Environmental Consequences of Past and Future Energy Production in the United States

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For decades, coal has been the primary source of fuel for electricity production in the United States. Yet, over a century of coal mining and combustion has created a legacy of water pollution: numerous cases of seepage of acid mine drainage into watersheds in the Appalachian basin, contamination of streams by effluents from surface mountaintop mining in West Virginia, and effluents flowing from hundreds of coal ash ponds into water resources across the nation. Our research in North Carolina has shown that most water resources located downstream from coal ash ponds are contaminated with toxic contaminants, such as arsenic and selenium, derived from unregulated coal ash stored in ponds. Our research has further developed a diagnostic "tool-box" that enables scientists to delineate and monitor contaminants' sources and pathways in the environment. Over the last decade, shale gas exploration has offered an alternative new energy source. Advances in drilling technologies and production strategies such as horizontal drilling and hydraulic fracturing have significantly improved the production of natural gas by stimulating fluid flow, and since the late 2000s these developments have spurred exponential growth of shale gas well drilling across the United States. Yet recent scientific findings have raised important questions regarding the environmental effects of shale gas drilling. The primary environmental issues are: possible methane contamination of shallow drinking water wells located near shale gas wells; possible pathways of saline water and connection between deep shale gas formation and shallow drinking water aquifers; lack of water availability in some regions; and the safe disposal of waste water generated during shale gas production, which is often highly saline, toxic and radioactive.

While low-cost coal and new shale gas reserves are vital for enhancing US energy security, the direct and indirect effects on the environment might have significant long-term implications for the ecological systems and human health.

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Dr. Avner Vengosh is a Professor of Geochemistry and Water Quality at the Nicholas School of Environment, Duke University. He has also a secondary appointment at the Department of Civil and Environmental Engineering at Duke University. He is an Associate Editor for the international journal Applied Geochemistry, member of the Environmental Surveillance Committee of the North Carolina Radiation Protection Commission, and member of the Geochemical Society, American Geophysical Union (AGU), Geological Society of America (GSA). In 2009, Dr. Vengosh gave testimony to the Subcommittee on Water Resources and Environment, U.S. House of Representatives, regarding: "The Tennessee Valley Authority's Kingston Ash Slide: Potential Water Quality Impacts of Coal Combustion Waste Storage". In 2011, Dr. Vengosh received the International Association of Geochemistry (IAGC) Fellow award. Dr. Vengosh research aims to integrate environmental geochemistry, advanced isotopic tracers, and environmental health in order to delineate the sources and pathways of contaminants in the environment and their possible impacts on human health. Currently his research is focused on three major themes: (1) The energy-water quality-health nexus that includes (i) the impact of shale gas drilling and hydraulic fracturing on the quality of shallow groundwater and surface waters in the Marcellus Shale (Pennsylvania, New York, West Virginia) and Fayetteville Shale (Arkansas); (ii) tracing the impact of coal combustion products on the environment (e.g., the TVA coal ash spill in Tennessee); (iii) the origin of contaminants associated with mountaintop mining in valley-fill head waters in West Virginia; (2) Water quality deterioration of water resources and impacts on development and health. Current studies focused on shallow groundwater in the sub-Saharan basins of Morocco and coastal aquifer of the southeastern United States. Studies also include the geochemistry of "new water" generated by reverse osmosis desalination of seawater and saline groundwater; and (3) The occurrence and impacts of naturally occurring contaminants on human health in different aquifer systems, worldwide. Current studies including high arsenic in private wells from North Carolina; high radium in Minnesota, high fluoride and arsenic in groundwater from the Rift Valley in Ethiopia; high salinity, fluoride, and radium in groundwater in Morocco; high radioactivity in fossil groundwater in Jordan, and high arsenic and fluoride in groundwater in Vietnam. Studies include developing new diagnostic tools to evaluate arsenic bioaccumulation in the local populations by measuring As in nails and conducting health surveys in exposed populations. Dr. Vengosh research has been supported by grants from both government agencies and private companies, with core grant research support primarily being from the federal government (National Science Foundation), with additional grant support from state and local governments, industry, and foundations.