GeoHealth News

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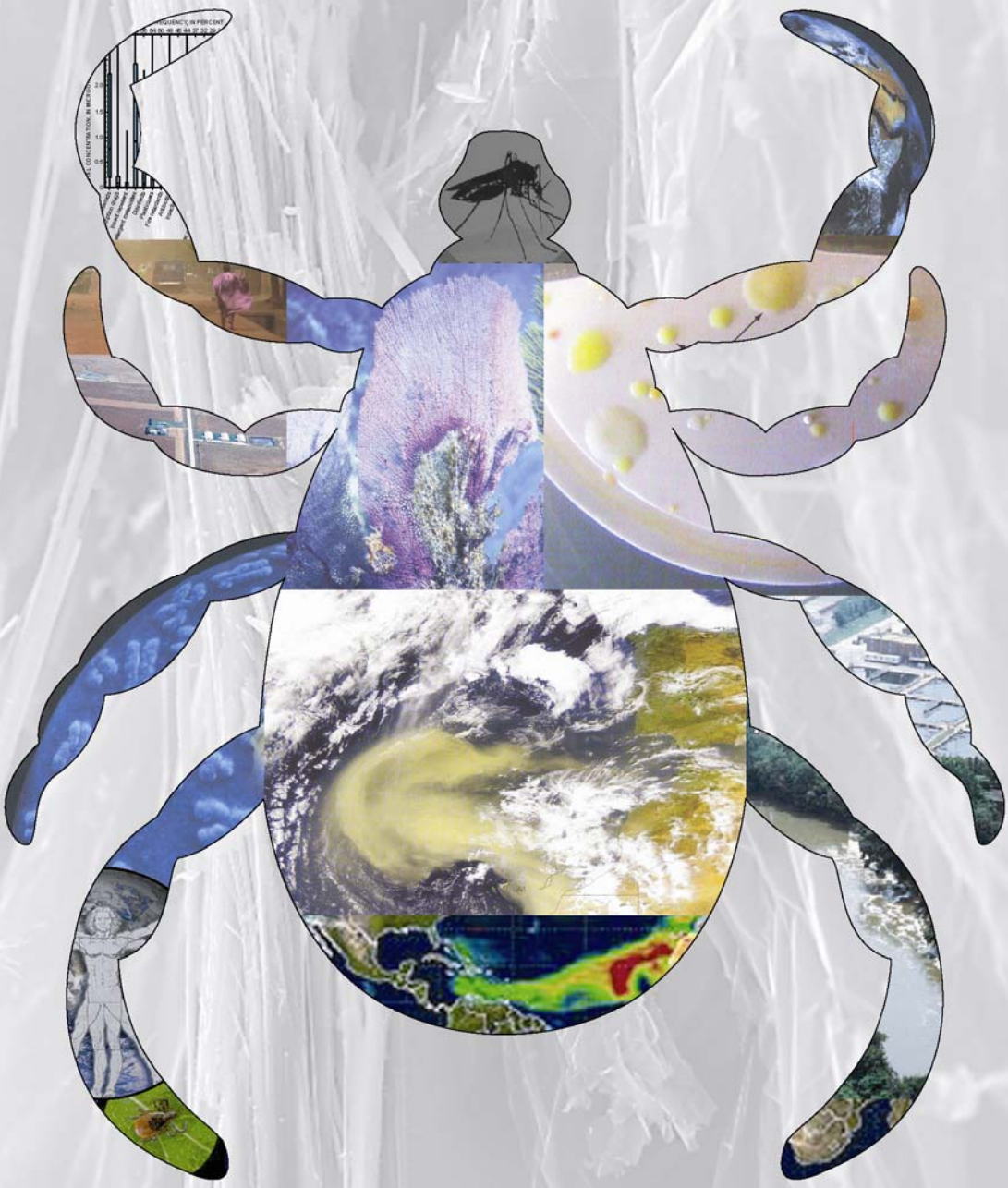

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Find the answers to intriguing Medical Geology questions.....**pages 10-11**

EDITORIAL COLUMN

By Joe Bunnell

Recently, on Tuesday, September 28, 2004, a magnitude 6.0 earthquake shook central California. While there were no casualties and relatively minor damage reported, a major quake in the same area killed two people last December. Parkfield (pop. 37) has been central to the war on earthquakes ever since researchers noted that, since 1857, a magnitude 6.0 earthquake has occurred there on average every 22 years. About 7 miles north of the Parkfield Earthquake, and a mere 1500 feet from the San Andreas fault, a borehole that will ultimately intersect the San Andreas fault at depth is being drilled by the National Science Foundation's $200 million EarthScope Program, in partnership with USGS. About a week before the temblor occurred, drilling operations ended at a depth of 8500 feet.

Three years earlier to the day of the Parkfield Earthquake, an archeolgical site in Dinosaur National Park, Utah, was reopened to the public after a coccidioidomycosis (aka valley fever) outbreak afflicted ten people, including two Department of the Interior (NPS) employees. The site was closed for over 50 days as a result. In all, 10 people were hospitalized with diffuse pulmonary infiltrates on chest radiographs; eight of them were hospitalized with pneumonia of unknown etiology – subsequently determined to be, in fact, valley fever. While two-thirds of the people infected with the causative agent generally remain asymptomatic, the disease can be deadly.

What is the connection between earthquakes and a serious fungal infection? Valley fever results from an infection caused by inhaling specific airborne pathogenic fungi, *Coccidioides immitis*. The fungi grow in soil, and when earthquakes trigger landslides, the spores can be carried by the wind over large distances. Almost 200 people became acutely ill with valley fever after the 1994 Northridge earthquake in southern California. Learn much more about valley fever in this issue's feature article!

By the way, you may have been wondering what happened to the GeoHealth News, as it has been about a year since our last "quarterly" issue. We won't bore you with all the details; suffice it to say that we owe a big THANK YOU to the Eastern Region Management for making the continued production of this newsletter possible. Please join me, too, in welcoming our new Editorial Assistant, Ms. Socheata Sam. As always, we welcome your comments, critiques, letters, and suggestions for stories.

SPOTLIGHT: USGS

FEATURE ARTICLE

Coccidioidomycosis: Mitigating the Risk

by Mark W. Bultman, Frederick S. Fisher, and Mark E. Gettings; Western Mineral Resources, Tuscan Arizona

Introduction

In the upper 20 cm of some desert soils in the southwestern U.S., northern Mexico, and parts of Central and South America lives a dimorphic fungus that is the only eukaryote regulated under the U.S. Anti-terrorism and Effective Death Penalty Act. This fungus is *Coccidioides* and it is the etiological agent of coccidioidomycosis, also called valley fever. As it grows in the soil in its saprophytic phase, it is characterized by branching segmented hyphae that form a network of mycelium. As the fungus matures arthroconidia (spores), 2 to 5 microns in size, are formed as barrel shaped segments of the hypha (figure 1). The arthroconidia can be easily separated from the hypha by soil disturbance (natural or anthropogenic) and consequently dispersed by the wind. If an appropriate host inhales airborne arthroconidia, primary infection may occur and the parasitic phase of the *Coccidioides* lifecycle is initiated. Appropriate hosts include humans and other vertebrates. The life cycle of *Coccidioides* concludes with the death and subsequent decay of the infected host, returning the fungus to its saprophytic form in the soil.

Figure 1. *Coccidioides* sp. hyphae showing initial formation of arthroconidia

Character of coccidioidomycosis in humans
Coccidioidomycosis begins with the inhaled arthroconidia growing into spherules in the host's lung tissue. The spherules mature, rupture, and release up to thousands of endospores. Each endospore can grow into a mature spherule and the infection propagates by this method. About 100,000 people are infected annually in the United States (Valley Fever Center for Excellence, 2002). Sixty to seventy percent of infected individuals will be asymptomatic and will develop long-lasting immunity. The remainder display symptoms that range from an influenza-like illness to over-whelming pneumonia starting 7-28 days after exposure. Most recover completely and develop long-lasting immunity. In a small number of cases (<1 percent), a progressive pneumonia can persist for months to years (Ampel, 2000). In about 0.5 percent of cases, the disease may disseminate into the skin, bones, soft tissue, or meninges (figure 2) and may require lifelong anti-fungal therapy. It can also disfigure, disable, or kill the infected individual.

Figure 2. Cutaneous coccidioidomycosis
Source: Mycology online, University of Adelaide, Australia.
http://www.mycology.adelaide.edu.au/

The risk of developing active pulmonary coccidioidomycosis varies by age, gender, and, possibly, the level of exposure to the fungus. Figure 3 displays the incidence rate for coccidioidomycosis by age in Arizona from 1990 through 1995. Figure 3 clearly shows that elderly individuals are more susceptible to acquiring active coccidioidomycosis (CDC, 1996). Males tend to get coccidioidomycosis at a higher rate than females and diabetics tend to get a more serious form of pulmonary coccidioidomycosis than non-diabetics (Ampel, 2000). Also, in cases where there is a large exposure to inhaled arthroconidia, such as workers at an archeological dig, almost everyone exposed comes down with active pulmonary coccidioidomycosis (CDC, 2001). The risk of developing disseminated coccidioidomycosis varies by ethnicity and other factors. Blacks, Filipinos, Native Americans, males, and pregnant women in the second and third trimester are at an elevated risk for disseminated infection (Ampel, 2000). Those at the greatest risk from coccidioidomycosis (pulmonary and disseminated) are individuals with an underlying immunosuppressive condition (HIV/AIDS, lupus, organ transplants, chemotherapy, etc). In fact, disseminated coccidioidomycosis is commonly fatal in HIV patients. HIV infected patients with the non-meningitis form of disseminated coccidioidomycosis had a fatality rate of 68 percent and a median survival of 54 days (Aberg, 2003). Those with coccidioidal

meningitis had a 33% fatality rate and a median survival of 6 months (Aberg, 2003).

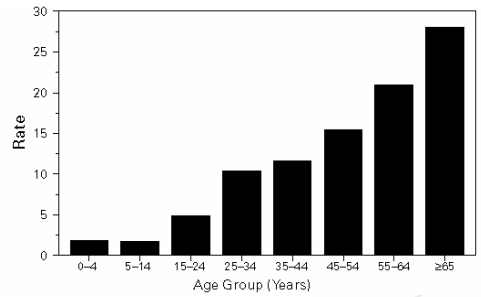

Figure 3. Mean annual incidence rate per 100,000 population of coccidioidomycosis by age group – Arizona, 1990-1995 (source: CDC 1996)

Coccidioidomycosis is a dangerous and expensive disease. Pappagianis (1980) estimated that the overall annual cost to the nation was one million person-days of labor. A review by the United States Centers for Disease Control and Prevention in Atlanta, Georgia (Goodman, *ed.*, 1994) of the medical records in Kern County, California showed that coccidioidomycosis accounted for approximately $66 million in direct costs of hospitalization and outpatient care during the period 1991-1993.

Based on demographic trends in the United States an increasing number of previously un-exposed high-risk individuals (mostly elderly) are moving into endemic areas. In addition, recent changes in climate may favor infection. These factors have combined to create an increasing number of cases of coccidioidomycosis in the U.S. In 2001, the Arizona Department of Health Services reported an incidence of 43 cases per 100,000 population, a 186 percent increase in the incidence rate since 1998 (CDC, 2003).

Geology and ecology of *Coccidioides* sp.

The coccidioidomycosis endemic area is shown in figure 4. This area represents the geographical extent of environmental conditions favorable for *Coccidioides* to complete its life cycle in the soil. Coccidioidomycosis was entirely attributed to *Coccidioides immitis* until recently. Work by Fisher and others (2002) has provided evidence of two species of *Coccidioides*; *Coccidioides immitis* and *Coccidioides posadasii*. *Coccidioides immitis* is found in the central valley of California, southern California, and Mexico. *Coccidioides posadasii* is found in the parts of the endemic area outside the central valley of California (Fisher and others, 2002).

Figure 4. Coccidioidomycosis endemic area

Ongoing project work at the USGS Mineral Resource Program's Southwest Field Office in Tucson, Arizona is aimed at 1) defining the geological/ecological habitat of *Coccidioides* sp.; 2) modeling that habitat with spatial and temporal models in order to map soils favorable for hosting *Coccidioides* sp. and delineating conditions where arthroconidia may be released into the atmosphere; and 3) with USGS Earth Surface Dynamics Program, to monitor and model dust emissions. The goal is to use this information to help mitigate coccidioidomycosis by predicting possible epidemics, sighting public facilities in areas where the fungus is not likely to be found, allowing biological and chemical control methods to be effectively utilized, and by allowing dust abatement methods to be used with greater effectiveness.

Laboratory and site-specific field studies have shown that many physical, chemical, climatic, and biological factors influence the growth of *Coccidioides* in the soil and the consequent development and deployment of arthroconidia.

With some exceptions endemic areas are generally arid to semiarid with low to moderate rainfall, mild winters, and long hot seasons. Mean annual soil temperatures range from 15^0 C to over 22^0 C. The presence of soils with textures that provide adequate pore space in the upper (20 cm) parts of the soil profile, for moisture, oxygen, and growing room is very important. Small amounts of clay foster water holding capacity, but large amounts of clay may be detrimental for *Coccidioides* growth. The presence of some organic material is needed for carbon and nitrogen but in most known occurrences it is generally sparse, less than 2%. Large amounts of organic compounds may be detrimental because they would foster the growth of bacteria and other fungal species that would compete with *Coccidioides.* Many *Coccidioides*growth sites have soils with elevated salinity, which may act an inhibitor of microbial competitors (Egeberg and others, 1964).

Detection of *Coccidioides* in the environment is difficult. Traditionally mice are inoculated with isolates from suspect soil. After a pre-determined time period the mice are sacrificed and their organs examined for evidence of infection as seen by the formation of the unique spherule form of *Coccidioides.* Recently, laboratories have turned to DNA analysis in an attempt to identify the cultured fungus. While there have been some successes using DNA, there is no standardized procedure and results so far are unreliable. Scientist collaborating with the USGS at the University of Arizona and the University of California Davis are working on the development and improvement of these new techniques. Presently, testing soil for the presence of *Coccidioides* is time consuming and difficult, thus there are few locations where it has been identified in the soil.

***Coccidioides* sp. habitat modeling**

Habitat modeling of the saprophytic phase of *Coccidioides* is difficult, because of the limited number of places where it is known to exist in soil. This prevents the establishment of statistical relationships between growth sites and their physical, chemical, and biological habitat parameters. Therefore habitat modeling is accomplished using analysis of the physical properties of known *Coccidioides* sites within a spatial fuzzy system. A spatial fuzzy system is a system of spatial variables where some or all of the spatial variables are described with fuzzy sets. The fuzzy system is capable of translating structured knowledge into a flexible numerical framework and processing it with a series of if-then rules.

Fuzzy systems can describe non-linear numerical processes with linguistic common sense terms and can handle differing precision and accuracy in the data. They produce models that can be repeated and updated easily.

A fuzzy system analysis was applied in Organ Pipe Cactus National Monument, Arizona. The resulting product is a map (Figure 5) depicting the favorableness of areas for hosting *Coccidioides* in soils based on a scale of 0 to 1, which we define as its fuzzy habitat suitability index. An important property of this kind of analysis is that "what if" scenarios can be used to predict changes in habitat with changing climate.

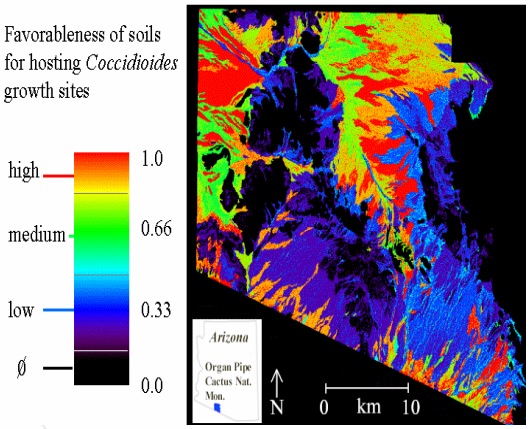

Figure 5. The fuzzy habitat suitability index of *Coccidioides* measured as the favorableness of soils for hosting *Coccidioides*, Organ Pipe Cactus National Monument, Arizona

Complex systems modeling of the life cycle of *Coccidioides*

Like all environmental systems, the life cycle of *Coccidioides* is determined by a complex set of interactions between the organism and its surroundings. One concept that we are now testing is the possibility that saprophytic *Coccidioides* can reestablish itself in soil after arthroconidia have been blown to a new location by an extreme wind event. Fisher and others (2001) have shown that there is spatial genetic differentiation in *Coccidiodes* and geographically separate genetic clades are

recognized in central California, southern California, Arizona, Mexico, Texas, and South America. This genetic differentiation argues against the ability of C*occidioides* arthroconidia to reestablish themselves in soils, at least over long distances. But, spread of the fungus by wind may still be an important local process. In an attempt to model the spread and survival of the fungus *Coccidioides* in soil via wind-borne arthroconida transport, a complex systems model has been developed using public domain agent-based modeling software. The hypothetical model posits that for a successful new site to become established, four factors must be simultaneously satisfied. 1) There must be transport of arthroconidia from a source site to sites with favorable soil (physical, chemical, and biological properties). 2) There must be sufficient moisture for fungal growth. 3) Soil temperatures at the surface and at depth must be favorable for growth. Finally, 4) the temperature and moisture must remain in favorable ranges for a long enough time interval for the fungus to grow down to depths at which arthroconidia will survive subsequent heat, aridity, and ultraviolet radiation of the hot, dry season typical of the Southwest U.S. climate.

Numerous model runs have shown that the probability of new sites depends on the four factors in a Bayesian way. These results indicate that the complexity introduced in the model from site favorableness, temperature, moisture, and duration of favorable temperature and moisture conditions is adequate to explain distributions of real sites described in the literature and that wind transport at a local scale may be possible. We are now working on integrating more physical habitat factors as well as soil favorableness information into the complex systems model.

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U.S. GEOLOGICAL SURVEY NEWS

Formation of new USGS Human Health Coordination Committee

Charles G. Groat (signed) Chip Groat
Director, USGS

I am pleased to announce that Herb Buxton has agreed to chair a USGS Human Health Coordination Committee. This committee, comprising program coordinators who currently support Human Health research, will work to increase coordination with human health agencies and coordination among USGS human health related activities. Some of the committee's first tasks will be to develop long-term strategies to identify focused research areas for the USGS, to strengthen our partnerships with human health agencies, and to identify opportunities for additional funding and growth. As chair of the Human Health Coordination Committee, Herb's first task will be to work with the Associate Directors to assemble the group. He will also serve as the USGS point of contact for health agencies and facilitate interdisciplinary response to their needs. Currently, Herb manages the Toxic Substances Hydrology Program and he will continue in that role concurrently.

Human health issues are a high priority for the American people, and, as a Federal agency, the USGS can provide critical science information in this area. However, many of our capabilities are underutilized, particularly in the areas of wildlife health-human health interactions and the use of our environmental databases (water quality, rock and soil geochemistry, land cover, etc). To maximize our impact, we must partner with the health sciences and medical fields to understand their information needs and to educate them about the value USGS can add.

As the Toxics Program Coordinator, Herb has worked closely with environmental and human health agencies on topics such as mercury cycling in aquatic ecosystems, contamination from hardrock mining, MTBE, pesticides and their degradation products, and pharmaceutically and hormonally active contaminants. He received his B.S. in Geology from Rensselaer Polytechnic Institute, and his M.S. in Geology from the State University of New York. After working as a research associate at the University of South Carolina's Hydrogeology Program, he has had a 25-year career with the USGS as a scientist and manager.

Please join me in welcoming Herb to this new leadership role.

MEETINGS

First Annual Sustainable Beaches Summit

By Christina Kellogg; Coastal and Marine Geology

The Sustainable Beaches Summit is a groundbreaking effort to bring together a diverse cross-section of professionals and coastal educators from federal agencies, state and local governments, non-governmental organizations, academia, and industry. The Summit convened March 29-31, 2004, in Walton County, Florida, at the Sandestin Golf and Beach Resort.

The first day of the Summit, Monday, March 29, features several workshops relating to various aspects of beach management. The workshops will allow participants to gain hands-on training in the latest beach management techniques and include field trips to the beautiful beaches of Walton County. The meeting convenes on Tuesday, March 30 with a morning plenary session, and will conclude on Wednesday, March 31. Tuesday and Wednesday will include sessions focusing on five major concurrent tracks relating to beach management: water, sediment, monitoring & mapping, tourism, and education/outreach. In addition to the sessions, all the major sponsors (listed below) will have booths with beach-related information available in the lobby.

The USGS Florida Integrated Science Center (FISC), Center for Coastal and Watershed Studies, located in St. Petersburg, FL, is sponsoring the monitoring and mapping track. This track, targeted to scientists and public health officials, will showcase USGS beach research. The dual nature of the track allows for the inclusion of both microbiological work being done with beach sediments, as well as some of

the regional studies of large-scale coastal change being done with a variety of new techniques.

The Center for Sea Change is sponsoring the tourism and policy track, with a focus on the economics and planning of sustainable tourism. This track is expected to appeal to planners, tourism professionals, developers, and policy staff.

The US Army Corps of Engineers is sponsoring the sand and sediment track, geared toward engineers and consultants. This track will include topics such as dredging, maintaining beach fill, and their new focus on regional sediment management.

National Oceanographic and Atmospheric Administration (NOAA) is sponsoring the education, outreach and literacy track. The intended audience is educators, scientists, and policy staff. The track will incorporate sessions on K-12 educational programs, aquariums, getting the community involved in programs, and beach protection.

The Clean Beaches Council, with input from the US Environmental Protection Agency (EPA) will be compiling the final track on water, including recreational water quality, watershed management, and impacts of wastewater on beaches.

Speakers have already been chosen for these tracks, and a preliminary agenda is available on the Sustainable Beaches Summit webpage. Interested parties are invited to register for the Summit on the website from now until February 14th. The Summit will provide an excellent venue for network building and creating synergy among beach professionals of all backgrounds.

Links

Sustainable Beaches Summit
http://www.cleanbeaches.org/sustainable/default.cfm

Clean Beaches Council
http://www.cleanbeaches.org/
FISC-Center for Coastal and Watershed Studies
http://coastal.er.usgs.gov/

GEOHEALTH IN THE MEDIA

Dust storms on the rise globally
September 4, 2004

Dust storms are increasing globally with far-reaching consequences for the environment and human health, scientists are warning. Up to three billion tons of dust is blown around the world annually, says Andrew Goudie at the University of Oxford, UK. Dust storms originating in Saharan Africa have increased ten-fold over the past 50 years, threatening human health and coral reefs thousands of miles away, and contributing to climate change, he warns.
Click here to view the complete article

Magnets pull cancer drugs to tumors
September 4, 2004

Tiny particles of iron may help doctors deliver targeted cancer drugs using the pull of a magnet, says a UK researcher. And such treatments could potentially improve the effectiveness of tumor-killing drugs while reducing the painful side effects associated with

traditional treatments." It's a new way of driving drugs around the body. Drug trafficking, if you will," says Andrew Harrison, a materials chemist at the University of Edinburgh, who is developing the technique. Click here to view the complete article.

Amphibian's life stages influence contaminant transfer from aquatic to terrestrial environments

July 24, 2003

Scientists at the University of Georgia's Savannah River Ecology Laboratory have taken the first step toward understanding how variations in the life stages of amphibians may influence contaminant transfer from aquatic to terrestrial environments. Using bullfrog larvae from a coal combustion waste-settling basin, the scientists investigated the effects of both developmental stage and the timing of metamorphosis on the concentrations of a series of trace elements in bullfrog tissues. Four stages in all were examined as were both spring and fall metamorphosis. The work has just been published in Environmental Toxicology and Chemistry. Click here to view the complete article

Report cites health risks of Farm-Raised Salmon

January 9, 2004

Salmon raised in ocean feedlots, the main source of supply for American consumers, contains such high levels of PCBs, dioxins and other toxic chemicals that people should not eat it more than once a month, according to an extensive study reported today in the journal Science. The study, which has triggered heated protests from the industry, focused on commercially raised salmon in both the Atlantic and Pacific. It found roughly 10 times more PCBs, dioxins and pesticide residues in farmed salmon than in the wild variety.
Click here to view complete article

High mercury risk in fish raises alarm

August 4, 2004

Mercury is turning up in fish in Washington state's remote lakes and reservoirs at levels that could be harmful to women and children, and more than half the fish tested nationwide also are contaminated, according to a study by an environmental coalition. The results highlight the need to take stronger action to reduce mercury pollution, particularly from coal-burning power plants, according to Clear the Air, a coalition pushing for more stringent mercury-emission standards. Click here to view the complete article

Air Pollution Retards Teen Lung Growth – Study

September 10, 2004

In the first long-term study of air pollution's effects on children, researchers reported this week that contaminated air stunts lung development in teenagers and the effects could extend well into adulthood. The findings, published in the New England Journal of Medicine, show that existing pollution controls in many parts of the United States are inadequate. Click here to view the complete article

WHO warns of global outbreak of bird flu

September 14, 2004

The World Health Organization (WHO) has warned of a global outbreak of avian influenza unless greater efforts are made to fight the disease in countries already affected by it and international co-operation is strengthened. The WHO is currently investigating one human case of avian influenza which happened in Viet Nam in August when other two cases were also reported there, a senior WHO official said over the weekend. Click here to view the complete article

China's changing farms damaging soil and water

September 18, 2004

China's economic revolution is coming at a cost. While improved prosperity and government incentives convinced millions of people to give up the rural life and move into towns and cities, China's agriculture is in rapid decline, prompting fears that the country that is home to one-fifth of the world's population will soon be unable to feed itself. Click here to view the complete article

Adipose Tissue Levels of Organochlorine Pesticides and Polychlorinated Biphenyls and Risk of Non-Hodgkin's Lymphoma

June 1, 2004

Quintana *et al*. found strong associations between the risk of non-Hodgkin's Lymphoma (NHL) and levels of several organochlorine compounds measured in body fat, particularly heptachlor epoxide and dieldrin. People with the highest body burdens of heptachlor epoxide and dieldrin had three times the risk of NHL, compared to people with the lowest levels of these persistent pesticide residues in their body fat. Their results provide further support for the argument that organochlorine contaminants are responsible, at least in part, for the changing incidence of non-Hodgkin's Lymphoma seen over the last few decades. Click here to view the complete article

Senators urge probe of EPA on Lead in Water

October 6, 2004

Two U.S. senators yesterday called for the inspector general of the Environmental Protection Agency to investigate whether the agency was properly protecting the public, saying they were alarmed by reports that utilities often violate rules designed to reduce lead in drinking water. Members of the Senate also renewed a push for strict new laws to reduce lead contamination in drinking water and to require that the public be alerted quickly to lead risks. The demands followed a Washington Post report yesterday that dozens of water utilities are manipulating lead test results, violating federal law in some cases and putting customers at risk. Click here to view the complete article

IN THE NEXT ISSUE…

What is the NBII?

The National Biological Information Infrastructure (NBII) <http://www.nbii.gov> is a broad, collaborative program to provide increased access to data and information on the nation's biological resources. The NBII links diverse, high-quality biological databases, information products, and analytical tools maintained by NBII partners and other contributors in government agencies, academic institutions, non-government organizations, and private industry. NBII partners and collaborators also work on new standards, tools, and technologies that make it easier to find, integrate, and apply biological resources information. Resource managers, scientists, educators, and the general public use the NBII to answer a wide range of questions related to the management, use, or conservation of this nation's biological resources.

ASK THE DOCTOR…

Q: Dear Dr. Pat Hologist,

With so much attention in the media about lead poisoning, I am worried about my family. How can I tell if my children are being exposed and how can I prevent it?

~Concerned in Washington

A: Dear Concerned,

Lead is everywhere! It especially exists in household items such as paint, batteries, drinking water, pottery and other ceramic dishes that are hand glazed. If your home is older than 20 years, lead can be apparent in the paint on the walls as well. In the United States, deteriorated lead-based paint in older homes and high levels of lead-contaminated house dust are the most common sources of lead poisoning in children.

It is difficult to detect lead poisoning initially because the symptoms are subtle and accumulate gradually. They may go unnoticed until levels become high and dangerous.

Symptoms in children are nonspecific and may include irritability, loss of appetite, weight loss, vomiting, constipation, and anemia. Although children are at a higher risk, adults are exposed as well. Symptoms in adults include pain, numbness or tingling of the extremities, muscular weakness, headache, abdominal pain, and memory loss.

Some causes of lead contamination come from soil, household dust, water, and lead paint. The best way to prevent lead poisoning is to go straight to the source and remove it!

The editors of this newsletter welcome:

- Suggestions on what to include in future newsletters
- Suggestions on the newsletter format
- Email addresses of USGS people who may be interested in receiving copies of the newsletter (Note: subscribers will receive email notification of future editions of the newsletter that will be posted on a USGS website).
- Contributions toward upcoming events of U.S. Geological Survey News (The editors of this GeoHealth newsletter value any input through their readers. Please don't hesitate to contact us at anytime and you for your replies.)

Editor- Joseph Bunnell

Contributing Editor- James L. Coleman

Editorial Assistant- Socheata Sam

For questions, contributions, or suggestions regarding any part of this newsletter, please contact:

Joe Bunnell: jbunnell@usgs.gov -- 703-648-6497.

For more information related to the topic of GeoHealth, go to http://energy.er.usgs.gov and select the "Medical Geology" logo link.