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Coal Energy and Environmental Impacts: Introduction

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Editorial

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Within the last decade, the importance of integrating the environment, people, and climate has transitioned from being an academic concern (e.g., WEF, 2011) into a broadly societal concern as the forecasted realities of environmental deterioration and global climate change come to pass, creating urgent public and environmental health issues. Joyce Msuya, Acting Executive Director of UN Environment Programme, stated, "*The science is clear. The health and prosperity of humanity is directly tied with the state of our environment*" (UN News, 2019). The sheer magnitude and complexity of these issues, particularly within the broader narrative of a ballooning world population and unsustainable consumption patterns, requires a coordinated, transdisciplinary, and international effort to increase public awareness, and develop and implement an effective response. Scientists, governments, global leaders, policy makers, intergovernmental organizations, stakeholders, and even concerned citizens have coalesced around an urgent need to address the profound, and enduring impacts, that human activities pose to the environment as the projected consequences of inaction threatens the health – and very existence – of the human population.

Central to these discussions is developing policy/energy usage strategies within the context of climate change, where a growing (and some would argue "overwhelming") body of evidence links global environmental change and ecosystem responses with the extraction and utilization of fossil fuels, particularly coal. Coal, the "largest source of solid fuel in the world" (Miller, 2011), has been universally (and indiscriminately) embraced by civilizations across the entire globe for thousands of years, playing a pivotal role in the creation and advancement of the industrial revolution(s), and the development of modern technologies. Unfortunately, this success comes at a price, as the consequences of long-term usage on air, water, soil, ecosystems, animal and human health are significant. The removal of coal from the global energy mix has been internationally prioritized as governments seek to reduce greenhouse gas emissions, and restrict the development of coal mines, power plants, and associated infrastructure (Brown and Speigel, 2019).

In this special issue of *Energy Geoscience*, "Coal Energy and Environmental Impacts", we explore the profound impact and influence (positive and negative) that this important energy resource has at the water-energy-food-health nexus and offer insight into the various facets of coal science, the environmental and human health impacts of coal, and the development of energy resources.

The introductory article by Hower and Groppo (2021) uses electron microscopy to investigate the modes of occurrence, and distribution, of rare earth element (REE) minerals in fly ash. Given the critical importance of REE within industrial applications, the recovery of REE from coal combustion by-products may offer a promising solution within a global context of supply and demand.

Finkelman et al. (2021) discusses the historical and current importance of coal, and provides a broad overview of environmental consequences, and human health impacts, resulting from long-term use of coal. The causal links between coal use, environmental impacts and human well-being are discussed in further detail by Gasparotto and Martinello (2021) and Ribeiro and Flores (2021). Gasparotto and Martinello (2021) provide a comprehensive review that digs into the connections between coal composition, inhalation of hazardous substances generated during coal combustion (e.g., coal micro-particles, nanoparticles, and its by-products), physiological changes within the body, and the pathogenesis of various diseases, such as respiratory and cardiovascular disease, systemic inflammation, and neurodegeneration. Ribeiro and Flores (2020) focus on a better understanding of environmental impacts caused by the disposal of coal mining residue from past mining activities and identify transport and exposure pathways using phase-selective extraction techniques and geochemical analyses.

It is worth noting that, while our ability to explicitly link exposure with health outcomes currently presents a profound knowledge – and analytical – gap, it also provides an opportunity for transdisciplinary collaborations involving doctors, geologists, chemists, physicists, economists, and several other disciplines in the future.

In order to effectively assess the mobility, availability, and contaminant risk associated with various phases of the coal "life cycle", from resource extraction to the final waste disposal, various experimental methods and sophisticated analytical techniques are required to comprehensively characterize representative coal material. Akinyemi et al. (2021) combined X-ray diffraction (XRD), physicochemical analyses, and thermogravimetric (TG) techniques to characterize select coals from the Benue Trough in Nigeria, and evaluate their suitability for various applications, such as power generation, plastics manufacturing, and/or domestic uses (e.g., household cooking and heating). Rautenbach et al. (2021) integrates experimental work with XRD, X-ray Fluorescence (XRF), petrographic, and QEMSCAN (Quantitative Evaluation of Materials by Scanning Electron Microscopy) analyses to examine the slagging behavior of South African pulverised feed coals during combustion.

While "climate change", or the "climate crisis" (e.g., Thunberg, 2019), has entered the general public's awareness and social lexicon - not only assimilating into popular culture (Noah, 2017; Colbert, 2018; SNL, 2018) and becoming a topic for casual conversation

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but a divisive and polarizing political issue as well (Kamarck, 2019; Yoder, 2019) - the climate change narrative, within the context of coal utilization, is largely focused on power generation within industrialized countries (IEA, 2019). However, as Sumbane-Prinsloo et al. (2021) point out, "almost 3 billion people, mostly in the developing world, do not have access to clean energy sources [and rely] on solid fuels." The incomplete combustion of solid fuels, such as coal, injects a proverbial "alphabet soup" of harmful compounds (e.g., heavy metals, mercury, sulfur dioxide, nitrogen oxides, particulate matter, and others; Union of Concerned Scientists, 2008) into the household environment, ultimately impacting human health. To better understand the thermal performance of coal and a coal-derived char in a typical household stove, Sumbane-Prinsloo et al. (2021) characterized coal and char samples using various analytical methods, and systematically evaluated the effect of particle size on performance. Their results provide insight into the development of suitable alternatives to replace feed coal.

Finally, Firpo et al. (2021) and Nieves et al. (2021) explore new uses for coal waste. Firpo et al. (2020) describe the production of a technosol made from coal waste – "transforming coal waste into a substrate for plant growth". Nieves et al. (2021) collected fly and bottom ash fly from a thermal-electrical unit and used the material to synthesize an ash-based geopolymer.

We appreciate the opportunity to present this special issue, and hope that readers will benefit from the breadth and scope of research addressing coal energy and associated impacts. We greatly appreciate the time and effort invested by the authors to draft and submit manuscripts, as well as the reviewers who volunteered their time and expertise to perfect the articles presented in this volume. Lastly, we would like to thank Prof. Dr M. Santosh for his encouragement, support, and guidance in preparing this issue. Despite the COVID-19 pandemic with all its challenges, we managed to present a special issue with interesting works by high-level authors.

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