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EDITORIAL

Characterization and remediation of contamination: the influences of mining and other human activities

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There are many definitions of the term contamination. Jefferis (2002 p. 75) provided the simple definition "contamination is a chemical, a living organism or energy in the wrong place." Paraphrasing this definition, contamination is the presence of an unwelcome component in a material, physical body, place, or other entity. In the natural environment, contamination implies that an exotic constituent that generally poses risks to biota living in that environment, particularly humans, has been introduced to the environment. Humans produce most contaminants, and cause many elements and compounds to be released into natural waters, soil, and the atmosphere that can then enter the human food chain. These elements and compounds are commonly called potentially harmful (or toxic) elements. Potentially harmful elements can have a very wide range of characteristics and origins. Potentially harmful elements can be heavy metals or metalloids (e.g., As, Cd, and Hg) released during mining or other industrial activities, or they can be organic compounds, such as medications (the excess of which can be released when they are used in clinical treatments). A very wide range of factors therefore affect contamination, and this variety affects the methods that are used to study and assess contamination processes and the methods that can be used to decrease the impacts of contaminants on the environment and human health.

Some of the most important questions about contamination are related to the potential of potentially harmful elements to cause real health effects in the general population. Most contamination is caused by industrial processes, in mines and factories, for instance. However, the risks posed to workers in mines and factories are (or should be) generally controlled and minimized because they are known risks. However, improperly controlled gases and/or liquids containing potential contaminants can be released into the surrounding environment and affect local inhabitants. Potential risks need to be assessed taking into account processes that affect the mobilities and, in particular, the bioavailabilities of the contaminants present. Regional, national, and international regulators have introduced legislation in which maximum amounts of contaminants that can be released into the environment for any reason have been set. However, very limited success has been achieved in holding governments or individuals responsible for emissions of greenhouse gases, which are considered to be the primary causes of anthropogenic climate change (Zeben 2015). It is also necessary to take into consideration the chemical forms in which contaminants are released. For example, mercury is considered to be a potentially harmful element, but it is necessary to know which form of mercury is present in the environment or in a product that is released to assess properly the potential for mercury to cause toxic effects. The potential for toxic effects

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occurring is low if mercury is present as cinnabar (HgS), which is stable under atmospheric conditions and is unlikely to dissolve in the digestive systems of mammals if it is swallowed. However, the potential for toxic effects occurring is very high if mercury is present as methylmercury, which has previously caused serious toxic effects, such as in the Minamata incident (Harada 1995).

Some of these matters are addressed in this special issue of *Environmental Science and Pollution Research*, which includes a selection of contributions to the "Second Energy and Environment Knowledge Week" (E2KW), held in Toledo, Spain, on 30 and 31 October 2014. The influences of mining and other human activities on the production and environmental dispersal of contaminants, the transfer of contaminants from inorganic media to organic media, and possible ways of decreasing the risks posed by contaminants are assessed in the contributions to this special issue.

Most of the papers in this issue are directly or indirectly related to mining. Mining may be the most active source of environmental contaminants. Mining certainly is the most active source of environmental contaminants if we consider mining to be the extraction of a wide range of resources, including construction materials, fuel, metals, and metalloids. All of these resources are extracted from the ground and then used in many different ways. The amount of care taken during the lifecycles of different resources varies widely. Mines are not usually near heavily populated areas, whereas industrial plants are normally clustered together close to large urban areas. The clustering of industrial plants means that numerous contaminants are likely to be emitted in industrial areas. However, mines are usually more important sources of contaminants than are industrial areas. This is particularly true for decommissioned and abandoned mines. A closed mine will usually be left unattended, which favors the continuous and uncontrolled release of contaminants. Mining activities (such as splitting rocks from the mine face using explosives, transporting and crushing the removed rock, and treating the rock with chemicals) are usually performed in the open air. Many minerals are unstable when exposed to the atmosphere and become weathered. The geochemical reactions that occur during weathering can change the physicochemical properties of natural water, and, in extreme cases, cause acid mine drainage (AMD) (Banks et al. 1997). The most important aspect of these processes is the possibility that biota (particularly edible flora and fauna) will be affected. The uptake of contaminants by edible flora and fauna will allow the contaminants to enter the human food chain. Mining is not the only cause of environmental contamination. For example, accidental leaks that are likely to cause environmental contamination can occur during industrial processes and the treatment and disposal of waste.

Mining and pollution: effects on water and aquatic systems

Mining always affects natural water (both surface water and groundwater) and the sediment in fluvial systems. Some mines affect natural water little and may only increase the turbidity of the water (although, in some cases, this can strongly affect aquatic ecosystems that require clear water). In other cases, the weathering of minerals in the material being exploited can have stronger effects, such as AMD. Valente et al. (2016) and García-Lorenzo et al. (2016) describe the effects of AMD in two decommissioned mining districts, the Iberian pyrite belt in SW Spain and SE Portugal and the La Unión district in Murcia (SE Spain). Valente et al. (2016) describe the geochemical and mineralogical characteristics of water in four artificial reservoirs in the Iberian pyrite belt that have been affected by AMD. They found that the reservoirs had been affected by AMD to different degrees, and that this was reflected in the characteristics of the biota present, particularly in the compositions of epipsammic diatom communities. García-Lorenzo et al. (2016) studied surface water from the AMD-generating site "Sierra Minera" in the La Unión district. They geochemically and mineralogically characterized the water and the minerals carried in the water and studied the efflorescence typically formed at these types of sites. They confirmed that AMD strongly affects the Sierra Minera area, and that the AMD is strongly acid and contains high concentrations of potentially harmful elements. The authors show that it is important to study efflorescences in arid areas such as the La Unión district. García-Ordiales et al. (2016) describe the effects of long-term mining activities in the Almadén mercury mining district in South Central Spain on sediment in an artificial reservoir. The Almadén mercury mining district has been more intensively mined for mercury than any other site in the world. Mercury has been extracted in the Almadén mercury mining district almost continually for 2000 years, and minor ore deposits (Pb–Zn–Ag deposits) were exploited from Roman times to the middle of the twentieth century. A great deal of waste material has accumulated near old mining sites in the Almadén mercury mining district. The Castilseras reservoir, an artificial reservoir in the central part of the Almadén mercury mining district, receives water draining from areas affected by these mining activities. Geochemical analyses of sediment samples from this reservoir showed that geogenic elements and elements clearly related to mining activities have become enriched. These elements could potentially be harmful to humans.

Mining and pollution: effects on biota

Mining products can be dispersed in the environment through a number of processes, including through the hydrolysis/

oxidation of minerals during weathering causing soluble compounds to form and through the dispersal of fine particles in water or the atmosphere. As Gomes et al. (2016) describe, soil at sites contaminated with AMD will retain large fractions of the metallic loads of the AMD, the metals typically accumulating in the clay fraction of the soil. Gomes et al. (2016) analyzed the clay fractions of soil from two contaminated sites in the Portuguese part of the Iberian pyrite belt and found that high arsenic concentrations were associated with clay minerals, jarosite, and goethite. The roles these minerals play in determining the bioavailabilities of potentially harmful elements in cultivated soils are therefore important when assessing risks related to mining activities. The processes through which contamination occurs can generate bioavailable compounds, and a number of studies have been performed with the aim of decreasing the bioavailabilities of these compounds. For example, Rodríguez et al. (2016) studied contaminated soil from an abandoned lead and zinc mine in Spain. They added four potentially useful amendments (organic and inorganic wastes from different industries) and used *Lupinus albus* plants as bio-indicators. They found that the amendments significantly decreased the availabilities of heavy metals to plants and significantly increased the plant biomass produced compared with the biomass produced by plants grown in control soil.

Higueras et al. (2016) studied the uptake of mercury by olive trees grown at three different sites affected by different types of mercury pollution (polluted soil and atmospheric deposition) and different degrees of mercury pollution. They determined the mercury contents of the soils and of the olive tree leaves and found that the uptake of mercury from soil followed a bi-logarithmic model. They also found high mercury concentrations in the leaves when the mercury concentration in the atmosphere was high, indicating that foliar uptake of mercury occurred.

The contamination of edible products is, however, of primary concern. Roba et al. (2016) analyzed heavy metals in vegetables and fruit grown in soil affected by mining activities in Baia Mare, Romania. They found that vegetables accumulated contaminants much more effectively than did fruit. The authors used their results in risk assessments for consumers of the vegetables and fruit and calculated daily intake rates and target hazard quotients. The daily intake rates and target hazard quotients were higher than would be desired close to the most obvious sources of contaminants (the metallurgical plant and tailing ponds).

Do contaminants really reach mammals eating plant products grown near mining areas? Patiño-Ropero et al. (2016) determined the concentrations and species of mercury in tissue samples taken from wild red deer (*Cervus elaphus*) and wild boar (*Sus scrofa*) in the Almadén mercury mining district. These animals do not live close to the most contaminated areas, but the authors found that mercury (both inorganic and organic) had been transferred to and accumulated in the tissues of the animals. They also describe and discuss the relationships between mercury and selenium species in the tissues. Further studies are required to improve our understanding of the interactions between mercury and selenium described by Gailer et al. (2000).

Other anthropogenic contamination scenarios

As mentioned above, mining is not the only source of environmental contaminants. Industrial plants are potential sources of an immense number of contaminants that can be organic, inorganic, or even technological, e.g., nanoparticles (Morris and Willis 2007). The disposal of waste is strictly regulated, but a great deal of work is involved in enforcing regulations.

The environmental effects of waste are of great concern. Sanchez-Ramos et al. (2016) studied the effects of water from several wastewater treatment plants released into a single aquatic ecosystem in Las Tablas de Daimiel National Park in central Spain. They found that the characteristics of the treatment plant discharge outlets strongly affected water quality, depending on such factors as the hydro-geomorphology of the system and the density of vegetation in the channels in the system. Environments receiving treated water can potentially self-purify, but this can be limited when sludge accumulates. Using untreated rather than treated water seems to be a good option when the water is not intended to be consumed by or to come into direct contact with humans. Seidl et al. (2016) assessed the sanitary hazards to pedestrians posed by the use of untreated water to clean streets. The biological, physical (particulate), and chemical contents of aerosols produced when cleaning streets with untreated water were worrying. However, some of the contaminants were present not because untreated water was used but because they were present on the pavements. Besides this, a pedestrian would not be exposed to the contaminants in the aerosol for long enough for the risks posed to be of great concern. The risks posed to the cleaning workers, who would be chronically exposed to the aerosol, would, however, need to be assessed in more detail.

The air in high mountain areas is typically expected to be clean and free of anthropogenic influences. However, Hegde et al. (2016) analyzed aerosols from the Himalayas (generally seen as being remote from contaminated sites) and found some worrying results. The carbon and nitrogen contents and isotopic signatures showed anthropogenic influences. The authors concluded that anthropogenic contaminants reach these high and remote areas under favorable meteorological conditions.

Cutting edge research into contamination caused by human activities, focused on the characterization and remediation of contaminants, is presented in this special issue. Case studies are presented in which the influences of human activities on environmental degradation are assessed. Among the human activities that are assessed, mining appears to be the most important in terms of effects on environmental media. However, even cleaning streets with untreated water may cause quantifiable negative effects if the process is performed incorrectly. Some new techniques and procedures are proposed for decreasing the impacts that human activities have on environmental media. We greatly appreciate the contributions made by the authors and reviewers. We also appreciate the assistance provided by ESPR editor-in-chief Philippe Garrigues and editors Zhihong Xu, Gerhard Lammel, Stuart Simpson, Céline Guéguen, and Michael Matthies during the review process and by editorial assistant Géraldine Billerot during the preparation of this special issue. Additional information about the E2KW 2014 conference speakers and titles can be found at http://congresse2kw.uclm.es/e2kw-2014. The conference was organized by the Energy and Environment Science and Technology Campus of International Excellence (CYTEMA) of the University of Castilla-La Mancha.

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