

THE STATE OF SOUTH CAROLINA

In the Court of Appeals

APPEAL FROM THE ADMINISTRATIVE LAW COURT

Shirley C. Robinson, Administrative Law Judge

Appellate Case No. 2017-000066

RECEIVED

APR 20 2017

SC Court of Appeals

Pickens County,

vs.

Appellant,

South Carolina Department of Health and Environmental and
MRR Pickens, LLC,

Respondents.

**REPLY IN SUPPORT OF INTERVENORS' MOTION
TO BE INCLUDED AS APPELLANTS**

TO: THE COURT OF APPEALS AND ALL PARTIES AND THEIR ATTORNEYS

The Intervenor Robert L. Traber, Matthew S. Stone, Randolph E. Revis, Sr., by P.R. Randy Martin, Tony Charping and Randall King hereby submit this Reply to move the Court for an Order including them as Appellants in this case.

Intervention is not Moot Because this Court has Jurisdiction over an Ongoing Case

In their joint response, respondents make two faulty arguments. The first is that the Administrative Law Court ("ALC") lacks subject-matter jurisdiction over the underlying case, thus rendering the motion to intervene in that case moot. This interpretation of the ALC's final order is contrary to its explicit words stating: "Both respondents have framed portions of their arguments using the term subject-matter jurisdiction. As a preliminary matter, the Court notes

that it has subject-matter jurisdiction over this case.” (Motion for Intervenor to be Included, Exhibit C, ALC Order at 2). The cases cited by respondents are inapposite, as they involve circumstances where the ALC found itself to be without jurisdiction, which again is not the case here. See W. Carolina Reg'l Sewer Auth. v. DHEC, 96-ALJ-07-0547-CC, 1997 WL 435927, at *1 (Apr. 10, 1997); Thomas & Victoria Rogers v. DHEC, 01-ALJ-07-0402-CC, 2001 WL 1397451, at *2 (Oct. 23, 2001); Brenda Bryant v. DHEC, 01-ALJ-07-0404-CC, 2001 WL 1326513, at *4 (Oct. 9, 2001). Since the ALC had jurisdiction over the underlying case, and this Court has appellate jurisdiction, Intervenor’s Motion to be Included is not moot.

This case is also easily distinguishable from Reichlyn, upon which respondents rely heavily. See Ex parte Reichlyn, 310 S.C. 495, 500, 427 S.E.2d 661, 664 (1993) (denying intervention after the parties had entered into a consent order). In Reichlyn, DHEC was enforcing compliance with remediation measures against a chemical company going through Chapter 11 bankruptcy. Id. at 497, 427 S.E.2d at 662-63. DHEC and the company reached a settlement that involved dismissing the bankruptcy. Id. After that bankruptcy was dismissed and the settlement agreement was formalized into a consent order, one of the parties to the bankruptcy proceeding sought to intervene in the DHEC enforcement proceeding. Id. The court relied on the prejudice to the parties of having to renegotiate a settlement and the fact that the consent order was already entered to deny intervention. Id. at 500, 427 S.E.2d at 664. In this case, intervention would not prejudice the parties to any extent. Respondents allege no prejudice, and there is none, in allowing intervenors to participate in the appeal. Intervenor is already represented by counsel for an existing party in the suit, and as adjacent property owners to the landfill site, they have a real and substantial interest in being part of this appeal. Furthermore, in this case, unlike

Reichlyn, there is ongoing judicial action for the intervenors to join. Id. at 500, 427 S.E.2d at 664.

Intervenors are Aggrieved Parties who Properly Sought Party Status in the ALC

Respondents' second argument, which is similarly unpersuasive, is that intervenors did not properly seek party status in the ALC and were not entitled to be admitted because they were not aggrieved by the action. ALC Rule 2(H) defines a party to a case as "each person or agency named or admitted as a party or **properly seeking** and entitled to be admitted as a party, including a license or permit applicant." S.C.A.L.C.R. 2(H) (emphasis added). Furthermore, "[o]nly a party aggrieved by an order, judgment, sentence or decision may appeal." S.C.A.C.R. 201(b). Intervenors, by filing a motion to intervene and demonstrating their real property interests implicated in the outcome of this case, were "properly seeking and entitled to be admitted as a party" before the ALC. S.C.A.L.C.R. 2(H). Thus, they were parties to the ALC case and should now be included as Appellants in the appeal before this Court. Dismissal of the case in the ALC for failure to exhaust administrative remedies dismissed the Intervenors' case against the Defendants as well, and the ALC's failure to rule on the Intervenors' motion should not be allowed to subjugate that fact.

When intervenors filed their motion to intervene on August 18, 2016, it was to intervene in an active case before the ALC. The motion to intervene was filed well before the ALC ordered dismissal on December 12, 2016. Therefore, intervenors did "properly seek" admission into an active case. Respondents cite Home Health for the proposition that intervenors have not properly sought admission into the case before the ALC. (Response at 8). However, the circumstances in Home Health were substantially different, as "Home Health Services, though it had notice of [the

permit application], **never sought to be admitted as a party to any of the administrative proceedings.**" Home Health Servs., Inc. v. S.C. Dep't of Health & Env'tl. Control, 298 S.C. 258, 261, 379 S.E.2d 734, 736 (Ct. App. 1989) (emphasis added). In this case, though, intervenors did seek to be admitted in the administrative proceedings once they learned of the Permit Modification. (Motion for Intervenors to be Included, Exhibit D & Affidavits of Intervenors, Exhibit A, Motion to Intervene). Therefore, Home Health is inapposite.

Respondents also assert that intervenors are not aggrieved by dismissal of the case in which they sought to intervene, the subject of which impacts their properties adjacent to the landfill site. (Response 8-9). The Permit Modification is a redesign of the landfill made with the purpose of supporting coal ash disposal. (Coleman Depo. Excerpts at 189, Attached as Exhibit A). Coal ash, or CCR,¹ contains toxic chemicals, such as mercury, lead, and arsenic. (Vengosh Report at 2, Attached as Exhibit B²). Coal ash is a known carcinogen, and is highly soluble in water, which causes leaching and water contamination issues for the environment when not properly protected. (Id. at 3-4). Leaching of toxic elements of coal ash would be especially problematic for a Class Two landfill because it contains domestic materials that induce low pH and low dissolved oxygen. (Id. at 4). This creates a mixture that "would inevitably generate leaching process of CCR and mobilization of toxic contaminants to landfill effluents that could be leaked to the environment." (Id.) Adding a liner would not be sufficient prevent the release of coal ash into the surrounding environment from a Class Two landfill. (Id.) In addition to surface

¹ "CCR" stands for coal combustion residuals.

² Dr. Vengosh's Affidavit and CV are also included with his report in Exhibit B to this Reply.

water and groundwater contamination, disposal of coal ash can also lead to wind-blown resuspension of tiny coal ash particles to the atmosphere, which transports to nearby populations where it can be respired into human lungs. (Id. at 5). As adjoining landowners whose health, air and water would be impacted by coal ash disposal, intervenors are aggrieved by dismissal of the Permit Modification challenge to allowing such toxic materials to come in contact with their persons and lands.

The case respondents rely upon to assert that intervenors are not aggrieved presents strikingly different facts from those involved here. The Court in Powell denied intervention and standing of a bank in a dispute between family members of the deceased over apportionment of interpleaded funds. Powell ex rel. Kelley v. Bank of Am., 379 S.C. 437, 443, 665 S.E.2d 237, 241 (Ct. App. 2008). The bank did not have a direct interest in how the funds were apportioned between family members, or any interest in the funds whatsoever. Id. at 447-48, 665 S.E.2d at 243. In this case, however, intervenors are adjacent landowners to the landfill site whose property and health will be injured if coal ash is disposed of at the landfill. Therefore, they have a direct and imminent injury stemming from the issuance of the Permit Modification.

WHEREFORE, Intervenor request that this Court issue an order allowing Robert L. Traber, Matthew S. Stone, Randolph E. Revis, Sr. by P.R. Randy Martin, Tony Charping and Randall King to be added to the caption as Appellants and participate as parties to this appeal. Intervenor further request that the briefing deadline be held in abeyance pending a decision on this motion.

Respectfully submitted,



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PROJECT

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Attorneys for the Appellant and Intervenor

April 17, 2017

Georgetown, South Carolina

STATE OF SOUTH CAROLINA
COUNTY OF PICKENS

IN THE COURT OF COMMON PLEAS
THIRTEENTH JUDICIAL CIRCUIT
C/A NO.: 2016-CP-39-100

MRR PICKENS, LLC,

PLAINTIFF,

vs.

DEPOSITION TRANSCRIPT

KENT M. COLEMAN

COUNTY OF PICKENS AND WILLIAM CATO,
WELDON CLARK, ROBERT BALLENTIN, JO
JOHNSON, DENNIS REINERT, and BOB
YOUNG, individually and in their
official capacity as appointed
members of the PICKENS COUNTY
PLANNING COMMISSION,

MARCH 8, 2016

DEFENDANTS.

DEPOSITION ON THE ORAL EXAMINATION OF KENT M. COLEMAN
REPORTED BY KRISTA GIBSON, COURT REPORTER AND NOTARY PUBLIC IN AND
FOR THE STATE OF SOUTH CAROLINA; SAID DEPOSITION TAKEN PURSUANT TO
NOTICE AND IN ACCORDANCE WITH THE SOUTH CAROLINA RULES OF CIVIL
PROCEDURE AT THE LAW OFFICE OF WILLIAMS MULLEN, 1441 MAIN STREET,
SUITE 1250, COLUMBIA, SOUTH CAROLINA ON TUESDAY, MARCH 8, 2016,
SCHEDULED FOR 10:00 A.M. AND COMMENCING AT 10:08 A.M.

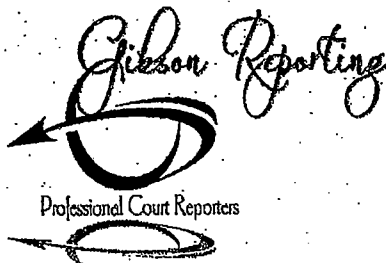


Exhibit A

A P P E A R A N C E S

REPRESENTING THE PLAINTIFF: *MRR Pickens, LLC*

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Department of Health and Environmental Control*

ETTA R. LINEN, ESQUIRE

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REPRESENTING THE DEFENDANT: *Pickens County Planning Commission*

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ALSO PRESENT: SHELLEY ROBBINS, CHRIS ROOF, AND DONALD
GRAVES (VIDEOGRAPHER)

1 doesn't really matter. What we did know was that in the
2 application, the permit application that we received for
3 the modification, they're required to do stability
4 calculations --

5 Q. Okay.

6 A. -- in the application for the waste.

7 Q. Right.

8 A. And in those stability calculations, they
9 submitted calculations that would be appropriate for C&D
10 waste and calculations that would be appropriate for coal
11 ash.

12 Q. Okay. And how far --

13 A. So they submitted --

14 Q. I'm sorry. Go ahead.

15 A. In the application for the modification, they
16 -- they had done the stability calculations for both
17 types of waste.

18 Q. All right.

19 A. So we -- we certainly knew at that point that
20 they were considering maybe putting some coal ash, but we
21 didn't really have any detail on where or how much and
22 that sort of thing.

23 Q. All right. The -- for the CEC reports that we
24 identified today and talked about, the first one, I
25 believe, was dated August of '14. I can pull up the

1 number. I think it was Exhibit 10 or 11, maybe. But it
2 was the August --

3 MR. POLIAKOFF: Thank you, Jessica.

4 MS. KING: I think that's it.

5 BY MR. POLIAKOFF:

6 Q. The August '14 -- it was the work plan.

7 A. March 2015. August of --

8 Q. I think the first one was August '14, which was
9 the work plan.

10 MS. KING: I think that's right.

11 A. December 2014 work plan, yeah. The work plan
12 was August of 2014; revised September of 2014.

13 Q. All right. So you would agree that submission
14 of engineering reports like this, the work plan, the site
15 specific hydrogeologic investigation, the application
16 for the minor permit modification, I mean, these are all
17 engineering reports that would be some significant
18 expense to put together. Would you agree?

19 A. Uh-huh. Sure.

20 Q. And adding a liner to a permit that doesn't
21 require a liner, that's an expense. Isn't it?

22 A. Yes.

23 Q. Fair to say that by August of 2014, you at
24 least had some idea that they were intending to put coal
25 ash into this landfill?

1 A. I don't -- I don't know if I knew any -- I don't
2 know about at that time frame. When this -- these
3 documents are all previous -- generally, they're
4 submitted previous to the actual technical application.

5 So when the technical application came in,
6 that's when it had the calculations for stability.

7 Q. All right.

8 A. And I don't know exactly. It would have been
9 probably after these documents. I don't know exactly
10 what date.

11 Q. Now, for companies that operate landfills that
12 are restricted to C&D and LCD, typically those don't have
13 liners?

14 A. Correct.

15 Q. Because a liner is an expensive item, right?

16 A. Yes. Uh-huh.

17 Q. So when you start getting reports in that would
18 indicate intent to -- at least requesting an option for a
19 liner, wouldn't you then start assuming that the permit
20 applicant/permittee is requesting something more than
21 just C&D LCD?

22 MS. KING: Objection to form.

23 MS. LINEN: Objection to form;
24 speculative.

25 BY MR. POLIAKOFF:

Assessment of the Environmental Effects Associated with Coal Ash Residuals disposal in Class Two Landfill in Pickens County, South Carolina

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1. Personal information

I was asked by Gary W. Poliakoff, Attorney at Law from Spartanburg, South Carolina to review the possible environmental effects and water contamination associated with the disposal of coal combustion residuals (CCR) in Class Two Landfill in Pickens County, SC. I am a professor of Geochemistry and Water Quality at the Nicholas School of the Environment at Duke University, and for over 30 years I have been engaged in research related to water quality and contamination. I have been working extensively on water quality issues in different parts of the world, including the Middle East (Israel, Jordan), Australia, Southeastern Asia (Vietnam, China), Northern Africa (Morocco), Europe (Italy, Cyprus, Greece, Turkey), and the U.S. My research aims to delineate the sources and pathways of contaminants in the environment and their possible impacts on human health through integrated research of environmental geochemistry, advanced isotope geochemistry (boron, strontium, carbon, lithium, and radium isotopes), and environmental health research (arsenic, fluoride, boron, chromium, radium).

After joining Duke University in 2005, my research group has investigated the energy-water nexus with extensive research on the environmental risks of unconventional energy exploration and hydraulic fracturing, coal mining, CCRs and their disposal. In particular, my team has investigated the composition of CCRs, their potential effects on the environment, and developed methods to delineate their distribution and impact on the environment. Since our early investigation of the 2008 Tennessee Valley Authority (TVA) coal ash spill, which was the largest coal ash spill in the U.S. history, we have published 10 papers specifically addressing the

contaminants occurrence in coals and CCR, their mobilization from coals to water, their fate in the environment, and contamination of water resources. Currently we are engaged in a study that investigates possible leaking of coal ash ponds from 22 sites in five states (NC, TN, KY, GA, VA) through the Southeastern U.S. and the impact on associated surface water and underlying groundwater. Overall, I have published 104 papers in peer-reviewed top journals (5 currently under review) at the top peer-reviewed journals in the U.S. In 2015, the Geological Society of America elected me as a Fellow.

2. What's in coal combustion residuals (CCR)

During coal combustion process, most of the toxic elements in the parent coals are retained to the coal combustion residuals (CCR, or coal ash). CCR encompasses fly ash, bottom ash, and flue gas desulfurization (FGD) materials, and represent one the largest industrial waste streams in the U.S. CCR typically contains five- to ten-fold (depending on coal properties) higher concentrations of toxic elements relative to the original coals. Numerous studies have characterized the occurrence and distribution of a wide range of elements in coals and CCRs (see examples in references 1-6). These studies have shown that CCRs are enriched in trace metals and metalloids such as arsenic, selenium, vanadium, chromium, lead, mercury, molybdenum, thallium, boron, manganese, iron, boron, strontium, and others, with concentrations up to several orders of magnitude higher than in typical soil. Some of these elements are highly toxic and carcinogenic and can affect human health and ecological system upon their release to the environment. In addition to trace metals, CCRs are characterized by relatively high concentrations of Naturally Occurring Radioactive Materials (NORM) that include uranium, radium, radon, lead, and polonium radionuclides. During the combustion of coal, most of the NORM are retained on CCRs, leading to their enrichment in CCR. Volatilization of lead and recapture by tiny particles results in further enrichment of lead and lead radioactive element (lead-210) in CCR by two-fold, relative to the other NORMs. A recent survey of NORM occurrence and distribution in CCR has shown that NORM levels in CCR are higher by five-fold higher relative to typical soil in the U.S. (7).

CCR was recognized as a Group I human carcinogen (based on occupational exposure studies) associated with increased risks of skin, lung, and bladder cancers (8). Specifically, arsenic and radium exposures in humans are associated with increased risks of skin, lung, liver, leukemia, breast, bladder, and bone cancers (8, 9) for exposure predominantly due to chronic ingestion or chronic inhalation, with the dose-response curve dependent on location, sources, and population susceptibility and/or tolerance.

3. Environmental risks of coal combustion residuals (CCR)

Many studies have shown that metals and metalloids are easily mobilized (removed) from CCR to water in aquatic environment (1-6). The high mobilization of CCR is due to the fact that metals and metalloids are entrapped to the surface of CCR following coal combustion, and consequently are readily leached out upon interaction with water. The mobilization of metals and metalloids specifically increases with increasing the acidity of the aquatic system, with high leaching rates at low pH. The leaching of metalloids like arsenic and selenium increases also with higher pH (10).

The possible leaching of metals and metalloids from CCR and the impact on the environment has been examined by three ways (1) leaching experiments and simulation at the laboratory (1-3; 10); (2) studying of effluents discharge from coal ash ponds, such as those in NC (11); and (3) studying the impact of CCR spills (10, 12-15). The fate of the different elements that are mobilized from CCRs depend on their chemical properties. Some elements are highly soluble in water and thus the interaction of water and CCR would lead to direct contamination of the water. Clear evidence for water contamination has been shown for toxic and carcinogenic elements such as arsenic, selenium, boron, and strontium (10-15). Other elements are less soluble in water such as lead, manganese, chromium, but changes in the water conditions such as low pH, which is common in landfills, could enhance their mobilization and transport in water.

The storage of CCR in surface impoundments has resulted in direct contamination of waterways. A detailed study from NC (11) investigated the effluents that are discharged from coal ash ponds through the National Pollution Discharge Elimination System (NPDES) Program. The NPDES Program was established by the Clean Water Act and requires the control and

permitting of point source discharges of wastewater. Data from all of the coal ash ponds in NC has shown that the discharge effluents were enriched in several toxic and carcinogenic elements (arsenic, selenium, molybdenum, thallium, boron) that has caused direct contamination of lakes and rivers in NC. The level of contaminants' enrichment was up to 100-fold relative to reference water, and exceeded in many cases the drinking water regulations (11). Furthermore, it was shown that contamination of lake water causes arsenic to be accumulated to lake sediments that are sinking to the lake bottom, followed by the release of arsenic back to the environment under changes in the reducing conditions (11). The accumulation and release of arsenic in the TVA spill in Kingston, TN resulted in extremely high levels of arsenic in water from the bottom of the river with concentrations of up to 2,000 ppb (relative to 10 ppb in drinking water regulations) (12). A current research by our team on coal ash impoundments from 22 sites across the southeastern U.S. has reveal that all of the ponds are leaking and CCR effluents have migrated and contaminated associated surface water and underlying groundwater.

Overall, these studies have collectively demonstrated that disposal of CCR without adequate protection causes direct contamination of associated water resources.

4. Specific risks of coal combustion residuals (CCR) to Class Two Landfill

Numerous studies have shown that landfills containing domestic materials (based on the definition of Class Two Landfill in SC) such as construction and demolition debris and land-clearing activities do not contain specific toxic elements. Yet the disposal of organic materials and accelerated biological degradation of the organic matter in landfills can induce acidic condition (low pH) and reduced condition (low dissolved oxygen). Mixing the domestic landfill materials with CCR would inevitably generate leaching process of CCR and mobilization of toxic contaminants to landfill effluents that could be leaked to the environment. Enhancement of the leaching process is expected under reducing and low pH conditions, which are typical to domestic landfills. Lining a Class Two landfill may reduce the direct infiltration of the landfill effluents, but this would not prevent contamination of nearby waterways and groundwater. Without comprehensive management of the landfill effluents that would include specific lining material, collecting and treating the landfill effluents, and establishing a monitoring network to monitor possible migration and leaks of the landfill effluents to the nearby surface water and

underlying groundwater – disposal of CCR to a Class Two Landfill could contaminate associated water resources.

The second risk for human health from CCR disposal in a landfill is the wind-blown resuspension of tiny CCR particles to the atmosphere and transport to nearby population. Fly ash-airborne particles with diameters less than 10 μm (PM10) are regarded as respirable and may affect the human lung and bronchus. The particles that are of most importance for human health are in the fine particulate (PM2.5) mode, which readily deposit deep in the lung. Previous research has shown that CCP ash has particulate sizes ranging from less than 1 μm to 100s of micrometers in size. Several studies have shown measured ambient fine particulate matter associated with elevated concentrations of toxic metals in the vicinity of coal-fired power plants (16,17). Overall, the literature clearly shows that CCR contains inhalable particulate matter, and that resuspension of fly ash from dry surface disposal can be transported to the atmosphere and therefore poses risks to the nearby and downwind population.

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STATE OF SOUTH CAROLINA	)	IN THE COURT OF COMMON PLEAS
	)	
COUNTY OF PICKENS	)	THIRTEENTH JUDICIAL CIRCUIT
	)	
MRR Pickens, LLC,	)	Civil Action No.: 2016-CP-39-100
	)	
Plaintiff,	)	
	)	
vs.	)	AFFIDAVIT OF
	)	AVNER VENGOSH, PH.D.
	)	
County of Pickens and William Cato,	)	
Weldon Clark, Robert Ballentine, Jo	)	
Johnston, Dennis Reinert, and Bob Young,	)	
individually and in their official capacity as	)	
appointed members of the Pickens County	)	
Planning Commission,	)	
	)	
Defendants.	)	

Personally appeared before me Avner Vengosh, who having been duly sworn, deposes and states:

1. That I am over the age of 18 years and am competent to issue this Affidavit.
2. That I hold a Ph.D. in Environmental Geochemistry and currently serve as Professor of Geochemistry and Water Quality at Duke University. My current Curriculum Vitae is attached hereto (33 pages, plus a 2-page summary).
3. That I was asked by Attorney Gary W. Poliakoff to review various materials and regulations related to proposed disposal of Coal Combustion Residuals (CCR) into a Class Two Landfill in Pickens county. A true and genuine copy of my Report, consisting of six pages, is attached hereto.
4. That, as stated in greater detail in my Report, deposit of Coal Combustion Residuals (CCR) into a South Carolina Class Two Landfill, even with a liner, would be most inappropriate and

would present serious risks of toxic exposure to the nearby population and to the environment
(including toxic effects to air quality and water quality).

SWORN and subscribed to before me this
16 day of FEB 2016.

Maury D. Klein

Notary Public for South Carolina

Print Name: MAURY D. KLEIN

My Commission Expires: 9/27/2016

Avner Vengosh



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Publications and Grants Summary

- Publications: total - 104 in peer-reviewed journals; Google Scholar Stats: h-index=43; 5,801 total citations; 15 papers with >100 citations each. Web of Science: h-index=30, 3,082 total citations.
- Grants: PI or co-PI on Federal and Foundation Awards totaling ~\$7.9 million since 2005.

EDUCATION

AUSTRALIAN NATIONAL UNIVERSITY, RESEARCH SCHOOL OF EARTH SCIENCE
Canberra, Australia

- Ph.D., 1990, Environmental Geochemistry (Thesis title: *Boron isotope geochemistry in the sedimentary environment*).

Advisor: Professor Allan Chivas and Professor Malcolm McCulloch.

HEBREW UNIVERSITY OF JERUSALEM, Jerusalem, Israel

- M.Sc., 1986, Isotope Geology (Thesis title: *Stable isotopes in coexisting phases of phosphatic, carbonate and siliceous rocks of the Mishash Formation, Israel*).

Advisor: Professor Yehushua Kolodny.

HEBREW UNIVERSITY OF JERUSALEM, Jerusalem, Israel

- B.Sc., 1984.

ACADEMIC APPOINTMENTS

DUKE UNIVERSITY, Durham, NC, USA

NICHOLAS SCHOOL OF ENVIRONMENT, DIVISION OF EARTH AND OCEAN
SCIENCES,

2010- *Professor (tenured)*

DUKE UNIVERSITY, Durham, NC, USA

NICHOLAS SCHOOL OF ENVIRONMENT, DIVISION OF EARTH AND OCEAN
SCIENCES,

2005 -2010 *Associate Professor (tenured)*

DUKE UNIVERSITY, Durham, NC, USA

PRATT SCHOOL OF ENGINEERING, DEPARTMENT OF CIVIL AND ENVIRONMENTAL
ENGINEERING,

2009 - *Secondary Appointment*

STANFORD UNIVERSITY, Stanford, California, USA,

DEPARTMENT OF GEOLOGICAL AND ENVIRONMENTAL SCIENCES

August 2003 – March 2004, *Visiting Professor (sabbatical leave)*

BEN GURION UNIVERSITY, Beer Sheva, Israel,
DEPARTMENT OF GEOLOGICAL AND ENVIRONMENTAL SCIENCES
1999 -2005 (since 2002 tenured position), *Associate Professor*

UNIVERSITY OF CALIFORNIA SANTA CRUZ, Santa Cruz, California, USA,
INSTITUTE OF EARTH AND MARINE SCIENCES
1996-1997, *Visiting Scientist (sabbatical leave)*

HYDROLOGICAL SERVICE, Jerusalem, Israel
RESEARCH DEPARTMENT
1991-1999, *Senior Lecturer*

HONORS

2011 – International Association of Geochemistry (IAGC) Fellow.
2013 – Best Science Paper Award, *Environmental Science & Technology*.
2014 – Second Runner-Up Best Environmental Policy Paper, *Environmental Science & Technology*.
2015 – Geological Society of America Fellow.

AFFILIATIONS & MEMBERSHIPS

Geochemical Society, American Geophysical Union (AGU), Geological Society of America (GSA), International Association of Geochemistry (IAGC).

PROFESSIONAL SERVICE

Reviewer for dozens articles per month in *Environmental Science and Technology*, *Geochimica Cosmochimica Acta*, *Chemical Geology*, *Applied Geochemistry*, *Journal of Hydrology*, *Water Research*, *Water Quality Research of Canada*, *Aquatic Geochemistry*, *Hydrogeology Journal*, *The Science of Total Environment*, *Journal Environmental Quality*.

Reviewer for numerous NSF grants.

2015-present **Editorial board** of the international journal *Environmental Science and Technology*.

2007-present **Associate Editor** of the international journal *Applied Geochemistry*.

2015 Invited speaker to the Joint US-UK workshop on Improving Understanding of Potential Environmental Impact Associated with Unconventional Hydrocarbons, National Environment Research Council (NERC) and National Science Foundation (NSF) joint workshop, Washington DC, November 5-6, 2015.

- 2015 Invited speaker in the Pardee keynote Symposia P4: Similar Information , different results: fracking from state to state, Geological Society of America, Baltimore, November 3, 2015.
- 2015 Chair of The Second Workshop on the Water-Energy Nexus in China", Kunshan, China, October 14-15, 2015.
- 2015 Invited keynote speaker to the ICCE 2015, Leipzig, Germany, September 20, 2015.
- 2015 Theme chair "Energy Resources", Goldshmidt Conference, Prague, Czech Republic, August 16-21, 2015.
- 2015 Chair of a session "Geochemical Characterizations of Unconventional Petroleum Reservoirs and Environmental Impacts Associated with their Production", Goldshmidt Conference, Prague, Czech Republic, August 16-21, 2015.
- 2015 Invited speaker at the National Academy of Science workshop "Chemistry and Engineering of Shale Gas and Tight Oil Resource Development", May 18-19, 2015 , Washington DC.
- 2014 Chair of workshop "Water-energy Nexus in China", Kunshan, China, November 7, 2014.
- 2014 Theme chair "Hydrogeochemistry", Goldshmidt Conference, Sacramento California, June 8-13, 2014.
- 2014 Keynote speaker in a session on shale gas development, 2014 European Union of Geoscience (EGU) meeting , Vienna, Austria, April 28-May 2, 2014.
- 2013 Keynote speaker to a session entitled "Environmental and Social Implications of Hydraulic-Fracturing-Driven Oil and Gas Development: Toward a More Holistic Assessment", 2013 GSA Annual Meeting & Exposition, Denver, October 27-30, 2013.
- 2013 Keynote speaker to a special session (Pardee Keynote Symposia) of the Geological Society of America, entitled "Energy and Health: The Emergence of Medical Geology in Response to the Shale Gas Boom", 2013 GSA Annual Meeting & Exposition, Denver, October 27-30, 2013.
- 2013 Testimony to the Office of Management and Budget (OMB) on new EPA's proposed effluent limitation guidelines (ELGs) for the steam electric sector; Washington, DC, April 12, 2013.
- 2012 Chair, Pardee Symposium, Geological Society America Meeting, Charlotte, NC, USA, 4-7 Nov 2012.
- 2012 A Congretional briefing on "*Environmental Consequences of Past and Future Energy Production in the United States*," Rayburn House Office Building, Washington DC, October 16, 2012.

- 2012 Keynote speaker to the Association of Ecosystem Research Centers (AERC) annual meeting, Washington Dc, October 16, 2012.
- 2009 A testimony to the Subcommittee on Water Resources and Environment, U.S. House of Representatives; "*The Tennessee Valley Authority's Kingston Ash Slide: Potential Water Quality Impacts of Coal Combustion Waste Storage*". Washington, DC, March 31, 2009.
- 2008 Keynote speaker at University Council on Water Resources/ National Insititue for Water Research annual conference " International water resources: Challenges for the 21st century" , Durham, NC, July 2008.
- 2007 Chair of a special session (Pardee Keynote Symposia) of the Geological Society of America, entitled "*Middle Eastern Water Resources in Times of Crisis*", 2007 GSA Annual Meeting & Exposition, Denver, October 28-31, 2007.
- 2007 Chair of a session entitled "*Natural Contaminants in Groundwater Resources: Occurrence, Geochemistry, Health, and Remediation*", American Geophysical Union (AGU), Joint Assembly Meeting, Acapulco, Mexico, May 22-25, 2007.
- 2007- present Member of the Environmental Surveillance Committee of the N.C. Radiation Protection Commission.
- 2006-2009 Principle Investigator of a USDA reseach project entitled "*An integrative investigation of the sources and effects of groundwater contamination for local communities and homeowners in North Carolina*".
- 2006-2009 Investigator of a USAID (MERC) research project entitled "*The salinity curse of the Middle East fossil groundwater: The Radioactivity factor*".
- 2006 Chair of a Workshop on "*Radon Occurrence, Health Risks and Policy, with an Emphasis on Radon in Ground Water Drinking Supplies*", Duke Garnens, Duke University, Durham, NC, (<http://www.nicholas.duke.edu/radon/>), October 4, 2006.
- 2003 Advisor to International Atomic Energy Agencythe for designing Cooperation Research Project on application of isotopes in studying agricultural return flow.
- 2003 - 2004 Vice-President, International Commission on Water Quality, International Association of Hydrological Sciences.
- 2001-2005 **Associate Editor** for the international journal *Water Resources Research*.
- 2001-2004 Coordinator of the geochemistry research group of European Union Firth Framework research BOREMED entitled "*Boron contamination of Water resources in the Mediterranean region: Distribution, Sources, Social impact and Remediation*".

- June 2001 Invited Speaker at *Water-Rock Interaction -10* International conference, Sardinia, Italy.
- 1999-2004 Coordinator of US-AID - Middle East Regional Cooperation Research (MERC) project entitled "*Water Quality along the Jordan River and evaluation of the sources of salts*".
- 2000 Organizer of a special workshop with the International Atomic Energy Agency, entitled "*Regional workshop on isotopes and geochemical methods in the study of water and salinization in arid region.*"
- 1999 Advisor for the design of Cooperation Research Project on application of isotopes in studying salinization, International Atomic Energy Agency, Vienna, Austria.

Duke University service

- 2007- 2011 Chair of *Water and Air Resources Program* at the Nicholas School of Environment and Earth Sciences, Duke University.

Member of Duke University Radioactivity Safety Committee, Duke University Misconduct committee, University Calendar Committee, Academic Council (2006-2008), Nicholas School of Environment Water Initiative Committee, and head of Search Committee for a Global Hydrology position.

PUBLICATIONS

(in bold, research done while Vengosh's graduate students or post-docs)

Refereed articles in scientific journals

Articles published after appointment at Duke

2016

104) Schlesinger, W.H. and Vengosh, A. (2016), Global Boron Cycle in the Anthropocene. *Global Biogeochemical Cycles*, doi:10.1002/2015GB005266.

2015

103) King, K.E., Darrah, T.H., Money, E., Meentemeyer, R., Maguire, R.L., Michener, L., Murtha, A.P., Jirtle, R., Murphy, S.K., Mendez, M.A., Robarge, W., Vengosh, A., Hoyo, C. (2015) Geographic clustering of elevated blood heavy metal levels in pregnant women. *BMC Public Health*, 15, 1035-1035.

102) Drollette, B.D., Hoelzer, K., Warner, N.R., Darrah, T.H., Karatun, O., O'Connor, M.P., Nelson, R.K., Fernandez, L.A., Reddy, C.M., Vengosh, A., Jackson, R.B., Elsner, M., Plata, D.L.

(2015) Elevated levels of diesel range organic compounds in groundwater near Marcellus gas operations are derived from surface activities. *PNAS* (doi: 10.1073/pnas.1511474112).

101) Darrah, T.H., Jackson, R.B., Vengosh, A., Warner, N.R., Whyte, C.J., Walsh, T.B., Poreda, R.J. (2015) The evolution of Devonian hydrocarbon gases in shallow aquifers of the northern Appalachian Basin: insights from integrating noble gas and hydrocarbon geochemistry. *Geochimica Cosmochimica Acta*, 170, 321-355.

100) Kondash, A. and Vengosh, A. (2015) Water footprint of hydraulic fracturing. *Environmental Science & Technology Letters*, 2, 276-280.

99) Lauer, N.E., Hower, J.C., Hsu-Kim, H., Taggart, R.K., Vengosh, A. (2015) Naturally occurring radioactive materials in coals and coal combustion residues in the United States. *Environmental Science & Technology*, 49, 11227-11233.

98) Vidal, A.C., Semenova, V., Darrah, T., Vengosh, A., Huang, Z., King, K., Nye, M.D., Fry, R., Skaar, D., Maguire, R., Murtha, A., Schildkraut, J., Murphy, S., Hoyo, C. (2015). Maternal cadmium, iron and zinc levels, DNA methylation and birth weight. *BMC Pharmacology and Toxicology*, 16:20. (DOI 10.1186/s40360-015-0020-2).

97) Elsner, M., Schreglmann, K., Calmano, W., Bergmann, A., Vieth-Hillebrand, A., Wilke, F.D.H., Klaus-Michael Wollin, K.-M., Georgi, A., Schmidt, W., Hofmann, T., Micić, V., Vengosh, A., and Mayer, B. (2015) Comment on the German draft legislation on hydraulic fracturing: The need for an accurate state of knowledge and for independent scientific research. *Environmental Science & Technology*, 49, 6367-6369.

96) Down, A., Schreglmann, K., Plata, D., Elsner, M., Warner, N., Vengosh, A., Moore, K., Coleman, D., Jackson, R.B. (2015) Pre-drilling background groundwater quality in the Deep River Triassic Basin of central North Carolina, USA. *Applied Geochemistry*, 60, 3-13.

95) Darrah, T.H., Jackson, R.B., Vengosh, A., Warner, N.R., Poreda, R.J. (2015) Noble Gases: A new technique for fugitive gas investigation in groundwater. *GroundWater*, 53, 23-28.

94) Nir, O., Vengosh, A., Harkness, J., Dwyer, G.S., Lahav, O. (2015). Direct measurement of the boron isotope fractionation factor: reducing the uncertainty in reconstructing ocean paleo-pH. *Earth and Planetary Science Letters*, 414, 1-5.

93) Harkness, J., Dwyer, G., Warner, N.R., Parker, K. Mitch, W.; Vengosh, A. (2015) Iodide, Bromide, and Ammonium in Hydraulic Fracturing and Oil and Gas Wastewaters: Environmental Implications. *Environmental Science & Technology*, 49, 1955-1963. (DOI:10.1021/es504654n).

92) Merola, R.B., Hien, T. T. , Quyen, D.T.T. , Vengosh, A. (2015) Arsenic Exposure to drinking water in the Mekong Delta. *Science of the Total Environment*, 511, 544-552.

- 91) **Ruhl, R.L., Dwyer, G., Hsu-Kim, H., Vengosh, A.** (2014) Boron and Strontium Isotopic Characterization of Coal Combustion Residuals: Validation of New Environmental Tracers. *Environmental Science & Technology*, 48 (24), 14790–14798.
- 90) **Warner, N.R., Darrah, T.H., Jackson, R.B., Millot, R., Kloppmann, W., Vengosh, A.** (2014) New tracers identify hydraulic fracturing fluids and accidental releases from oil and gas operations. *Environmental Science & Technology*, 48 (21), 12552–12560.
- 89) **Parker, K.M., Zeng, T., Harkness, J., Vengosh, A. Mitch, W.A.** (2014) Enhanced formation of disinfection by-products in shale gas wastewater-impacted Drinking Water Supplies. *Environmental Science & Technology*, 48, 11161-11169 (DOI: 10.1021/es5028184).
- 88) **Darrah, T.H., Vengosh, A., Jackson, R.B., Warner, N.R., Poreda, R.J.** (2014) Noble gases identify the mechanisms of fugitive gas contamination in drinking-water wells overlying the Marcellus and Barnett Shales. *Proceedings of the National Academy of Sciences of United States of America*, 111 no. 39, 14076–14081.
- 87) **Leslie, D., Lyons, W.B., Warner, N., Vengosh, A. Olesik, J., Welch, K., Deuerling, K.,** (2014). Boron isotopic geochemistry of the McMurdo Dry Valley lakes, Antarctica. *Chemical Geology*, 386, 152–164.
- 86) **Vengosh, A., Hirschfeld, D., Vinson, D., Dwyer, G., Raanan, H., Marie, A., Zaarur, S., Ganor Y.** (2014) Response to Comment on “High Naturally Occurring Radioactivity in Fossil Groundwater from the Middle East”. *Environmental Science & Technology*, 48 (16), 9943–9945.
- 85) **Rango, T., Vengosh, A. Jeuland, M., Tekle-Haimanot, Weinthal, E., Kravchenko, Paul, C., McCornick, P.** (2014) Fluoride exposure from groundwater as reflected by urinary fluoride and children’s dental fluorosis in the Main Ethiopian Rift Valley. *Science of the Total Environment*, 496, 188-197.
- 84) **Lgourna, Z., Warner, N.R., Bouchaou, L., Boutaleb, S., Hssaisoune, M., Tagma, T., Ettayfi, N. and Vengosh, A.** (2015) Elucidating the sources and mechanisms of groundwater salinization in the Ziz Basin of southeastern Morocco. *Environmental Earth Sciences*, 73, 77-93.
- 83) **Jackson, R.B., Vengosh, A., Carey, J.W., R.J., Darrah, T.H., O'Sullivan, F., Pétron, G.** (2014). The Environmental Costs and Benefits of Fracking. *Annual Review of Environment and Resources*, 39 (1), (DOI: 10.1146/annurev-environ-031113-144051)
- 82) **Kravchenko, J., Darrah, T.H., Miller, R.K., Lyster, H.K., Vengosh, A.** (2014) A review of the health impacts of barium from natural and anthropogenic exposures. *Environmental Geochemistry and Health*, 36, 797-814 (DOI: 10.1007/s10653-014-9622-7).
- 81) **Vengosh, A., Jackson, R.B., Warner, N.R., Darrah, T. H., Knodash, A.J.** (2014) A Critical Review of the Risks to Water Resources from Unconventional Shale Gas Development and Hydraulic Fracturing in the United States. *Environmental Science & Technology*, 48, 8334-8348. (dx.doi.org/10.1021/es405118y).

80) Kravchenko, Y., Rango, T., Akushevich, I., Behailu, A., McCornick, P., Merola, R.B., Paul, C., Weinthal, E., Harrison, C., Vengosh, A., Jeuland, M. (2014). The effect of non-fluoride factors on risk of dental fluorosis: Evidence from rural populations of the Main Ethiopian Rift. *Science of the Total Environment*, 488-489, 595-606 (<http://dx.doi.org/10.1016/j>).

79) Knodash, A.J., Warner, N.R., Lahav, O., Vengosh, A. (2014) Radium and Barium Removal through Blending Hydraulic Fracturing Fluids with Acid Mine Drainage. *Environmental Science & Technology*, 48, 1334-1342.

78) Merola, R.B., Kravchenko, J., Rango, T., Vengosh, A. (2014) Arsenic exposure of rural populations from the Rift Valley of Ethiopia as monitored by keratin in toenails. *Journal Of Exposure Science And Environmental Epidemiology*, 24, 121-126 (doi: 10.1038/jes.2013.77).

2013

77) Liu, Y-B., Chen, T-Y., Mackee, W.G., Ruhl, L., Vengosh, A., and Hsu-Kim, H. (2013) Selenium Speciation in Coal Ash Spilled at the Tennessee Valley Authority Kingston Site. *Environmental Science & Technology*, 47, 14001-14009.

76) Warner, N.R., Christie, C.A., Jackson, R.B., Vengosh, A. (2013) Impacts of shale gas wastewater disposal on water quality in western Pennsylvania. *Environmental Science & Technology*, 47, 11849-11857 (DOI: 10.1021/es402165b).

75) Vinson, D.S., Tagma, T., Bouchaou, L., Dwyer, G.S., Nathaniel R. Warner, N.R., and Vengosh, A. (2013) Occurrence and mobilization of radium in brackish to saline groundwater in coastal aquifers as inferred from geochemical and isotopic tracers (Ra, Rn, Sr, S, O, H). *Applied Geochemistry*, 38, 161-175.

74) Foster, G.L., Hönisch, B., Paris, G., Gary S. Dwyer, G.S., Rae, J.W.B., Elliott, T., Gaillardet, J., Hemming, N.G., Louvat, P., Vengosh, A. (2013) Interlaboratory comparison of boron isotope analyses of boric acid, seawater and marine CaCO₃ by MC-ICPMS and NTIMS. *Chemical Geology*, 358, 1-14.

73) Vengosh, A. Linberg, T.T., Merola, B., Ruhl, L., Warner, N.R., White, Al., Dwyer, G.S., and Di Giulio, R.T. (2013). Isotopic imprints of mountaintop mining contaminants. *Environmental Science & Technology*, 47, 10041-10048 (DOI: 10.1021/es4012959).

72) Jackson, R.B., Vengosh, A., Darrah, T.H., Warner, N.R., Down, A., Poreda, R.J., Osborn, S.G., Zhao, K., and Karr, J.D. (2013) Increased stray gas abundance in a subset of drinking water wells near Marcellus shale gas extraction. *Proceedings of the National Academy of Sciences of United States of America*, 110(28): 11250-11255 (doi: 10.1073/pnas.1221635110).

71) Godebo, T.R., Vengosh, A., Dwyer, G., Bianchini, G. (2013) Mobilization of arsenic and other naturally occurring contaminants in groundwater of the Main Ethiopian Rift aquifers. *Water Research*, 47, 5801–5818.

70) Vengosh, A., Warner N.R., Jackson, R.B., Darrah, T.H., (2013). The Effects of Shale Gas Exploration and Hydraulic Fracturing on the Quality of Water Resources in the United States. *Procedia Earth and Planetary Science*, 7, 863–866.

69) Warner N.R., Kresse, T.M., Hays, P.D., Down, A., Karr, J.D., Jackson, R.B., Vengosh, A. (2013) Geochemical and isotopic variations in shallow groundwater in areas of Fayetteville Shale development, north central Arkansas. *Applied Geochemistry*, 35, 207–220. (<http://dx.doi.org/10.1016/j.apgeochem.2013.04.013>).

68) Warner, N.R., Lgouna, Z., Bouchaou, L., Boutaleb, S., Tagma, T., Hsaissoune, M., Vengosh, A. (2013). Integration of geochemical and isotopic tracers for elucidating water sources and salinization of shallow aquifers in the sub-Saharan Drâa Basin, Morocco. *Applied Geochemistry*, 34, 140–151.

67) Deonaraine, A., Bartov, G., Johnson, T.M., Ruhl, L., Vengosh, A., and Hsu-Kim, H. (2013). Environmental impacts of the Tennessee Valley Authority Kingston coal ash spill. 2. Effect of coal ash on methylmercury in historically contaminated river sediments. *Environmental Science & Technology*, 47(6), 2100–2108. (DOI: 10.1021/es303639d).

66) Bartov, G., Deonaraine, A., Johnson, T.M., Ruhl, L., Vengosh, A. and Hsu-Kim, H. (2013) Environmental impacts of the Tennessee Valley Authority Kingston coal ash spill. 1. Source apportionment using mercury stable isotopes. *Environmental Science & Technology*, 47(6), 2092–2099 (DOI: 10.1021/es303111p).

2012

65) Warner, N.R., Jackson, R.B., Darrah, T.H., Osborn, S.G., Down, A., Zhao, K., White, A., Vengosh, A. (2012). Reply to Engelder: Potential for fluid migration from the Marcellus Formation remains possible. *Proceedings of the National Academy of Sciences of United States of America*, 109 no. 52 E3625, DOI: doi: 10.1073/pnas.1216133110

64) Vinson, D.S., Lundy, J.R., Dwyer, G.S., and Vengosh, A., (2012). Implications of carbonate-like geochemical signatures in a sandstone aquifer: Radium and strontium isotopes in the Cambrian Jordan aquifer (Minnesota, USA). *Chemical Geology*, 334, 280–294.

63) Ruhl, L., Vengosh, A., Dwyer, G.S., Hsu Kim H., Schwartz, G., Romanski, A., and Smith, S.D. (2012). The impact of coal combustion residue effluent on water resources: A North Carolina example. *Environmental Science & Technology*, 46, 12226–12233.

62) Warner, N.R., Jackson, R.B., Darrah, T.H., Osborn, S.G., Down, A., Zhao, K., White, A., Vengosh, A. (2012). Geochemical evidence for possible natural migration of Marcellus formation brine to shallow aquifers in Pennsylvania. *Proceedings of the National Academy of Sciences of United States of America*, 109, 11961–11966 (doi: 10.1073/pnas.1121181109).

- 61) **Rango, T., Kravchenko, J., Atlaw, B., McCornick, P.G., Jeuland, M., Merola, M., Vengosh, A.** (2012). Groundwater quality and its health impact: an assessment of dental fluorosis in rural inhabitants of the Main Ethiopian Rift. *Environment International*, 43, 37-47.
- 60) **Ettayfi, N., Bouchaou, L., Michelot, J.L., Tagama, T., Warner, N., Boutaleb, S., Massault, M., Lgourna, Z., Vengosh, A.** (2012) Geochemical and isotopic (oxygen, hydrogen, carbon, strontium) constraints for the origin, salinity, and residence time of groundwater from a carbonate aquifer in the Western Anti-Atlas Mountains, Morocco. *Journal of Hydrology*, 438, 97-111.
- 59) **Adair, S., Pearson, B.R., J Monast, J., Vengosh, A. Jackson, R.B.** (2012). Considering shale gas extraction in North Carolina: lessons from other states. *Duke Environmental Law and Policy Forum*, XXII, 257-301.
- 58) **Lindberg, T.T., Bernhardt, E.S., Bier, R., Helton, A., Merola, R.B., Vengosh, A. and Di Giulio, T.D.** (2011) Cumulative impacts of mountaintop mining on an Appalachian watershed. *Proceedings of the National Academy of Sciences of United States of America*, 108, 20929-20934.
- 57) **Jackson R.B., Osborn S.G., Vengosh, A., Warner, N.R.** (2011). Reply to Davis: Hydraulic fracturing remains a possible mechanism for observed methane contamination of Drinking water. *Proceedings of the National Academy of Sciences of United States of America*, 108, E872.
- 56) **Osborn, S., Vengosh, A. Warner, N. Jackson, R.** (2011). Reply to Saba and Orzechowski and Schon: Methane contamination of drinking water accompanying gas- well drilling and hydraulic fracturing. *Proceedings of the National Academy of Sciences of United States of America*, 108, 8172-8176.
- 55) **Osborn, S., Vengosh, A. Warner, N. Jackson, R.** (2011). Methane contamination of drinking water accompanying gas drilling and hydro-fracking. *Proceedings of the National Academy of Sciences of United States of America*, 108, 8172-8176.
- 54) **Vinson, D.S., McIntosh, J.C., Dwyer, G.S., Vengosh, A.** (2011). Arsenic and other oxyanion-forming natural contaminants in an alluvial basin aquifer: Evaluating sources and mobilization by isotopic tracers (Sr, B, S, C, O, H, Ra). *Applied Geochemistry*, 26, 1364-1376.
- 53) **Vinson, D., Schwartz, H., Dwyer, G., Vengosh, A.** (2011): Evaluating salinity sources of groundwater and implications for sustainable reverse osmosis desalination in coastal North Carolina, USA. *Hydrogeology Journal*, 19, 981-994.
- 52) **Sowers, J. Vengosh, A., Weinthal, E.S.** (2011) Climate change, water resources, and the politics of adaptation in the Middle East and North Africa. *Climatic Change*, 104, 599-627 (DOI 10.1007/s10584-010-9835-4).
- 51) **Ruhl, L., Vengosh, A., Dwyer, G.S., Hsu-Kim, H., Deonarine,** (2010). The Environmental Impacts of the Coal Ash Spill in Kingston, Tennessee: An Eighteen-Month Survey. *Environmental Science and Technology*, 44, 9272-9278.
- 50) **Pratson, E., Vengosh, A., Dwyer, G., Pratson, L. and Klein, E.** (2010). The Effectiveness of Arsenic Remediation from Groundwater in a Private Home. *Ground Water Monitoring and*

Remediation, 30, 87-93.

- 49) Bouchaou, L., Qurtobi, M., Michelot, J.L., Zine, N., Gaye, C.B., Aggarwal, P.K., Mara, H., Zerouall, A., Taleb, H. and Vengosh, A. (2009). Origin and residence time of groundwater in the Tadla basin (Morocco) using multiple isotopic and geochemical tools. *Journal of Hydrology*, 379, 323-338.
- 48) Ruhl, L., Vengosh, A., Dwyer, G.S., Hsu-Kim, H., Deonarine, A., Bergin, M., Kravchenko, J. (2009). Survey of the potential environmental and health impacts in the immediate aftermath of the coal ash spill in Kingston, Tennessee. *Environmental Science and Technology*, 43, 6326-6333.
- 47) Vengosh, A., Hirschfeld, D., Vinson, D.S., Dwyer, G.S. Raanan, H., Rimawi, O., Al-Zoubi, A., Akkawi, E., Marie, A., Haquin, G., Zaarur, S., and Ganor, J. (2009) High Naturally Occurring Radioactivity in Fossil Groundwater in the Middle East. *Environmental Science and Technology*, 43 (6), 1769-1775. DOI: 10.1021/es802969r.
- 46) Vinson, D.S., Vengosh, A., Hirschfeld, D. and Dwyer, G.S. (2009). Relationships between radium and radon occurrence and hydrochemistry in fresh groundwater from fractured crystalline rocks, North Carolina (USA). *Chemical Geology*, 260, 159-171.
doi:10.1016/j.chemgeo.2008.10.022.
- 45) Raanan, H., Vengosh, A., Paytan, A., and Nishri, A. (2009) Quantifying saline groundwater flow into a fresh water lake using the Ra isotope quartet: A case study from the Sea of Galilee (Lake Kinneret), Israel. *Limnology and Oceanography*, 54(1), 119-131.
- 44) Vinson, D.S., Campbell, T.R. and Vengosh, A. (2008). Radon-222 transfer from groundwater used in showers to indoor air. *Applied Geochemistry*, 23, 2676-2685.
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- Deonarine, A., Hsu-Kim, H., Ruhl, L., Vengosh, A., 2010.** Riverine mercury contamination after the 2008 coal ash spill at the Kingston Fossil Plant, TN. 20th Annual V.M. Goldschmidt Conference Knoxville, TN. June 21-25, 2010.
- Deonarine, A., Hsu-Kim, H., Ruhl, L., Vengosh, A. 2010.** Assessment of mercury and methylmercury in the Emory, Clinch and Tennessee River system after the December 2008 coal ash spill at the Kingston Fossil Plant, TN. TVA-Kingston Fly Ash Release Environmental Research Symposium, March 11-12, 2010. Harriman, TN.
- Ruhl, L., Vengosh, A. & Dwyer G, 2010.** Differential leaching of trace metals and their isotopes from coal combustion products. TVA-Kingston Fly Ash Release Environmental Research Symposium, March 11-12, 2010. Harriman, TN.
- Ruhl, L., Vengosh, A. & Dwyer G, 2010.** The impact of the Tennessee Valley Authority (TVA) coal ash spill of the quality of the Emory and Clinch Rivers: the first year evaluation TVA-Kingston Fly Ash Release Environmental Research Symposium, March 11-12, 2010. Harriman, TN.
- Ruhl, L., Vengosh, A., Dwyer G, A. Deonarine; H. Hsu-Kim, 2009.** Water quality monitoring of the Emory and Clinch River: the impact of the Tennessee Valley Authority coal ash spill, Kingston, TN. SETAC North America 30th Annual Meeting; Human-Environment Interactions: Understanding Change in Dynamic Systems; Hilton Riverside, New Orleans, Louisiana, USA, 19 - 23 November 2009.
- Raanan, H. and Vengosh, A., 2009.** Radium isotopes as natural tracers of groundwater seepage in low salinity systems. Geological Society of America, Portland, Oregon ; 18-21 October 2009; GSA *Abstracts with Programs*. Vol. 41, No. 7, p. 348.
- Nunnery, A., Warner, N., Baker, P., Dwyer, G.S., Vengosh, A. Fritz, S.C., Lowenstein, T.K., Godfrey, L. and Rigsby, C.A., 2009.** Climate significance of large lakes on the Bolivian Altiplano of South America. Geological Society of America, Portland, Oregon ; 18-21 October 2009; GSA *Abstracts with Programs*. Vol. 41, No. 7, p. 274.
- Warner, N., Tagma, T., Bouchaou, L., Boutaleb, S., Lgourna, Z., Pankratove, I., Ettayfi, N., Hsissou, Y., Belkacim, S. and Vengosh, A. 2009.** Investigation of groundwater chemistry of the western Atals and Ant-Atlas mountains in Morocco using boron, strontium, and radium isotopes. Geological Society of America, Portland, Oregon ; 18-21 October 2009; GSA *Abstracts with Programs*. Vol. 41, No. 7, p. 579.
- Vinson, D.S. Lundt D.S., Vengosh, A., and Dywer, G.S., 2009.** Radium in the Jordan sandstone, Minnesota: Distribution and geochemical controls in an aquifer recharged by meltwater. Geological Society of America, Portland, Oregon ; 18-21 October 2009; GSA *Abstracts with Programs*, Vol. 41, No. 7, p. 700.

Ruhl, L., Vengosh, A., and Dwyer, G.S., 2009. Boron and strontium isotope proxies for tracing the environmental impact of the TVA coal ash spill. Geological Society of America, Portland, Oregon; 18-21 October 2009; *GSA Abstracts with Programs*, Vol. 41, No. 7, p. 334.

Vengosh, A., **Ruhl, L.**, Dwyer, G.S., 2009. The isotopic imprint of coal ash impact on the environment. 8th International Symposium on Applied Isotope Geochemistry. La Malbaie, Quebec, Canada, August 30-September 4, 2009.

Vengosh, A., Dwyer, G.S., Rimawi, O., Al-Zoubi, A., Ganor, J., 2009. The origin of fossil groundwater from the Nubian sandstone aquifers in the Middle East: A multi-isotope (Ra, B, Sr, S, O, H) investigation. Goldschmidt Conference, Davos, Switzerland, June 21-26, 2009.

Vinson, D.S., Lundy, J.R., Dwyer, G.S., Vengosh, A., 2009. Coupled use of Sr and Ra isotopes to assess Ra mobility and water-rock interaction in sandstone aquifers. Goldschmidt Conference, Davos, Switzerland, June 21-26, 2009.

Vengosh, A., **Ruhl, L.**, Dwyer, G., Hsu-Kim, H., Deonarine, A., Bergin, M., Kravchenko, J. (2009) The environmental and health effects of the coal ash spill at Kingston, Tennessee: Preliminary assessment. World of Coal ash 2009 (WOCA), Lexington, Kentucky, May 4-7, 2009.

Vengosh, A., **Vinson, S. Eigel, S. Merola, B.R.,** Pratson, E., Dwyer, G., Benneer, L.S., Klein, E., Tootoo, J., Weinthal, W.S., Wiesner, M. (2009) An integrative study of the sources and effects of naturally occurring contaminants in private wells in North Carolina: A water quality prospective. USDA-CSREES 2009 National Water Quality Conference. St. Louis, MO. February 8-12, 2009.

Dwyer, G. S. and Vengosh, A. (2008) Alternative filament loading solution for accurate analysis of boron isotopes by negative thermal ionization mass spectrometry. American Geophysical Union, Fall Meeting 2008, abstract #H51C-0824.

Vengosh, A., **Hirschfeld, D., Vinson, D.S.,** Rimawi, O., Al Zoubi, A., Marie, A., Ganor, J. Dwyer, G. S. (2008) Isotopic Tracers (Ra, Sr, O, H) for Elucidating the Sources of High Naturally Occurring Radioactive Groundwater from the Disi Aquifer, Jordan. *GSA Abstracts with Programs*, GSA, Vol. 40, No. 6, p. 120.

Raanan, H., Vengosh, A., Paytan, A., Nishri, A., and Kabala, Z. (2008) Ra Isotopes as a Tool for Quantifying Saline Groundwater Flow into a Fresh Water Lake. A Case Study from the Sea of Galilee (Lake Kinneret), Israel. *GSA Abstracts with Programs*, GSA, Vol. Vol. 40, No. 6, p. 346.

Vinson, D.S., Lundy, J.R., Dwyer, G.S. and Vengosh, A. (2008) Isotopic Indicators (^{223}Ra , ^{224}Ra , ^{226}Ra , ^{228}Ra , ^{222}Rn , $^{87}\text{Sr}/^{86}\text{Sr}$) of Radium Mobilization and Retardation In the Mt. Simon Aquifer, Minnesota. *GSA Abstracts with Programs*, GSA, Vol. 40, No. 6, p. 339.

Vengosh, A. (2007) Isotopic Reconnaissance of water quality degradation in the Middle East. Geological Society of America (GSA) Annual Meeting, Denver (28-31 October 2007); *GSA Abstracts with Programs*, GSA Vol. 39, No. 6, p. 342.

Vengosh, A. Kloppmann, W., Guerrot, C., Millot, R., Pankratov, I. (2007). The isotopic composition of man-made fresh water: Seawater and brackish groundwater reverse osmosis desalination. Geological Society of America (GSA) Annual Meeting, Denver (28-31 October 2007);

GSA *Abstracts with Programs*, Vol. 39, No. 6, p. 114.

Vinson, D.H., Hirsschfeld, D., Dwyer, G. and Vengosh, A. (2007) Radium and radon in fresh groundwater: Insights along solute and redox gradients in the North Carolina Piedmont. Geological Society of America (GSA) Annual Meeting, Denver (28-31 October 2007); GSA *Abstracts with Programs*, Vol. 39, No. 6, p. 178.

Raanan, H., Vengosh, A., Nishri, A., Paytan, A. (2007) radium isotopes as a proxy for groundwater-fresh water lake interaction: A case study from the Sea of Galilee, Israel. Geological Society of America (GSA) Annual Meeting, Denver (28-31 October 2007); GSA *Abstracts with Programs*, Vol. 39, No. 6, p. 479.

Vengosh, A., **Peri, N.,** Haquin, G., Paytan, A., Pankratov, I., Elhanani, S., Karpas, Z. (2007) Mechanisms of Radium Mobilization for Radium-Rich Groundwater from the Nubian Sandstone and Carbonate Aquifers in the Negev, Israel: Implications for Fossil Groundwater Resources in the Middle East. American Geophysical Union, Joint Assembly, Acapulco, Mexico, May 22-35, 2007.

Vengosh, A. Campbell, T., **Vinson, D.,** Klein, E., Dwyer, G., Benneer, L., Weinthal, E., Wiesner, M., Pratson, E. and Miranda, M.L. (2006) Natural contaminants in private wells in North Carolina. USDA-CSREES 2007 National Water Quality Conference. January 28-February 1, 2007 Savannah, Georgia.

Vinson, D.H., Campbell, T.R., Field, R.W., and Vengosh, A. (2006) Transfer of radon from groundwater into homes and the contribution of showering to indoor radon: Policy implications for unregulated private well owners at the intersection of geology and health in the North Carolina Blue Ridge. Geological Society of America *Abstracts with Programs*, Vol. 38, No. 7, p. 122. 2006 Philadelphia Annual Meeting (22-25 October 2006).

Vengosh, A., **Pery, N.,** Paytan, A. Haquin, G., Elhanany, S. and Pankratov I. (2005). Sources, mechanisms, and implications for natural radionuclide contamination in groundwater basins in the Middle East. Geological Society of America, Salt lake City, Utah, October 2005.

Vengosh, A., **Pery, N.,** Paytan, A. Haquin, G., Elhanany, S. and Pankratov I. (2004). Tracing the Origin of Radioactivity in Groundwater from the Negev, Israel. American Geophysical Union, San Francisco, December 2004.

Vengosh, A., **Hening, S.,** Ganor, J., Bullen, T.D., Weyhenmeyer, C.E., Sturchio, N.C., and Paytan, A. (2004). The origin and age of groundwater in the Nubian Sandstone aquifer in the Negev, Israel, in Wanty, R.B., and Seal, R.R., II, eds., *Water Rock Interaction*, v. 1, Proceedings of the Eleventh International Symposium on Water-Rock Interaction, Saratoga Springs, New York, July 2004: New York, A.A. Balkema, p. 509-512.

Vengosh, A. Weinthal, E., Marei, A., Gutierrez, A., Kloppmann, W. (2003). Addressing the Water Crisis in the Gaza Strip: Integration of Geochemistry, Numerical modeling, and Policy. American Geological Society, Seattle, Washington, USA. November 2-5, 2003.

Vengosh, A., Marei, A., Guerrot, C., Pankratov, I. (2002). An enigmatic salinity source in the Mediterranean coastal aquifer and Gaza Strip: Utilization of isotopic (B, Sr, O) constraints for

searching the sources of groundwater contamination. Goldschmidt Conference, Davos, Switzerland, August 18-23, 2002. *Geochim. Cosmochim. Acta*, 66, A804.

Farber, E., Vengosh, A., Shavit, U., Holtzman, R., Segal, M., Gavrieli, I., and Bullen, T. (2002). Exploring the Sources of the salinity in the Lower Jordan River. International symposium on the Geochemistry of the Earth's Surface (GES-6). Honolulu, Hawaii, May 2002, Abstracts Volume Sixth, 135-155 pp.

Vengosh, A., **Farber, E.**, Shavit, U., Holtzman, R., Segal, M., Gavrieli, I., Bullen, T.M., and Mayer, B. (2001). What Science can contribute for future cooperation in the Middle East: The Jordan River. American Water Resources Association, International Specialty Conference on Globalization and Water management: the Changing Value of Water. August 6-8 2001, Dandee, Scotland, UK.

Vengosh, A., **Farber, E.**, Shavit, U., **Holtzman, R., Segal, M., Gavrieli, I., Bullen, T.M., (2001).** *Exploring the sources of salinity in the Middle East: A hydrologic, geochemical and isotopic study of the Jordan River.* In: Cidu, R., Proceeding of the Tenth International Symposium on Water-Rock Interaction, WRI-10, Villasimuis, Sardinia, Italy, June 2001, (keynote lecture), Vol. 1, 71-79, A.A. Balkema Publishers.

Vengosh, A., **Farber, E.**, Shavit, U., Holtzman, R., Segal, M., Gavrieli, I., Bullen, T.M., and Mayer, B. (2001). *Tracing the origin of salinity of the Jordan River.* 4th International Symposium on Applied Isotope Geochemistry, June 25-29, 2001, Pacific Grove, California, USA, pp. 162-164.

Vengosh, A., Kolodny Y. and A.J. Spivack (1998) *Ground-water pollution determined by boron isotope systematics.* In: 'Application of isotopic techniques to investigate groundwater pollution', Cooperation Research Program, The International Atomic Energy Agency (IAEA), IAEA-TECDOC-1046, pp. 17-37, October 1998, Vienna.

Vengosh A. (1992). *Boron isotope variations during brine evolution and water-rock interaction.* Kharaka Y.K. and Maest A.S. (eds.), Proceedings of the 7th International Symposium on Water-Rock Interaction, Park City, Utah, 1992. A.A. Balkema, Rotterdam, p. 693-696.

TEACHING

Courses at Duke University: Introduction to Hydrogeology (EOS123), International Water Resources (EOS227), Stable and Radioactive Isotopes in Environmental Sciences (EOS271), Water Seminar (EOS226).

Graduate students:

Duke University:

- Jennie Harkness (PhD, 2013 -)
- Nancy Lauer (PhD, 2013 -)
- Andrew Kondash (PhD, 2014 -)

- Hadas Raanan (PhD, 2005-2011). Research topic: *Radium isotope geochemistry as a tracer for groundwater-surface water interaction.*
- David Vinson (PhD, 2005-2011). Research topic: *The impact of salinity and water chemistry on radium mobilization in groundwater systems.*
- Nathanel Warner (PhD, 2008-2013). Research topic: *Tracing the origin of salinization and radium contamination in water resources of Morocco.*
- Laura Rühl (PgD, 2008-2012). Research topic: *The geochemistry and isotopic characterization of coal ash and its impact on the environment.*
- Brittany R. Merola (PhD-2010 -). Research topic: *Biomarkers of arsenic and fluoride from contaminated water resources.*
- Daniella Hirschfeld (Master of Environmental management, 2006-2008). Research topic: *Radium isotopes in groundwater in Jordan.*
- Kristen Tull (Master of Environmental management, 2006-2008). Research topic: *Mini-Superfund" Site in Kawerau, New Zealand: A Closer Look at Water Quality.*
- Britany R. Merola (Master of Environmental management, 2007-2009). Research topic: *Arsenic Exposure from Groundwater in Union County, North Carolina.*
- Heidi Hausman (Master of Environmental management, 2007-2009). Research topic: *Responsible Development in Tulum, Mexico: Considering Water Quality and Subaqueous Cave Locations.*

Ben Gurion University:

- Efrat Farber (PhD, 2000-2005). Research topic: *The lower Jordan River: river salinization, relationship with adjacent groundwater and future management.*
- Yohanan Artzi (M.Sc., 1999-2003) Research topic: *The origin of salinity in the coastal aquifer of Israel.*
- Osnat Velder (M.Sc., 2000-2003) Research topic: *Mapping of oxygen isotopes and salinity in groundwater from the coastal aquifer of Israel.*
- Sharona Henig (M.Sc., 2002-2004) Research topic: *Geochemical and isotopic (oxygen, hydrogen, boron, and strontium) characterization of groundwater from the Kurnub Group aquifer in the Negev and the Arava Valley, Israel.*
- Dana Roded (M.Sc., 2003-2005) Research topic: *Identification of the origin of nitrate pollution in the coastal aquifer by isotopic traces.*
- Nitzan Pery (M.Sc., 2003-2005) Research topic: *Radioactivity in groundwater from the Negev, Israel.*

AWARDS AND GRANTS

Duke University

- | | |
|-----------|---|
| 2016-2017 | North Carolina Water Research Institute, Vengosh (PI). <i>Tracing Groundwater Contamination Near And Away From Coal Ash Ponds in North Carolina</i> (\$100,000). |
| 2016-2017 | National Institution of Health (NIH), National Institute of Environmental Health Sciences, Nagel, S. University of Missouri (PI), Vengosh, A. (co-PI). <i>Endocrine disrupting activity associated with hydraulic fracturing</i> (\$239,743). |

- 2015- Southern Environmental Law Center. Vengosh, A. (PI). *Applying geochemical tracers for elucidating the leaking of coal ash ponds*. (\$60,000).
- 2015-2016 Park Foundation. Vengosh, A. (PI), *Radioactivity and Isotopic Markers of Oil and Gas Liquid and solid Wastes in New York and Pennsylvania* (\$60,000).
- 2014-2017 National Science Foundation. Vengosh (PI), Jackson R.B., Darrah, T. *SusChEM: Geochemical Characterization and Evaluation of the Environmental Impacts of Hydraulic Fracturing Fluids* (\$258,436). (EAR-1441497).
- 2014-2015 Park Foundation. Vengosh, A. (PI), Jackson R.B., Plata, D. *The environmental and health risks of oil and gas wastewater in New York and Pennsylvania* (\$70,000).
- 2014-2015 Duke Energy Initiative. Vengosh, A., Weinthal, E., Dalia Patino-Echeverri, Marc Deshusses. *A global perspective of water scarcity and unconventional shale gas development* (\$40,000).
- 2013-2014 National Science Foundation Exploratory Research (EAGER). Darrah, T. (PI), Vengosh, A., Jackson J. *A novel geochemical approach for environmental risk assessment of stray gas contamination in shallow aquifers within active and prospective shale gas development zones* (\$100,000). (EAR-1249255)
- 2013-2014 Park Foundation. Vengosh, A. (PI), Jackson R.B., Plata, D. *The environmental effects of oil and gas wastewater disposal in New York and Pennsylvania* (\$70,000).
- 2013-2017 National Science Foundation. Ferguson, L. (PI), Wiesner, M., Tarabara, V., Bang, J., Plata, D., Hsu-Kim, H., Gunsch, C., Seshusses, M., Vengosh, A., Golden, J. *PIRE: Water and Commerce: Technologies to enable environmental sustainability in global markets* (\$4,750,443).
- 2012-2015 National Science Foundation. Hsu-Kim, H. (PI), Vengosh, A., Hower, J. *Characterization of contaminants and isotopic tracers associated with coal combustion products* (\$301,000).
- 2011-2012 Park Foundation. Jackson, R.B. (PI), Vengosh, A. *Impact of Gas Drilling and Hydraulic Fracturing on Water Quality* (\$50,000)
- 2012-2013 North Carolina Water Resources Research Insitute. Jackson, R.B. (PI), Vengosh, A. *Baseline groundwater quality sampling in parts of Lee and Chatham Counties, North Carolina*. (\$50,000).
- 2011-2012 Duke University - Problem-Focused Interdisciplinary Research-Scholarship Teams (PFIRST). Jeuland, M., Vengosh, A., Weinthal, E., McCornick, O. Crump, J. and Krauchanka, J. *Understanding linkages between climate change, water resources, and health in Ethiopia* (\$30,000)

- 2011-2012 National Science Foundation. Vengosh, A. (PI), Jackson, R. Weinthal, E. *Environmental and social implications of hydraulic fracturing and gas drilling in the United States: An integrative science and policy workshop* (\$45,000)
- 2011-2012 Duke Cancer Institute. Vengosh, A. (PI), Krauchanka, Y. *Environmental contaminants in drinking water from rural communities of Union county, North Carolina: an integrated approach for evaluation of biomarkers of human exposure to arsenic and trace metals.* (\$50,000)
- 2011-2012 North Carolina Water Resources Research Institute. Vengosh, A. (PI), Hsu-Kim, H. *The impact of coal combustion products on the quality of water resources in North Carolina.* (\$50,000)
- 2010-2013 Oak Ridge Associated Universities. Vengosh, A. (PI), Hsu-Kim, H., Hower, J., Johnson, T. *Geochemical and isotope characterization of TVA coal combustion products: Identification of contaminants and modeling their fate in the environment.* (\$357,115).
- 2010-2011 Duke Global Health Institute. McCornick, P. and Vengosh, A. *Processes controlling groundwater quality and impacts on human health in the Main Ethiopian Rift.* (\$50,000).
- 2010-2013 DOE. Rob Jackson (PI), Avner Vengosh, Mark Little. *The Potential Risks of Freshwater Aquifer Contamination with Geosequestration Simulation and Risk Assessment of Carbon Capture and Storage (CCS).* (\$298,304).
- 2009-2010 National Science Foundation. Vengosh, A. (PI), Backer, P., Dywer, G.S. and Hsu-Kim, H. Title: *Environmental effects of the coal ash spill and remediation at Kingston, Tennessee* (\$105,000).
- 2009 Fred and Alice Stanback gift to the Nicholas School of Environment. Vengosh, A. (PI). Seed funding *The Environmental and Health Effects of the coal ash spill at Kingston, Tennessee* (\$50,000).
- 2008-2012 NATO Science for Peace and Security Program. Vengosh A. (PI) and Bouchaou, L. *Investigating salinity and radioactivity in water resources in Morocco.* (EUR 234,000).
- 2008-2009 Center of Global Change, Duke University. Vengosh, A. (PI) Jackson, R. Hsu-Kim, H. Emily S. Bernhardt, E.S. *The drought effect on water availability and quality of North Carolina water resources: Groundwater-surface water interaction and contributions of recycled wastewater* (\$50,000)
- 2007-2009 Kuwait Institute for Scientific Research (KISR). Vengosh, A. (PI). *Radium isotopes in the Persian Gulf and associated groundwater.* (\$30,000).

- 2007-2008 Health Research Council of New Zealand, Hikuroa, D. and Vengosh, A. (PI's); *"Preliminary investigation of the link between naturally occurring contaminants and health in Tarawera Valley, New Zealand"*; (\$5,000).
- 2006-2009 United States Department of Agriculture (USDA); Vengosh, A. (PI), Klein, E. Benneer, L., Weinthal, E. Wiesner, M., Mirenda M. *An integrative investigation of the sources and effects of groundwater contamination for local communities and homeowners in North Carolina* (\$570,000).
- 2006-2009 United States Agency for International Development (US-AID), Middle East Research Program (MERC). Ganor, J. (PI), Vengosh, A., Marie, A. Rimawi, O. (PIs). *The salinity curse of the Middle East fossil groundwater: The Radioactivity factor* (\$500,000).
- 2005-2006 Cancer and the Environment: Seed Funding Award of Duke Comprehensive Cancer Center and Nicholas School of the Environment, Duke University. Avner Vengosh (PI), James J. Vredenburg, Jennifer Garst, Richard Di Giulio, Lincoln Pratson, and Emily M. Klein. *"The Link Between Environmental Radon and Cancer: A Pilot Study For a New Biogeochemical Tracer and Geographical Relationships"* (\$25,000).

Ben Gurion University, Beer Sheva, Israel

- 2003-2004 Blaustein Visiting Scholar award, School of Earth Sciences, Stanford University, California, USA.
- 2002-2005 United States States Agency for International Development (US-AID), Middle East Research Program (MERC). Vengosh, A. (PI), U. Shavit, I. Gavrieli, E. Salameh, R. Daud, A. Marie. *"Water Quality along the Jordan River and evaluation of the sources of salts: Phase Two"* (\$499,000)
- 2001-2004 Water Commission, Israel. Vengosh, A. *"Using isotopic tracers for elucidating the sources and mechanism of nitrate pollution of groundwater from the coastal aquifer of Israel"* (300,000 NIS).
- 2001-2004 European Community: FP5 program "Energy, Environment and Sustainable Development", "Sustainable Management and Quality of Water". Kloppmann, W., Vengosh, A. et al., *"Boron contamination of Water resources in the Mediterranean region: Distribution, Sources, Social impact and Remediation"* (Euro 1,200,000 for the total project, Euro 120,000 for BGU).
- 2000-2003 International Atomic Energy Agency, Research Co-operation Projects, Y. Ganor and A. Vengosh, *"Boron and strontium isotopic compositions of ground water from the Lower Cretaceous Kurnob sandstone: Geochemical characterization of inland saline ground water"* (\$15,000)

- 1999-2003 United States Agency for International Development (US-AID), Middle East Research Program (MERC). Vengosh, A. (PI), U. Shavit, I. Gavrieli, E. Salameh, R. Daud, A. Marie. *"Water Quality along the Jordan River and evaluation of the sources of salts: A geochemical prospective"* (\$499,000)
- 1999-2002 International Atomic Energy Agency, Research Co-operation Projects, Vengosh, A. *"Environmental Isotopes, Boron, and Bromide Variations in the Coastal Aquifer of Israel: The Impact of Long-term Exploitation"* (\$18,000).
- 1999-2000 Department of Energy, Lawrence Livermore National Laboratory. Vengosh, A., Marie, A., *"The Mediterranean Coastal aquifer and the Shallow Aquifer System in Jericho area"* (\$12,000).
- 1998-2001 Ministry of Science, Israel. I. Gavrieli (PI), Y. Yechieli, A. Vengosh, A. Starinsky, *"Dating and geochemical characterization of shallow ground water from the coastal aquifer of Israel"*. (\$190,000)

Hydrological Service, Jerusalem, Israel

- 1997-1998 University of California Water Resources. J. Gill and A. Vengosh. *"Multi-isotope investigation of ground water contamination in Salinas Valley, California"*. (\$25,000).
- 1995 -1998 Israel Academy of Science. I. Gavrieli (PI), A. Starinsky (PI), A. Vengosh, A. Ayalon. *"Boron, sulfur, strontium, oxygen, and hydrogen isotopes in freshwater of a carbonate aquifer: Judea Mountain, Israel"*. (\$140,000).
- 1996 - 1998 Water Commission Research grants. A. Starinsky and A. Vengosh. *"Relationships between contaminants and salinity in the coastal aquifer of Israel"* (210,000 NIS)
- 1995 -1997 International Atomic Energy Agency (IAEA). Y. Kolodny and A. Vengosh. *"Boron isotope investigations of polluted groundwater and contamination sources: Establishing the rules of the game"* (\$12,000).
- 1992 - 1995 The German-Israeli Cooperative Grant (BMFT and MOST). A. Vengosh, R. Keren, K.G. Heumann (PI's). *"The influence of the coastal aquifer rocks on groundwater composition and contamination"*. (148,000 DM).
- 1993 - 1995 The Ashdod-Yavneh Regional Association for Environmental Protection. A. Vengosh. *"Sources of Salinization of Groundwater from Gan Yavne-Gedera-Ashdod Area, the Coastal Plain Aquifer, Israel"* (100,000 NIS).

- 1993 - 1996 Water Commission Research grants. Y. Yechieli, (PI), D. Ronen, and A. Vengosh. *"Isotopic measurements and dating of intrusion of saline groundwater at the interface zone, the Coastal Plain Aquifer of Israel"*. (160,000 NIS).
- 1993 - 1996 Water Commission Research grants. A. Starinsky and A. Vengosh. *"A survey of natural isotopic and chemical tracers in groundwater from Yarqon-Taninim aquifer as indicators for salinization"* (210,000 NIS).
- 1991 - 1994 Water Commission Research grants. E. Mazar and A. Vengosh. *"A conceptual model for aquifer systems in the coastal plain of Israel: A pilot study along Tel Aviv-Judea Mountain"* (240,000 NIS).
- 1986 - 1990 Research School of earth Sciences, The Australian National University, Canberra, Australia. Ph.D. Scholarship for Avner Vengosh.

Media:

Research on water resources in the Gaza Strip

- November 3, 2003 - Geological Society of America: *Water On The Gaza Strip: Time Bomb Or Ray Of Hope* (<http://www.geosociety.org/news/pr/03-34.htm>)
- November 13, 2003 - Nature 426, 110 (13 November 2003) | doi:10.1038/426110b
Geologists call for desalination of Gaza Strip's water
(<http://www.nature.com/nature/journal/v426/n6963/full/426110b.html>)
- March 4, 2003 - Environmental Change and Security Program: *The State of the Water Crisis in Israel and The Palestinian Authority: Integrating Science and Policy*
(http://www.wilsoncenter.org/index.cfm?topic_id=1413&categoryid=A82CCAEE-65BF-E7DC-46B3B37D0A3A575F&fuseaction=topics.events_item_topics&event_id=23109)

Research on Radioactivity and fossil groundwater in the Middle East

- May 6, 2010, National Geographic News: *"Underground 'Fossil Water' Running Out"*
(<http://news.nationalgeographic.com/news/2010/05/100505-fossil-water-radioactive-science-environment/>)
- February 25, 2009 - Reuters, London: Ancient Jordanian wells radioactive, study finds
(<http://www.reuters.com/article/latestCrisis/idUSLN96135>)
- February 26, 2009 - The Jerusalem Post: Radioactive materials found in Jordanian wells
(www.jpost.com/servlet/Satellite?cid=1235410729639&pagename=JPost%2FJPostArticle%2FPrinter)
- February 27, 2009 - The Jordan Times : Government: water is safe
(<http://www.jordantimes.com/?news=14653>)
- March 9, 2009 - The Jordan Times: Clear waters
(<http://www.jordantimes.com/?news=14872>)
- March 4, 2009 - Green Prophet: Study on Jordanian Groundwater Sparks Controversy
(<http://greenprophet.com/2009/03/04/7321/jordan-groundwater-controversy/>)

- March 3, 2009 - KISR will check; Aquifer 'radiation' in Kuwait unlikely (<http://www.arabtimesonline.com/kuwaitnews/pagesdetails.asp?nid=29378&ccid=9>)
- February 23, 2009 - The New Security Beat: Hot Water: High levels of radioactivity found in Jordan's groundwater (<http://newsecuritybeat.blogspot.com/2009/02/hot-water-high-levels-of-radioactivity.html>).
- March 6, 2009 - The Grist: Tall Glass of denial - Fallout from Jordan's radioactive water (<http://www.grist.org/article/Tall-glass-of-denial>)
- March 6, 2009 - Science Daily: Jordan's Fossil Water Source Has High Radiation Levels (<http://www.sciencedaily.com/releases/2009/02/090224163647.htm>).
- February 25, 2009 - Haaretz: Report: Mideast in danger of exposure to high levels of radioactive water (<http://www.haaretz.com/hasen/spages/1066925.html>).
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- September 15, 2006 - Health Risks of Radon in North Carolina Groundwaters to be Examined at Nicholas School Workshop on Oct. 4 (<http://www.nicholas.duke.edu/news/ns-radon.html>)

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- October 4, 2006; The News and Observer: Experts address N.C. radon hazard (<http://www.newsobserver.com/102/story/494204.html>)
- April 1, 2006; Washington Post: April 01, 2006 - EPA May Weaken Rule on Water Quality.
- July 14, 2004; BBS news: South Israeli water 'radioactive' (http://news.bbc.co.uk/2/hi/middle_east/3894263.stm)

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RESEARCH INTERESTS

Dr. Vengosh research aims to delineate the sources and pathways of contaminants in the environment and their possible impacts on human health through integrated research of environmental geochemistry, advanced isotope geochemistry (boron, strontium, carbon, lithium, radium isotopes), and environmental health research (arsenic, fluoride, boron, chromium, radium). Dr. Vengosh research is focused on the energy-water nexus with extensive research on the environmental risks of shale gas exploration and hydraulic fracturing, coal mining, coal combustion residues and their disposal. Dr. Vengosh's team is currently engaged in research of unconventional energy development in different parts in the U.S. and China, the environmental and human health effects of coal ash in the U.S. and China, and the relations between the occurrence and distribution of inorganic contaminants on human health in the U.S., Morocco, Vietnam, Ethiopia, and China.

EMPLOYMENT

DUKE UNIVERSITY

Professor, Division of Earth and Ocean Sciences, Duke University	2010-Present
Associate Professor, Division of Earth and Ocean Sciences, Duke University	2005-2010

BEN GURION UNIVERSITY OF THE NEGEV, ISRAEL

Associate Professor, Dept. of Geological and Environmental Sciences	1999-2005
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HYDROLOGICAL SERVICE, ISRAEL

Senior Lecture, Research Department	1991-1999
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EDUCATION

Australian National University, Canberra, Australia (PhD)	1986-1990
Hebrew University of Jerusalem, Israel (M.Sc.)	1984-1986
Hebrew University of Jerusalem, Israel (B.Sc.)	1981-1984

SELECTED AWARDS, RECOGNITIONS, AND SERVICES

2015 – Geological Society of America Fellow.

2014 – Second Runner-Up Best Environmental Policy Paper, *Environmental Science & Technology*.

2013 – Best Science Paper Award, *Environmental Science & Technology*.

2011 – International Association of Geochemistry (IAGC) Fellow.

2015-present Editorial board of the international journal *Environmental Science and Technology*.

2007-present Associate Editor of the international journal *Applied Geochemistry*.

2001-2005 Associate Editor for the international journal *Water Resources Research*.

SELECTED PUBLICATIONS (out of 104 peer-reviewed journal articles; Google Scholar Stats: h-index=43; Web of Science: h-index=30; for full list of publications see: <http://sites.nicholas.duke.edu/avnervengosh/publications/>)

- Schlesinger, W.H. and Vengosh, A. (2016), Global Boron Cycle in the Anthropocene. *Global Biogeochemical Cycles*, doi:10.1002/2015GB005266
- Kondash, A. and Vengosh, A. (2015) Water footprint of hydraulic fracturing. *Environmental Science & Technology Letters*, 2, 276-280.
- Lauer, N.E., Hower, J.C., Hsu-Kim, H., Taggart, R.K., Vengosh, A. (2015) Naturally occurring radioactive materials in coals and coal combustion residues in the United States. *Environmental Science & Technology*, 49, 11227-11233.
- Darrah, T.H., Vengosh, A., Jackson, R.B., Warner, N.R., Poreda, R.J. (2014) Noble gases identify the mechanisms of fugitive gas contamination in drinking-water wells overlying the Marcellus and Barnett Shales. *PNAS*, 111, 14076-14081.
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- Warner, N.R., Christie, C.A., Jackson, R.B., Vengosh, A. (2013) Impacts of shale gas wastewater disposal on water quality in western Pennsylvania. *Environmental Science & Technology*, 47, 11849-11857.
- Warner, N.R., Jackson, R.B., Darrah, T.H., Osborn, S.G., Down, A., Zhao, K., White, A., Vengosh, A. (2012). Geochemical evidence for possible natural migration of Marcellus formation brine to shallow aquifers in Pennsylvania. *PNAS* 109, 11961-11966.
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THE STATE OF SOUTH CAROLINA

In the Court of Appeals

APPEAL FROM THE ADMINISTRATIVE LAW COURT

Shirley C. Robinson, Administrative Law Judge

Appellate Case No. 2017-000066

Pickens County,

vs.

South Carolina Department of Health and Environmental and
MRR Pickens, LLC,

Respondents.

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SC Court of Appeals

Appellant,

CERTIFICATE OF SERVICE

I hereby certify that on this date I served the foregoing Reply in Support of Intervenor's Motion to be Included as Appellants on Respondents SCDHEC and MRR Pickens, LLC, by placing copies of same in the U.S. Mail addressed to:

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Robert F. Goings
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Amelia A. Thompson

April 17, 2017

Georgetown, SC



South Carolina Environmental Law Project

Lawyers for the Wild Side of South Carolina

a 501c3
non-profit organization

April 17, 2017

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The Honorable Jenny Abbott Kitchings
Clerk of Court, SC Court of Appeals
P.O. Box 11629
Columbia, SC 29211

Re: Pickens County v. SCDHEC
Appellate Case No. 2017-000066

Dear Ms. Kitchings:

I am enclosing for filing please find the Reply in Support of Intervenor's Motion to be Included as Appellants, along with my certificate of service in the above-captioned case. I am also enclosing seven copies of the reply and request that you kindly return a clocked-in copy of in the enclosed pre-paid envelope.

Thank you very much for your kind cooperation and assistance.

Yours very truly,

Amelia A. Thompson

cc: Etta R. Linen, Esquire
Robert F. Goings, Esquire
Jessica J. O. King, Esquire
Gary Poliakoff, Esquire

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SC Court of Appeals

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