THE GEOLOGICAL SOCIETY OF AMERICA®

GEOLOGY AND HEALTH DIVISION

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Geology and Health Division Newsletter

IN THIS ISSUE

Message from the Chair

by Malcolm Siegel, PhD, MPH

Dear fellow Medical Geologists

This past year, the COVID-19 pandemic has presented all of us with many new challenges; however, it has also provided some new opportunities. We have seen creative uses of internet technologies such as ZOOM and virtual reality to improve access to fieldtrips and virtual conferences. Many of these conferences have become more accessible due of their low costs because we don't have to pay for travel and lodging at remote conference sites. Some of these meetings are sponsored by professional societies or associations that are related to Medical Geology. For example, the International Society of Exposure Science held its annual conference virtually on August 30 to September 2, 2021. (General Information – International Society of Exposure Science (intlexposurescience.org)). Exposure science is an emerging scientific field that includes interests, techniques and a knowledge base which are very relevant to Medical Geology. The conference included sessions on topics such as application of sensors in exposure assessment, climate change, disparities in environmental exposure and health and emerging environmental exposures.

The widespread interest in infectious diseases, the immune system, and techniques to monitor the exposure's to COVID-19, has provided easily accessible resources on subjects such as environmental immunology, environmental and health impacts of wastewater effluent discharge, and information about the microbiome. These are topics that have previously gotten little exposure in the geological community, however, these linkages between the environment, human exposure, and diseases maybe become important areas of Medical Geology research in the future.

Despite the challenges presented by the pandemic, the Geology and Health Scientific Division had a successful 2020. At GSA CONNECTS 2020, our members presented one short course, one Pardee Symposium, and convened eight technical sessions. We had 81 presentations, 10 posters, and 52 workshop participants. **By one estimate, that's over 1,500 minutes of Geology and Health!** Our presence at the 2021 hybrid annual meeting (GSA CONNECTS 2021) promises to be impressive as well. Our Division members have organized one short course, five topical sessions, and cosponsor two other sessions and a Pardee Symposium. Our Medical Geology community has become more vibrant. During the past 12 months, more than 30 discussion items were posted on our Community Discussion Board and we had an active participation in our Facebook and Twitter accounts. This year, we awarded a student research grant and a Lifetime Achievement award and will award a student travel grant and a cash award for the best poster at the annual meeting. Please support these activities and our sessions at GSA CONNECTS 2021 as a way of increasing the impact of Medical Geology in the geosciences.

THE GEOLOGICAL SOCIETY OF AMERICA®
CONNECTS 2021
10–13 October
Portland, Oregon, USA

Student Poster Award

Attending GSA in Portland? Please help us judge research posters and determine the G&H student poster award winner

Geology & Health-Sponsored Sessions

Portland, Oregon
October 10-13, 2021

Geology & Health

G&H will have a table at the Annual Meeting Icebreaker. Please stop by to say 'hi' and pick up some swag!

Pardee Keynote Symposium
P3. Geoheritage: Celebrating Our Past, Protecting Our Future

G & H Technical Sessions
T26. Environmental Geochemistry and Health

T50. Arsenic, Fluoride, and Other Geogenic Contaminants in Groundwater Basins: Linking Advances in Natural Sciences and Applications of Artificial Intelligence and Data Science for Long-Term Risk Prediction and Policy Interventions

T57. Secured Groundwater towards a Sustainable Earth

T126. Source, Fate, and Roles of Natural Organic Matter in Geochemical Cycling of Metals and Metalloids in Surface and Groundwater Systems

T148. Head, Shoulders, Knees, and Toes: Delineating Biogeochemical and Metabolic Pathways Linking Environmental Exposures and Human Health

T150. Recent Advances in Geology and Health (Posters)

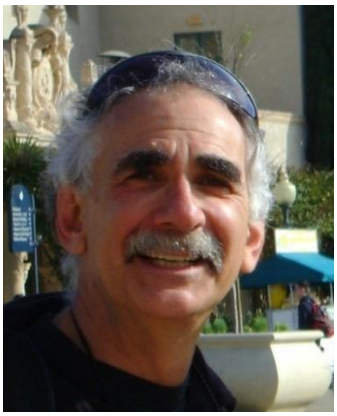
T 151. That Signpost up Ahead: At the Crossroads of Geoscience and Society-A Public Policy Perspective (I and II)

G&H Business Meeting

Join us in Portland for G&H annual business meeting
Tuesday, October 12, 2021, 6:30-8:30 PM
at
Lucky Labrador Brewing
915 S.E. Hawthorne Blvd
Portland, OR

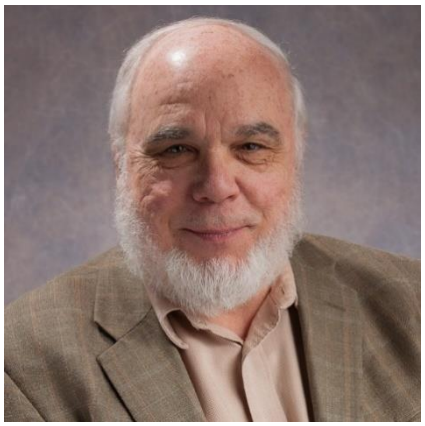
New Officer Introductions, awards, and social hour

Meet the Current G & H Board



Malcolm Siegel, Chair

Throughout my career, I have specialized in the geochemistry, treatment, and public health assessment of water resources. However, it wasn't until I was in my mid-50's that I discovered that I wanted to be a Medical Geologist when I grew up. I hold a BA in Chemistry from Columbia University and a PhD in Geological Sciences/Geochemistry from Harvard University and in 2004, I received a Master of Public Health/Epidemiology degree from the School of Medicine at the University of New Mexico. During a 30-year career at Sandia National Laboratories, Albuquerque, New Mexico (1981-2011), I led research teams involved in studies of environmental geochemistry, groundwater remediation, and drinking water treatment for the US Department of Energy. My work also included studies of environmental impacts of uranium mining and experimental studies of treatment of groundwaters with high radionuclide and arsenic levels in rural New Mexico. I retired from Sandia Labs in December 2011 and am currently on the adjunct faculty in the Department of Internal Medicine at the University of New Mexico. Over the past 20 years, I have taught courses in geochemical modeling, environmental surface chemistry and environmental health at UNM and I was part of a School of Medicine team that examined the relationship between skin cancer and the combined exposures to sunlight and arsenic in drinking water in New Mexico. As Vice President of LJS Consulting, my projects have included evaluation of environmental impacts of a uranium processing plant for the Bureau of Indian Affairs and treatment studies for a new uranium sorbent for private industry. I am an editor of the book, *Practical Applications of Medical Geology*, which was recently published by Springer International Publishing.



Nelson Eby, 1st Vice Chair

I am a Professor in the Department of Environmental, Earth and Atmospheric Sciences at the University of Massachusetts Lowell (UML). My general area of expertise is geochemistry, but I have eclectic interests that range from forensic geology to archaeology. Recent projects include - characterizing the glass (Trintite) produced during the first atomic bomb blast, petrology and geochemistry of the Coastal New England dike swarm, using tree-ring cores to map environmental change and atmospheric pollutants, identifying specific contaminant components associated with a zinc smelter, and determining the source of metals in dusts.

I have taught a variety of courses including Earth Systems, Environmental Geochemistry, Mineralogy, Igneous and Metamorphic Petrology, Sedimentation and Stratigraphy, Geology for Engineers, Forensic Geology, and Structural Geology. The result is that I have broad perspective of the geosciences. My editorial experience includes Editor-in-Chief for *Lithos*, Regional Editor for the *Journal of African Earth Sciences*, and Associate Editor for *Canadian Mineralogist*. I am a Fellow of the American Mineralogical Society, the Geological Society of America, and the Geological Society of London.

Laura S. Ruhl, 2nd Vice Chair

I have been interested in Medical Geology since I was an undergraduate student and bought myself a copy of The Essentials of Medical Geology (first edition). I'd always been interested in the natural world around me and that of human health, so medical geology was a natural fit. I continued pursuing this interest throughout my academic career and continue with health and environmental research today. While I enjoy learning about all things Medical Geology related, my research focuses on water chemistry associated with energy resources and mining, development and application of environmental isotopic tracers, urban geochemistry and hydrology, health issues related to water chemistry, and medical geology issues related to human stone growth.

I received my BS and MS degrees in Geological Sciences from the University of Florida in 2006 and 2008, respectively. In 2012, I completed my PhD at Duke University in Earth and Ocean Sciences. I then became an assistant professor then associate professor at the University of Arkansas at Little Rock in the Earth Science Department. I teach a variety of classes including hydrogeology, geochemistry, environmental geology, geology and ecology of the Bahamas, physical geology, medical geology, and field geology to undergraduate and graduate students.

Saugata Datta, Past-Chair

I am a Professor of Hydrogeology and Aqueous Geochemistry at University of Texas at San Antonio-Geological Sciences. My research interests focus on issues of water resources, water availability, and understanding the cycling of different metals and organic compounds in groundwaters, surface waters, soils, and sediments, as well as how land use pattern changes affect the distribution of such metals and pollutants in our environments. Every one of my research projects with students has prominent health impact studies associated, targeting both human and ecosystem health. Along with research, I teach and mentor graduate and undergraduate students and develop courses for students at UTSA, high school-community teaching in San Antonio and schools in Mexico, India and Argentina. My firsthand affiliation with Geology and Health is through research, students and mentors, and having served this Division for many years including 1st Vice Chair, 2nd Vice Chair, Chair, and now Past Chair.

Jean Morrison, Secretary-Treasurer

I am a Research Geologist at the U.S. Geological Survey in Denver, CO and received a BS in Geology from the University of Wisconsin, a MS in Environmental Science and Engineering from the Colorado School of Mines, and a PhD in Geochemistry from the Colorado School of Mines. My research focus is low temperature geochemistry as it relates to trace element mobilization in the environment. I have studied the environmental effects of stream quality from historic mining, the geologic controls on the distribution and mobilization of trace elements and how anthropogenic effects perturbate natural weathering. The same geochemical techniques can be used to identify covered mineral deposits which can help locate mineral deposits for exploration and/or understand their natural environmental signature prior to mining.

I have been a member of GSA since 1999 and a member of the Geology and Health Division since 2009. I have co-chaired several Geology and Heath Division-sponsored sessions at Annual GSA meetings and have served as Newsletter Editor from 2011-2020. I've been impressed with renewed member engagement in the last year. As Secretary-Treasurer of the Division, I will provide updates from the board and look to members for feedback for Geology and Health-related news and events.

Ann Ojeda, Communications Chair

I am an Assistant Professor in the Department of Geosciences at Auburn University. I earned a PhD from University of Oklahoma in Geology with a focus in environmental geochemistry. My research focus is integrating geochemistry and public health to address questions related to water quality and water contamination from organic compounds. Many of my projects use chemical forensic techniques like stable isotope signatures and multi-variate statistics to understand sources as well as fate and transport of organic material. I teach several courses at Auburn including Environmental Geochemistry and Aqueous and Environmental Geochemistry.

I serve as the Chair of the Communications Committee of the Division. I organize our social media accounts (join the conversations on Facebook and Instagram!) and publicize GHD happenings through the Community Board. If you have research updates or ways in which you incorporate geology and health into your courses, I'd love to share those with our community.

Reto Giere, Member-at-Large

Reto is a Professor of Earth and Environmental Science at the University of Pennsylvania. He received his PhD from ETH Zürich, Switzerland, and has held appointments at Purdue University, the Australian Nuclear Science & Technology Organization, Albert-Ludwigs-Universität in Freiburg, and the Carnegie Institution for Science, amongst others. His broad research interests involve environmental geochemistry, energy and waste, mineralogy and petrology, and health impacts of atmospheric pollution. Reto is a member of the University of Pennsylvania's Center for Excellence in Environmental Toxicology (CEET). Additionally, Reto is an Editor of the Journal of Petrology and Chief Editor of the European Journal of Mineralogy.

Tom Varner, Student Organizing Committee

I am a PhD student at the University of Texas at San Antonio in the Environmental Sciences and Engineering program. I received a BS in Geology from the University of Mississippi in 2018, where I was introduced to the field of Medical Geology and have since been interested in the relationship between geologic processes and human health. My research examines the mechanisms responsible for the release of arsenic from sediments into the drinking water aquifers along the Meghna River, Bangladesh. My current project focuses on the impacts of iron enrichment in riverbank sediments as an oxyanion regulator between the inland aquifer and the river.

As the Student Representative of the Geology and Health Division I aim to connect new students with the Division and to increase the student member involvement. If you are interested in finding out more about the Division or the field of Medical Geology, I would love to hear from you. You may also message us through our GSA Geology and Health Facebook page.

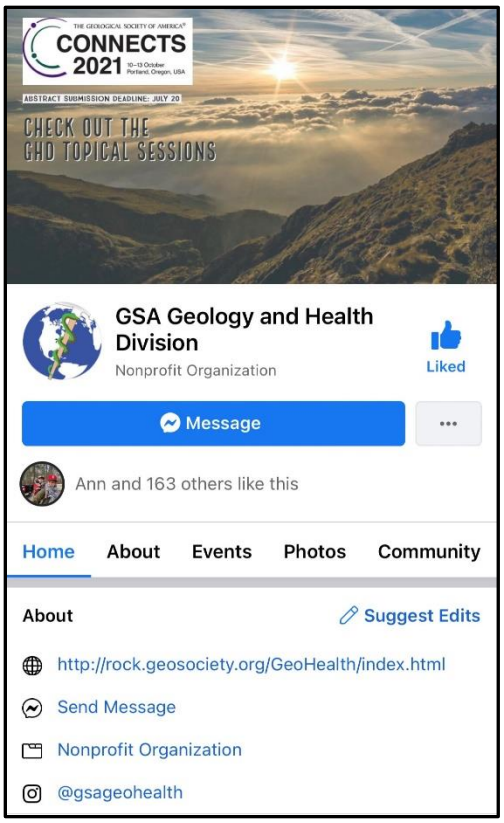
G&H Committee Updates

Communications Committee

The goal of the Communications Committee is to connect the Division members to resources, research, and opportunities in the field of geology and health. We have a broad and diverse membership base, and through this committee, I hope that we can expand the reach of our Division. In the last year, we've continued our social media presence on Facebook and Instagram with news, research highlights, and featured research articles of geology and health. We also use social media platforms to promote Geology and Health sponsored events for GSA 2021 by highlighting sessions and workshops leading up to the meeting.

You can connect with us on the Geology and Health Community Page on the Division website (https://community.geosociety.org/geologyhealthdivision/home). If you have ideas for content or resources to share, I'm happy to discuss or make those available.

Join the conversations on social media by searching @gsageohealth on Facebook and Instagram and be sure to check your email for updates and events through the Community Board.



Awards and Service Opportunities

Student Research and Travel Grants

The Division presents grants annually for Student Research and Travel Grants to GSA meetings.

Any student presenting a poster in a Geology and Health-sponsored session will automatically be eligible for Best Poster Award at GSA Annual Meeting.

We are looking for members to serve on the award committee.

Committee Service

Members are needed to lead and serve on Division committees.

Some committees are: Membership, Awards, Student, and Funding. The time commitment is modest, and your service will help maintain the sustainability of the Division.

GSA Community Website

Do you know that GSA has Community pages that allow Divisions to post questions, comments, job postings, and information? Share all your G&H-related information with your colleagues by logging into the GSA Member Community website: (https://community.geosociety.org).

Students: The Future of Geology & Health Research

Congratulations to Jonas Toupal! The winner a $1000 G&H student research grant!

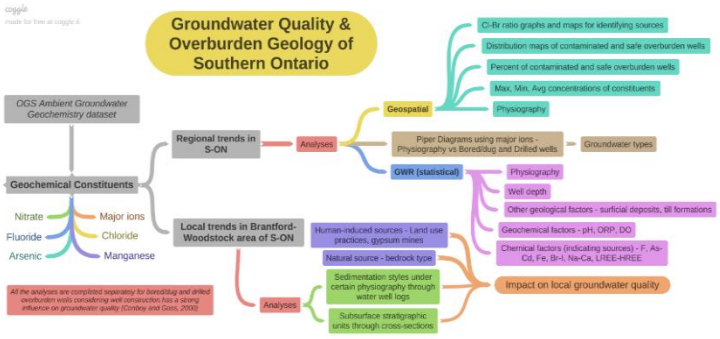
Jonas Toupal is PhD student in Geochemistry at the University of Pennsylvania. His areas of interest are environmental geochemistry, lithium deposits, and remediation of mining areas. His goal is to work in remediation of polluted mining areas.

Jonas's research is focused on studying the potential environmental contamination resulting from development of lithium hard rock deposits. Such deposits are common around the globe, but due to the difficult and expensive nature of retrieving lithium from these minerals, they have not been extensively mined in the past. With lithium demand increasing as a result of personal electronics and electric vehicle popularity, these deposits are becoming economically viable. It is important to know the possible geochemical signatures before they are developed on large scale around the world. The primary goal of the project is to understand which elements are likely to be leached from mining of Li-minerals and what concentrations might they be found in. Lithium, fluorine, and cesium are the elements of interest, as they are present in the minerals and potentially harmful in drinking water. ICP-OES and Ion Chromatography are the main tools employed.

Congratulations to Nazia Narwin and Mahfujur Rahman! The winners of 2020 Annual Meeting G&H Poster Awards!

Nazia Narwin

MSc candidate, School of Environmental Sciences, University of Guelph, Ontario, Canada



Poster Presentation: DISTRIBUTION OF ARSENIC, FLUORIDE AND MANGANESE IN OVERBURDEN WATER WELLS, SOUTHERN ONTARIO, CANADA

Nazia Nawrin received her BSc and MSc (specialization in Hydrogeology) from the University of Dhaka, Bangladesh. She has been working as a faculty member (Lecturer) at University of Dhaka since 2017 and is currently on study leave to pursue her second MSc degree in Environmental Science at the University of Guelph, Canada. Nazia's research mainly focuses on the groundwater quality and overburden geology of southern Ontario, Canada based on the OGS ambient groundwater geochemical data, OGS physiographic map, and OGS three-dimensional surficial deposits mapping.

Research Statement: Groundwater can be affected by surface or subsurface, as well as anthropogenic or naturally occurring contaminants, while subsurface geology affects the distribution and transmission of the contaminants into aquifers. The current physiography of southern Ontario, Canada was significantly influenced by Quaternary glacial events, resulting in complex overburden (shallow subsurface) geology over the bedrock. This investigation builds on the Ontario geological survey (OGS) Ambient Groundwater Geochemistry (AGG) dataset by integrating the OGS physiographic map and 3D surficial deposit mapping in the Brantford-Woodstock area of southern Ontario to help examine the possible geological influence on groundwater quality. The study mainly focuses on the distribution of five geochemical constituents - arsenic, fluoride, manganese, chloride, and nitrate in 515 bored/dug and drilled wells completed in overburden sediment of specific physiography (e.g., Till Moraines, Bevelled Till Plains, Drumlins, Clay Plains etc.) across southern Ontario. Geospatial analysis of these five constituent concentrations and physiographic features that have sufficient number of water wells from AGG dataset, showed the distribution of impacted water wells and level of contamination throughout southern Ontario. The results of geospatial and GWR analyses of groundwater geochemistry and geology may help us to assess whether physiography can be used to predict water well susceptibility and to inform future water quality management at a regional scale.

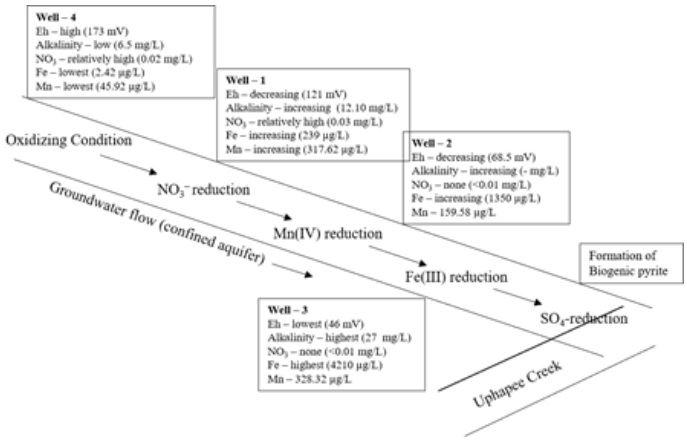
Mahfujur Rahman

PhD candidate, Department of Geosciences, Auburn University, Auburn, Alabama

Poster Presentation: GEOCHEMISTRY OF GROUNDWATER AND NATURALLY OCCURRING BIOGENIC PYRITE IN THE HOLOCENE FLUVIAL AQUIFERS IN UPHAPEE WATERSHED, MACON COUNTY, ALABAMA

Mahfujur Rahman received his BSc and MSc (Hydrogeology) from the University of Dhaka, Bangladesh. He subsequently earned another MS in Geology (Hydrogeology) from Auburn University and is currently a PhD student in the Department of Geosciences, Auburn University. His research focuses on the geochemistry of naturally occurring arsenic contaminated groundwater and arsenic bioremediation.

Research Statement: Arsenic (As) is one of the most common metalloid contaminants found in groundwater in Holocene alluvial aquifers worldwide including the United States. The study area for this research was in Macon County, Alabama. The main objectives were to (i) determine the geochemistry of groundwater and naturally occurring biogenic pyrite in a natural fluvial aquifer along groundwater flow path near Uphapee Creek; (ii) understand the biogeochemical reactions controlling the fate and transport of As and other trace elements under changing redox condition; and (iii) assess the capability of naturally formed biogenic pyrite to sequester As. Electron microprobe (EMP) analysis showed that the pyrite grains contain 0.20–0.92 wt.% of As. The scanning electron microscope and energy dispersive spectroscopy (SEM-EDS) also confirmed similar level of As and the presence of additional trace elements such as cobalt (0.19 wt.%) and nickel (0.15 wt.%), indicative of pyrite's capacity to sequester As and other trace elements. Inductively coupled plasma mass spectrometry (ICP-MS) analysis showed that the As concentration in the groundwater was not high, and it was within the EPA drinking water standard. Groundwater geochemistry data indicated a redox sequence of oxidation, denitrification, Mn(IV) reduction, Fe(III) reduction, and sulfate reduction along the flow path in the fluvial aquifer. The downgradient increases in dissolved Mn and then Fe concentrations reflect increased Mn(II) and Fe(II) production via microbial competition as the aquifer becomes progressively more reduced. Bacterial sulfate reduction seems to dominate near the end of the groundwater flow path, as the availability of Mn- and Fe-oxyhydroxides becomes limited in sediments rich in lignitic wood where increasing sulfate reduction leads to the formation of biogenic pyrite. The groundwater is a Ca-SO_4 type and is not SO_4 limited; thus, sulfate may serve as an electron acceptor for the bacterial sulfate-reducing reactions that sequester As into pyrite, which in turn results in very low groundwater As concentration (<2 µg/L).



Student Research Spotlight

Colloidal silver enhanced ceramic water filter: Aiding in the water crisis

Erin Smith, Mercyhurst University, PA

On a global scale, water-borne diseases are a direct cause of 2 million annual deaths as the only accessible drinking water is contaminated for 1.8 billion people. Multiple organizations, such as UNICEF, WHO, and Potters for Peace, have attempted to alleviate this profound inadequacy of potable water for so many. Often, water filtration systems at the point of source of the water are less effective and more economically burdensome. More current research shows that improvements in technology will lead to more affordable at-home, or point-of-use, water treatment systems. The use of ceramic water filters, aided by colloidal silver for bacterial removal, have shown effectiveness in removing total coliforms and *E. coli* at 87% and 92%, respectively. Ceramic filters constructed in a concave form are categorized as Gravity Driven Membranes (GDM), meaning there is no outside source of energy other than gravity acting upon the filter. This type of gravity-driven filtration is one of the leading differences in cost effectiveness when comparing point-of-source and point-of-use water filters. UNICEF sources put this type of ceramic filter at $20.00 per family. Silver has been used for purification of water for more than 2,000 years and recent research shows that “increased penetration of silver into the bacterial cell… leads to bacterial cell death”. The cost and effectiveness of colloidal silver enhanced ceramic water filters utilizing a GMD demonstrates significant promise as a dependable point-of-use water filter for those facing the water crisis. An at-home test run of this water filter has demonstrated an ease to its creation and use. With a background in ceramics, it was simple to add sawdust to the clay to increase porosity and therefore, the filtration abilities of the vessel. After filtering a few rounds of water from an unfiltered, outdoor source, a multimeter test proved the cleanliness of the water. Additional nitrate, nitrite, and at-home water bacterial tests also proved to show the success of the filter. At an approximation of $20.00 per family, it is clear these simple filters can efficiently and effectively filter water with minimal energy input.

The role of river water-groundwater mixing on iron and arsenic cycling in Bangladesh

Kyungwon Kwak (TAMU), Peter S.K. Knappett (TAMU), M Bayani Cardenas (UT Austin, and Saugata Datta (UTSA)

The arsenic contamination of groundwater has led to adverse health effects in Bangladesh over the past decades. The shallow alluvial aquifers in Bangladesh typically have high concentrations of geogenic arsenic (As), which exceed the World Health Organization's (WHO) drinking water limit of 10 µg/L. The Meghna River gains groundwater from these shallow aquifers for most of the year, and typically has very low As concentrations that are often below detection limits. Where does the As go? A possible answer is the dynamic mixing zones in the Meghna riverbanks. Arsenic adsorbs on the surfaces of iron (Fe) oxides and can be released to pore-waters when the Fe oxide minerals are reductively dissolved. A dynamic mixing zone of Fe-reducing groundwater and oxidizing surface water operates under tidal and seasonal fluctuations. These dynamic mixing zones containing reactive Fe-oxides potentially act as both sinks and sources of As within the hyporheic zone along the Meghna River. The objective of my current research is to better understand the role of mixing between groundwater and river-water on As and Fe cycling in the riverbanks.

We collected and analyzed groundwater and river water samples during the early dry season. We found that concentrations of dissolved As, Fe, DOC, DIC, and ammonium increased towards the river (Fig. 1), while the conservative tracers ($\delta^{18}O$, chloride, and specific conductance) decreased towards the river. These findings indicate that, even with mixing with oxidizing river water, the Fe oxides experience significant reductive dissolution which deplete the available adsorption sites for As. We hypothesize that overbank organic mud deposits might be responsible for providing enough DOC to drive reductive dissolution of Fe oxides. Future work would include geochemical modeling using PHREEQC and COMSOL Multiphysics to identify the chemical reactions responsible for the observed fluxes and concentrations.

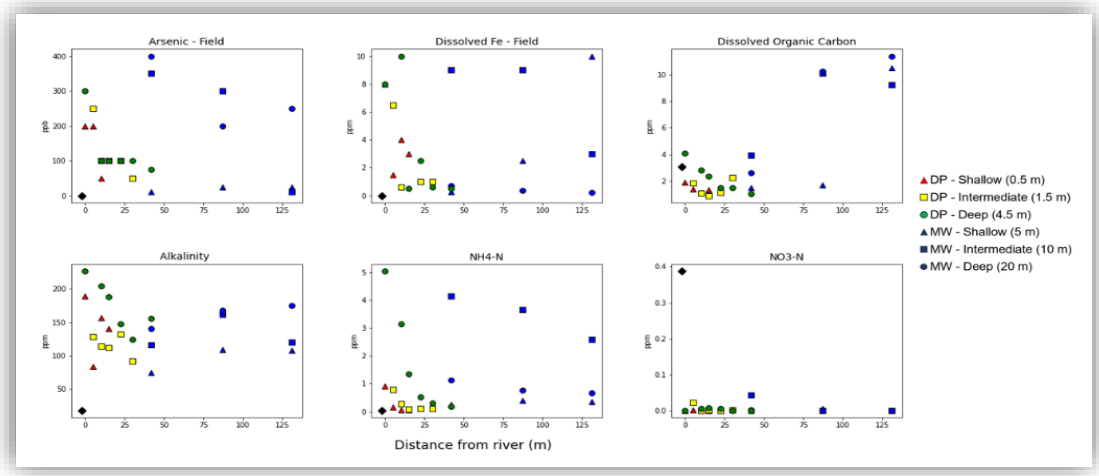


Figure SEQ Figure * ARABIC 1. Concentration profile (Dissolved As, Fe, DOC, DIC, NH4-N, NO3-N)

Medical Geology Perspectives: Exposure Science and Medical Geology

By Malcolm Siegel, PhD, MPH

Exposure and dose assessment is the key interface between geology and human health. The emerging field of Exposure Science provides useful techniques and unifying concepts that could be useful to medical geologists in facilitating communication and collaboration with biomedical environmental health scientists.

According to the National Academy of Sciences (NAS, 2017), due to recent advances in biomedical techniques, the distinction between exposure and dose is now arbitrary. They suggested eliminating the term *dose* and defined *exposure* as the contact between a *stressor* and a *receptor* at *any level* of biological organization. Populations, individuals, organ systems and single cells are different levels of biological organization. This concept is illustrated in the diagram below. Here, the *exposure-epidemiology* interface occurs at the contact between the presence of a substance in the general environment and a specific exposure medium, such as air, water, or soil. The *exposure -toxicology* interface occurs where the exposure medium comes into contact with a human through external exposure.

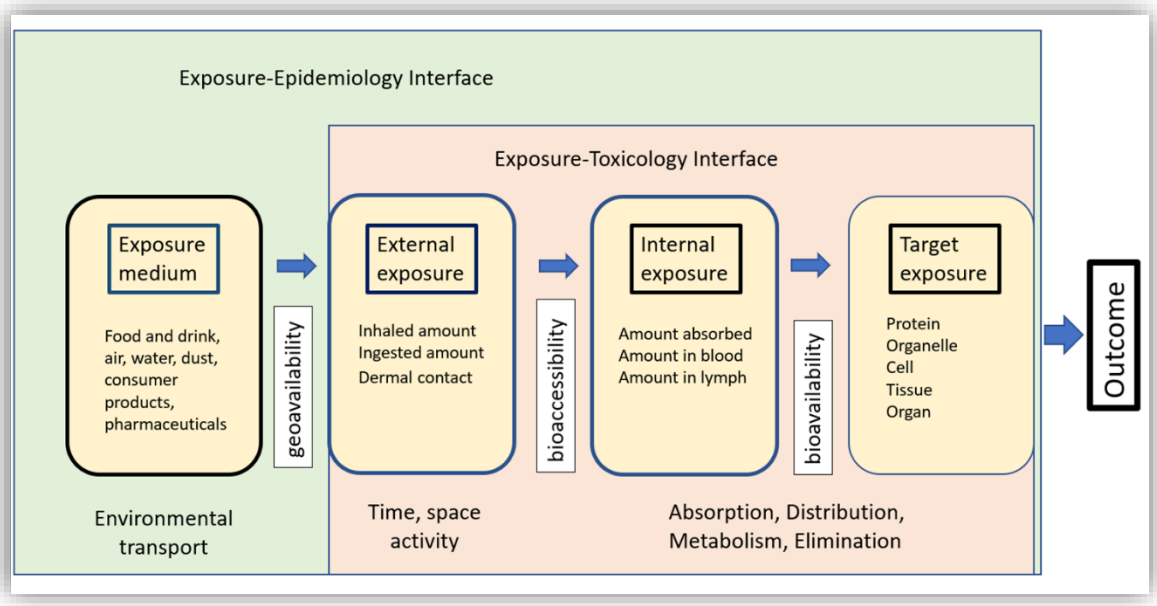


Figure 1. Wild, C.P. (2012). International Epidemiological Association 41:21-42.

Transfers between the compartments in the above figures are controlled by physical, biological, hydrogeochemical and biochemical processes. Thus, the amount of a contaminant that reaches a potentially exposed population is characterized by a *geoavailability* that is controlled by transport and biogeochemical interactions. The amount of ingested contaminant that reaches a biologically important site in the body is controlled by its *bioaccessibility* and *bioavailability*, which are controlled by biochemical and physiological processes.

One of the important tools in Exposure Science is the use of *physiologically-based pharmacokinetic models*. In these models, different organs are represented as compartments; transfer between compartments is characterized by a flux. This kind of modeling should be familiar with geochemists who have modeled earth systems for decades. The pharmacokinetic models can be run in the *forward* direction: that is starting with external exposures and seeing how they lead to target exposure and health effects. Alternatively, these models can be run in the *reverse* direction, using measured concentrations of chemicals in different body fluids, and then working backwards to infer external exposure.

Much of current research in Exposure Science is formulated within the frameworks of the *exposome* and *omics* technologies. The former is defined as the totality of a person's exposure from conception to death. It includes *general external exposures*, *specific external exposures* from the environment and *internal exposures* within the biological environment of the human body.

Omics technologies deal with the characterization of groups of biological molecules that control the structure, function, and dynamics of an organism. These include 1) *genomic* studies in which the DNA in people who have and do not have a disease or condition of interest are compared,2) *epigenomics*, the analysis of chemicals that regulate gene expression or function, 3) *adductomics*, the analysis of chemicals that bind to DNA or selected proteins and interfere with DNA function or replication, 4) *transcriptomics*, the analysis of variations in RNA that prevent the process of transcription and synthesis of proteins, and 5) other emerging techniques.

This leads to concepts that are particularly relevant to medical geologists: – the *bottom up* and *top-down* approaches in Exposure Science and the *meet in the middle* concept. In the *bottom-up approach*, research is focused on each category of external exposure and use omics technologies to find *biomarkers of exposure* to characterize individual exposomes. The second, complementary approach, the *top-down approach*, focuses on *biomarkers of effects* and uses untargeted omic methods to characterize the different chemical markers related to health status in a single sample of biological fluid. The omic profiles of diseased and healthy individuals are compared and then hypotheses are generated to identify particular exposures. Each of these approaches is characterized by significant uncertainties, however, this *meet in the middle approach* leads to reduction in the uncertainty when they arrive at similar conclusions.

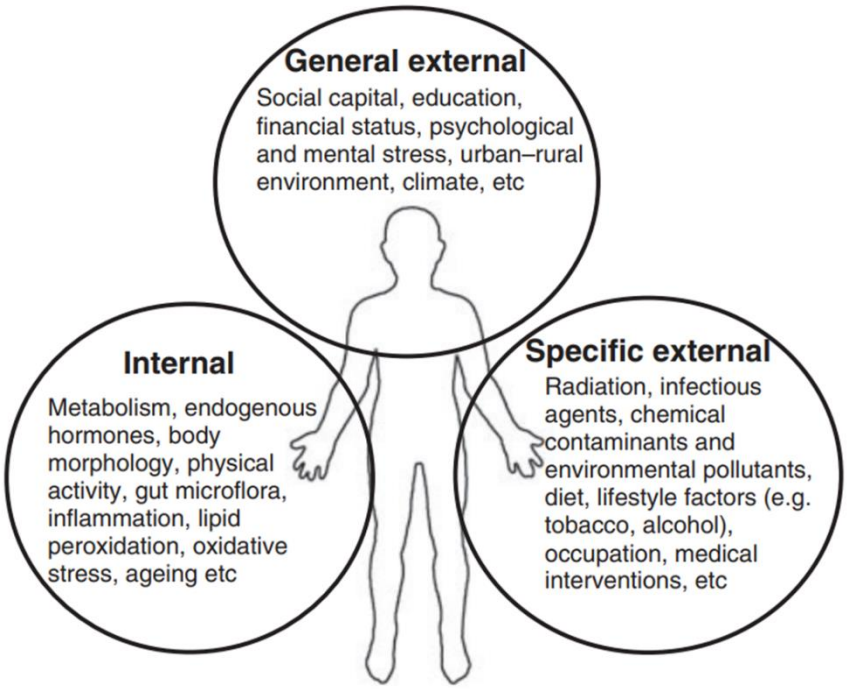


Figure 2 Exposome: the totality of a person's exposure from conception to death

These concepts, such as the exposome and omics technologies, are familiar to environmental health professionals but in future should be in the standard toolbox of medical geologists. The publication by the National Academy mentioned above provides an accessible summary of the state- of -the art as of 2017. Journals such *Environmental Health Perspectives* and the International Society of Exposure Science report recent research. At the GSA2020 Connects Online conference in October 2020, our Division organized Session T209, *It's the Dose that Makes the Poison: Advances in exposure and dose assessment for practical Medical Geology*. Wiley Interscience has expressed interest in soliciting a proposal on the subject for a book in the American Geophysical Union series on Geohealth. This demonstrates the growing interest in this field and if you are interested in participating in such a project, please contact me to discuss it.

National Academies of Sciences, Engineering, and Medicine 2017. Using 21st Century Science to Improve Risk-Related Evaluations. Washington, DC: The National Academies Press. https://doi.org/10.17226/24635

2021 MEMBERSHIP INFORMATION

230
Total Members

69 (30%)
Member/Fellow

90 (39%)
Senior Member/Fellow

0 (0.0%)
Honorary Fellow

16 (7%)
Early Career

51 (22%)
Student

2 (1%)
K-12 Teacher

2 (1%)
Affiliate

Membership Information by year

	2016	2017	2018	2019	2020	2021
Member/Fellow	72	69	87	87	69	69
Senior Member/Fellow	57	65	65	65	81	90
Honorary Fellow	0	0	0	1	0	0
Early Career	18	19	21	21	10	16
Student	62	46	54	54	35	51
K-12 Teacher	0	0	2	2	4	2
Affiliate	2	3	3	3	3	2
Total	211	202	233	233	202	230

Financial Information

As of 8/2021 Total Funds in G&H $9510.10

Upcoming Meetings

2021 GSA Annual Meeting 10-13 Oct 2021
Portland, OR

2021 American Public Health 24-27 Oct 2021
Association (APHA)
Denver, CO & Online

2021 ASA, CSSA, SSSA
International Annual Meeting 7-10 Nov 2021
Salt Lake City, UT
or Limited Virtual

2021 SETAC North America 42nd 14-18 Nov 2021
Annual Meeting
FULLY VIRTUAL

2021 AGU Fall Meeting 13-17 Dec 2021
New Orleans, LA & Online

2022 GSA Section Meeting 14-15 March 2022
South-Central Section
McAllen, TX
Abstract Deadline Dec. 7

2022 GSA Joint Section Meeting 15-17 March 2022
Cordilleran & Rocky Mountain
Las Vegas, NV
Abstract Deadline Dec. 7

2022 GSA Joint Section Meeting 7-8 April 2022
North-Central Section
Southeastern
Cincinnati, OH
Abstract Deadline Dec. 14

October 2021

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

November 2021

S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

December 2021

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	