher levels of the metal (3).

Toxoplasma gondii

T. gondii, the obligate protozoan parasite which causes toxoplasmosis, is found worldwide and infects an estimated 25-30% of the world's population (2, 7, 8). Although the prevalence of toxoplasmosis is much lower in North America than in most international areas (10 to 30% vs. 50-80% in tropical Africa) (7), there are still approximately 60 million people infected with *T. gondii* in the United States alone (8). All mammals are vulnerable to the organism; humans, an intermediate host, are most often affected through accidental ingestion of oocysts in food, soil, or water (7, 8). The oocysts migrate through the individual's body, forming permanent cysts in assorted organs and tissues, most notably the brain (2, 7). Healthy individuals are generally asymptomatic, but primary infection in pregnant women and those with severely weakened immune systems is cause for concern as congenital transmission with resultant stillbirth/ spontaneous abortion of fetuses or life-threatening disease in children or adults may occur (2, 7, 8, 9). If untreated, toxoplasmosis is a lifelong infection, and reactivation in immunocompromised individuals may recur later in life (2, 7, 8).

The NHANES study reviewed 23,030 participant surveys across eight years. Overall, 11.0% of those surveyed were seroreactive to *T. gondii*. The researchers again found a significant link between elevated blood lead and cadmium levels and infection with *T. gondii,* particularly among subjects 13 years of age and older. With each doubling of blood lead levels, participants had a 20% increase in odds of being seropositive for the parasite. Increased blood cadmium levels were also present in infected subjects, though the correlation was lower. Consumption of raw or undercooked meat by adults (i.e. differences in eating habits and increased chances for exposure) may have accounted for some of the age-related variability in seropositivity of results. While the means of *T. gondii* infection may have varied somewhat among participants, subjects were likely all exposed to both lead and cadmium through shared environmental exposure routes such as contaminated food, water, and soil (7).

Another striking finding from this study was that researchers concluded that water consumption in the United States may play more of a significant role in transmission of *T. gondii* to humans than previously anticipated. Some populations do not have access to water that has been adequately treated for removal of oocysts (i.e., filtering, coagulation, flocculation, settling, ultraviolet radiation), and assessment of environmental contamination is difficult. This may be particularly true of those utilizing well water and home-untreated company tap water (7).

HBV

Hepatitis B is a liver disease caused by infection with the hepatitis B virus and may manifest in either an acute or chronic form (2, 11). In many instances, HBV infection is asymptomatic, and the number of new cases in the United States totals nearly 20,000 annually, with the highest rates among men between 25 and 44 years of age. Chronic hepatitis B is an even greater issue, with estimates of total US cases over 1 million and worldwide cases over 240 million. Nearly 786,000 deaths result worldwide from HBV-related liver complications. HBV is transmitted through blood or mucosa (i.e. through sexual contact, shared needles, exposure to infected blood or saliva, and childbirth). For those with chronic infections, premature death from cirrhosis, liver cancer, or end-stage liver disease may result (11).

Prior studies have linked both lead and cadmium exposure to liver damage and increased viral activity; cadmium may also contribute to the progression of hepatocellular tumors in mice previously infected with HBV (11). Another study found that nearly 50% of pre-schoolers with chronic exposure to lead from e-waste had decreased hepatitis B surface antibody levels post-vaccination, thus increasing the vulnerability of their immune systems to future HBV infections (11, 12). Furthermore, blood lead levels in HBV patients were found by researchers to be significantly higher than those in healthy subjects in a 2013 Babylonian study (11, 13).

In the NHANES study, serological data of unvaccinated subjects was examined for the presence of total antibodies against hepatitis B core (HBc antigen), which is found in HBV infected individuals but does not serve as a marker for immunity due to vaccination. 17,389 total participant results were included in the study. Overall, 4.9% of the study population was seroreactive for HBV, and the researchers found a significant link between elevated blood lead and cadmium levels and infection with HBV. With each doubling of blood lead levels, participants had a 20% increase in odds of being seropositive for the virus. Doubling of blood cadmium levels, resulted in a nearly 40% increase in odds of seropositivity to HBV (2). Subjects likely shared the same lead and cadmium environmental exposure routes (i.e., contaminated food, water, and soil) (7).

Conclusion

Exposure to heavy metals like lead and cadmium through environmental pathways is clearly a concern for both the general public and public health officials, particularly in light of possible deleterious effects on individual health. As the world population increases, the need for more waste disposal and living area will expand proportionally, and the vulnerability of the public to infective organisms will increase. Those with immunosuppressive conditions will be particularly affected by environmental contamination issues and chronic infections, such as those described in this article, will likely be a problem of mounting concern in the future.

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About The LAByrinth

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