EPIDEMIO-ECOLOGY NEWS

Volume 1, No. 2 August 1, 2002

Featured Article

The Movement of Soil and Sediment in Earth's Atmosphere: Microbiology and Ecosystem Health

D.W. Griffin, C.A. Kellogg, V.H. Garrison, C. Holmes, and E.A. Shinn

United States Geological Survey, Center for Coastal and Regional Marine Studies, 600 4th St. South. St. Petersburg, Florida 33701

Primary Author Contact Information:

Phone: 727-803-8747ext.3113

Email: dgriffin@usgs.gov

A rain of dirt

While soils and sediments in Earth's atmosphere originate from arid regions around the globe, the majority of 'dust' originates from two locations, the Sahara and Sahel regions of Africa and the deserts of Asia. Dust storms originating in the arid regions of North Africa occur year round and account for approximately 75% of all soils and sediments lifted into our atmosphere. In the months from June through October dust originating from Africa routinely impacts the Caribbean, Central and North America. In the remaining months the African dust storms typically impact South America, Europe and the Middle East. Dust storms originating in the Asian deserts usually occur from February through April of each year. While the Asian deserts are smaller than the Sahara and the dust season is only three months long, they are a significant source of airborne soils and sediments. *(Continued on page 2)*

Editorial Column

Dust is the theme of this, the second issue of Epidemio-Ecology News. In the time it took you to read that sentence, you just inhaled 5,000 particles of dust. We are all constantly awash in a sea of airborne dust, most of it invisible to our eyes, and some of it deadly. We are really like Sparky Schultz's cartoon character Pig-Pen from the Peanuts comic strip -- you know the kid who always walked around generating this big dust cloud that practically obscured his very body from view. In fact, even when you're just sitting on the couch watching TV, you generate about 100,000 dust particles per cubic foot of air. When you sit down or stand up, you make about 2,500,000 particles per cubic foot. Walking generates around 10,000,000 and vigorous horseplay can make about 30,000,000 particles per cubic foot of air. If you're horseplaying with your dog, or even worse, a horse, we'll have to switch to scientific notation. Now, I'm not commenting on your personal hygiene. Aside from any "dirt" you may have on you, you are constantly sloughing off dead skin cells, hair, and mites, even coming straight from the shower. We just don't see them usually. Sometimes in a shaft of light you can see dust particles floating around, but those are just the largest particles called "dust," 20 to 30 microns in diameter. The dust we breathe, however, ranges down to sub-micron particle sizes. In this issue, Dale Griffin and others at our Coastal and Marine Geology Program Center in St. Petersburg, Florida offer a fascinating and authoritative look at the public health implications of globally transported dust.

In June 2002, the International Society of Ecosystem Health sponsored a conference in Washington, D.C. that featured a Medical Geology Working Group. The participants identified research priorities and made key recommendations for promoting the growth and development of Epidemio-Ecology. For a full report on the proceedings, go to http://home.swipnet.se/medicalgeology, and then click on "Meetings-reports: Report from a workshop in Washington in June." Given the swirling controversy over the names "Epidemio-Ecology" and "Medical Geology," you won't be surprised to hear that this was the first topic the Working Group tackled. Suggested as the best name that most accurately describes what we do, "Hydrobiogeochemoepidemiopathoecology" is arguably the worst one yet. We're going to have to live with a compromise term, until we can agree on a better one.

The editors thank those of you who sent in ideas and comments after the first issue, and welcome your continued input.

For contributions toward the Editorial Column or Featured Article please contact Joe Bunnell: jbunnell@usgs.gov ; 703-648-6497.

The current estimate on the quantity of soil moving some distance in Earth's atmosphere each year is approximately 2 billion metric tons and some feel that this may be a significant underestimate (**Figure 1.** *A dust cloud the size of Spain rolling off the Western coast of the Sahara Desert*). If you converted that 2 billion ton estimate into Volkswagen Beetles (based on weight), that would be enough Beetles to create a 119 meter tower over the entire 176 km^2 surface area of Washington, D.C. From a microbiology perspective there is an additional piece of trivia - the 2 billion ton estimate converts to 2 quadrillion grams. At a conservative estimate of 10,000 bacteria per gram, that's enough bacteria, if placed end to end, to form a microbial bridge between Earth and Jupiter. Additionally, such dust also transports fungal and viral microbial pathogens. With respect to human and ecosystem health, one has to ask what percentage of the associated microbial population is pathogenic and how many of these disease-causing microbes are capable of surviving long range airborne transport? What risks do these and other potential hazards such as herbicides, pesticides and radioisotopes that have also been identified in dust clouds pose to impacted populations of humans and ecosystems? These are questions with global implications, questions that are being addressed by a surprisingly small number of researchers.

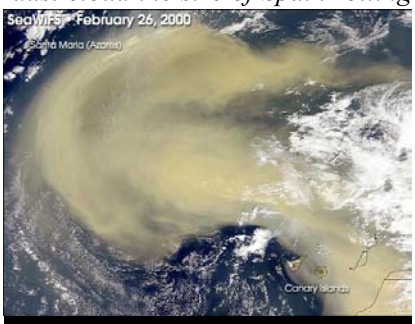

Figure 1. NASA SeaWifs Image of a large dust cloud blowing off the West Coast of Africa on 26 February 2000. http://visibleearth.nasa.gov/cgi-bin/viewrecord?512

The Good

The movement of soils and exposed sediments in atmospheres is a natural planetary process; Martian dust devils as imaged by NASA's interstellar exploration efforts are a prime example. Analysis by researchers on ice cores taken in the Arctic and Antarctic have demonstrated periods of both heavy and light global dust transport as Earth has evolved to our current point in time. Terrestrial and aquatic plant life have evolved to take advantage of the nutrient-rich particles (iron, phosphate and organic detritus) in clouds of dust that fall out of the atmosphere. Research has shown that plant life in the upper canopy of the South American rain forest derive their nutrients from African dust. Rain forests located on the Northern Hawaiian Island chain are believed to obtain a significant fraction of their nutrient budget from Asian desert dust. Researchers are currently investigating the influence of nutrient-laden dust on growth of phototrophic microorganisms in oligotrophic regions of our oceans. The deposition of clay-laden African dust on Caribbean Islands through time enabled 'Pre-Columbian' Indians to produce pottery from an otherwise clay-limited soil. Clearly the global movement of dust has benefited both ecosystems and humanity.

The Bad and the Ugly

One of the first links to be made between long range transport of desert dust and ecosystem health was the isolation and identification of a terrestrial fungus (*Aspergillus sydowii*) as the causative agent of the Caribbean-wide seafan disease agent from atmospheric samples collected in the United States Virgin Islands. There is a replete history of research that has implicated long-range dispersion fungal pathogens of plants and crops over vast expanses of terrestrial and marine environments. In the 1970's sugarcane rust caused by *Puccinia melanocephala* was surmised to have spread from Africa to the Caribbean and then to North America via airborne transport. Similarly, the coffee rust agent *Hemileia vastatrix* was suspected of being delivered from Africa to the Caribbean via the atmosphere. Outbreaks of foot-and-mouth disease have been reported in Korea following large dust events originating in China's deserts. Research on the source of the pseudorabies virus (cause of Aujeszky's disease in pigs) after outbreaks occurred in Denmark in December of 1988 concluded that the infections were probably due to atmospheric transport of the viral pathogen from Germany. Recent research conducted at the University of South Florida's Department of Marine Sciences has implicated African dust deposition and outbreaks of harmful algal blooms (red tide) along Florida's coastline.

The National Institute of Allergy and Infectious Diseases identifies airborne dust as the primary source of allergic stress worldwide. Areas such as the Aral Sea (The Aral Sea, along with other inland bodies of water such as Lake Chad in Africa and Lake Owens in California, are significant sources of dust due to the fine nature of exposed sediments produced by drought and/or source water diversion, i.e. falling water tables) and the Caribbean, where desert dust activity is common, have some of the highest recorded incidence rates of human asthma on the planet. Barbados experienced a 17-fold increase in the incidence rate of asthma from 1973 to 1996. This observed increase in incidence coincided with the increased dust flux from the Sahara and Sahel to the Caribbean. A number of diseases such as 'Al Eskan Disease' a.k.a. 'Desert Storm Pneumonitis,' and 'Desert Lung Syndrome' have been attributed to exposure to atmospherically suspended desert dusts. Exposure to airborne dust containing bacterial endotoxin and mycotoxins produced by fungi is known to cause disease and death.

Large outbreaks of meningococcal meningitis (caused by the bacterium *Neisseria meningitidis)* resulting in both illnesses and death are routinely reported in West African countries following dust events. In the Americas, small outbreaks of coccidioidomycosis (caused by the fungal pathogen *Coccidioides immitis*) following dust events are common.

Widespread use of pesticides and herbicides in farming and the subsequent airborne transport of toxin-laden soils pose a risk to human health. People living in the vicinity of the Aral Sea have suffered from illnesses due to the organosphosphate pesticide phosalone exposure. Analysis of human breast milk collected from women in southern Kazakhstan found levels of

beta-hexachlorocyclohexane (an organochlorine pesticide residue) that were some of the highest concentrations published in scientific literature. Additional research in the region found high concentrations of this pesticide residue and dichloro-diphenyl-trichloroethane (DDT) compounds in children's blood. The Arctic is impacted by pesticide and herbicide-laden clouds of desert dust originating from both Asia and Africa where they are used to maximize crop yield and, ironically, to counter other threats to public health. Pesticides in Arctic animals and Inuit Indian breast milk have been documented. A recent concern in long range dust movement and those populations persistently exposed to these dust particulates is recent evidence that isotopes such as beryllium-7 may accumulate on dust particles as they move through the atmosphere. While the potential risk to human populations is not presently clear, this emerging issue in global dust movement is a research area of much concern.

Atmospheric Soils and Sediments and the USGS

Our research group at the USGS, Center for Coastal and Regional Marine Studies has documented increases in the numbers of airborne microorganisms in the US Virgin Islands, when the region is being impacted by African dust. The US Virgin Island data has shown that during dust events the number of organisms that can be cultured or observed using nucleic acid stains typically ranges from 2 to 10 times what is seen during normal/clear conditions (similar wind velocity and directions as seen during a dust event). Due to collaborative efforts, we are also currently conducting research in Mali, Africa and on the Mediterranean coastline of Turkey. These projects have been undertaken in order to understand the significance of what we are observing in the Caribbean versus dust cloud point of origin (Mali) and regions being impacted that are in closer proximity to the source (Turkey). We are also collaborating with NASA and the US Air Force to address the presence of microorganisms moving in Earth's atmosphere at high altitudes. Data obtained from Mali samples (**Figure 2**) indicates that approximately 90% of the organisms that start the airborne trip in Africa die before they reach our Caribbean sample site. While this may seem significant one should keep in mind that a single gram of soil contains on average of approximately a million bacteria cells and with a die off rate of 90%, that still leaves 100,000 viable bacteria -- and that's just in a single gram! Of those US Virgin Island isolates we have identified using DNA sequencing of the ribosomal gene, ~20% are species known to cause disease in a broad range of plant life and ~10% are known opportunistic human pathogens. New efforts undertaken this summer include DNA fingerprinting of the entire microbial community captured in our air samples (in order to identify uncultivable populations) and analysis of the previously observed viral community which are known to be present in our samples (microscopy and molecular techniques to define the virus community). Samples for use in screening dust events for pesticides and herbicides are currently being collected in the US Virgin Islands and radioisotope work on dust samples has shown extremely high levels of beryllium-7 and lead-210.

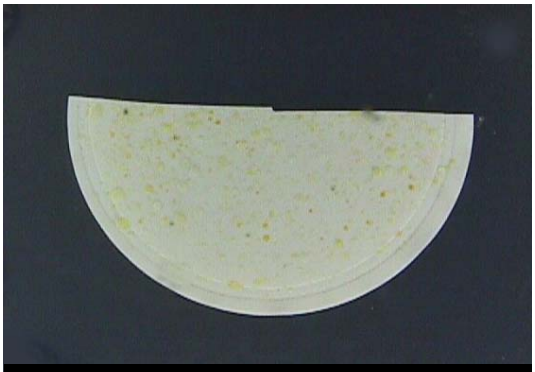

Figure 2. Mali, Africa atmospheric sample taken during a dust event and showing heavy growth of bacteria and fungi. Volume filtered was ~75 liters or the approximate volume of a 20 gallon aquarium.

This is but a short synopsis of what our research has shown us and where it is leading us. Our focus is currently human and ecosystem health (particularly coral reef health) as it relates to the long-range transport of African dust. Future efforts should expand into the Asian dust arena and collaborative efforts with USGS scientists currently involved in understanding dust issues in the American Midwest. For more specific information on our research data and the world of dust and health please see the following articles or website.

Griffin, D.W., C.A. Kellogg, V.H. Garrison and E.A. Shinn. 2002. The Global Transport of Dust: An atmospheric river of dust, microorganisms and toxic chemicals crosses oceans. *American Scientist.* **90**(3):228-235

Griffin, D.W., V.H. Garrison, J.R. Herman and E.A. Shinn. 2001. African Desert Dust in the Caribbean Atmosphere: Microbiology and Public Health. *Aerobiologia.* **17**(3):203-213

Griffin, D.W., C.A. Kellogg, and E.A. Shinn. 2001. Dust in the Wind: Long Range Transport of Dust in the Atmosphere and its Implications for Global Public and Ecosystem Health. *Global Change and Human Health.* **2**(1):20-33

Shinn, E. A., G.W. Smith, J.M. Prospero, P. Betzer, M.L. Hayes, V. Garrison, and R.T. Barber. 2000. African Dust and the Demise of Caribbean Coral Reefs. *Geological Research Letters* **27**: 3029-3032.

http://coastal.er.usgs.gov/african_dust/

Acknowledgements

Our research has been supported by funding from NASA's Earth Science and Public Health Program (grant # 7242-60050).

Upcoming Events

* A Medical Geology textbook being edited by Olle Selinus of the Swedish Geological Survey is making progress. Several USGS scientists are participating in this groundbreaking publication, scheduled date for publication is in early 2003.

* The Sixth International Symposium on Environmental Geochemistry will be held in Edinburgh, Scotland 7-11 September 2003. This should be a major conference bringing together scientists from many different disciplines and societies all interested in epidemio-ecology (even if they don't know it yet).

* Human Health Sciences: Geo Sciences: Bridging the Gap, Topical Session at the Annual Meeting of Geological Society of America will be held in Denver, Colorado 27-30 October 2002. For further information please visit www.geosociety.org/meetings/2002.

U.S. Geological Survey News

USGS Health Conference
Plans for the USGS National Conference on Health-Related Research are moving forward. We have yet to confirm the exact dates and hotel, but we are making progress. A draft "call for abstracts" has been developed and sent to outside reviewers for comment – we want to make sure that we appeal to the public health and biomedical community as well as biologists and earth scientists. A web site is being developed for on-line submission of abstracts. Lists of potential keynotes speakers, sponsors and partners have also been developed – additional suggestions are welcome.
Human Health web site:
The USGS human health web site has a new URL:
http://health.usgs.gov
This site contains the same information on USGS health-related activities that was formerly at the long and un-memorable www.usgs.gov/themes/environment_human _health.html
Please visit the site and provide any updates to Jan Hren (jhren@usgs.gov)
New listings/links welcome!

Hormone Disruption Research Act of 2002
HR 4709 was introduced in the House on May 9,2002, to amend the Public Health Services Act to authorize the Director of the National Institute of Environmental Health Sciences (NIEHS) to conduct and coordinate a research program on hormone disruption. The bill was referred to the Subcommittee on Research on May 15. This bill mentions the USGS' considerable experience assessing the occurrence of chemicals in the environment, ecological health, and the hazards to wildlife health and associated human health posed by chemicals in the environment, as a result of monitoring by the USGS of the Nation's water resources and wildlife disease, and research by the USGS on the effects of chemicals on wildlife. The bill calls for $500,000,000 for NIEHS for the 5-fiscal-year period beginning with fiscal year 2003. The Director of NIEHS may transfer funds to other Federal agencies to carry out the Director's responsibilities outlined in the bill.
Some of the language in HR 4709 which mentions USGS includes the following:
"...The Director of the Institute (NIEHS) shall establish within the Institute a comprehensive program to--
(A) conduct research on the impact of chemicals that affect human health through disruption of the hormone systems;
(B) conduct research on the occurrence of hormone disrupting chemicals in the environment and their effects on ecological and wildlife health, in cooperation with the United States Geological Survey (referred to in this section as the `USGS');
(C) coordinate the design of a multi-agency research initiative on hormone disruption;
(D) coordinate research on hormone disruption in the United States with such research conducted in other nations; ...
The Director of the Institute (NIEHS) shall have principal responsibility, in consultation with the Director of the USGS, for conducting and coordinating research on the effects of hormone disrupting chemicals on human health and the environment."
The full bill can be found at:
http://www.loc.gov/

Epidemio-ecology in the Media

Los Angeles Times

January 13, 2002 *Malcolm Ritter*

RESPONSE TO THE TERROR; Ground-Zero Workers Air Concerns Over Health Impact: Some firefighters and others around the World Trade Center site since the September 11 attack have had breathing problems – and wonder if the worst is yet to come.

Abstract:
It's too soon to tell how many firefighters will be permanently disabled and forced to retire because of the respiratory problems, said Fire Department spokesman Frank Gribbon. But so far about 30 firefighters have started the retirement process because of respiratory problems after working at the trade-center disaster, which either caused their lung ailments, or made prior ones worse, Gribbon's said. http://pqasb.pqarchiver.com/latimes/

Popular Science

June 19, 2002 *Paul Beck*

Cleaning up Old King Coal

Abstract:
Energy: Some say it's too big a job, but scientists would sure like to try. More than half of America's electricity comes from coal—and coal is dirty stuff, contributing mightily to smog, acid rain, and climate change. Can it be cleaned up? The government says yes: President Bush has pledged $2 billion for his Clean Coal Power Initiative. But environmentalists scoff at the idea. "The term 'clean coal' is like 'safe cigarettes,'" says David Hawkins of the National Resources Defense Council. "There's no such thing." Available technologies do little to reduce carbon dioxide emissions, critics say, and these emissions are a major contributor to climate change. What's more, coal has to be mined (often by tearing up irreplaceable ecosystems) and transported, producing substantial emissions before it's even burned.
http://www.popsci.com/popsci/science/article/0,12543,233031,00.html.

For more articles related to this issue's feature please visit any of the following hot links provided:

National Geographic
* China's Dust Storms Raise Fears of Impending Catastrophe
* Red Wind Blowing
* Did Mercury in "Little Blue Pills" Make Abraham Lincoln Erratic?

Popular Science
* Arsenic levels vary widely, but they are dangerously high in much of the country.
* Farmed fish are safer.

Scientific American
* A Touch of Poison
* Dangerously High Levels of Arsenic Found in Vietnamese Drinking Water
* Botanical Arsenic Sponge

The editors of this newsletter welcome

* Suggestions on what to include in future newsletters
* Suggestions on the newsletter format
* E-mail addresses of USGS people who may be interested in receiving copies of the newsletter. (Note: subscribers will
  receive e-mail notification of future editions of the newsletter that will be posted on a USGS website).
* Contributions

**For comments or contributions toward Upcoming Events or U.S. Geological Survey News please contact Samara Holtzman: sholtzman@usgs.gov: 703-648-6479.

In The Next Issue

Photographed at her home in Serbia in April 2002, this woman may be affected by an unusual and severe kidney disorder resulting from drinking well water in an area where low-rank coal deposits act as aquifers. Find out about Balkan Endemic Nephropathy in the next issue of Epidemio-Ecology News, November 2002.