Strontium, barium, and radium as tracers of oil and gas contaminant accumulation in biota and sediment

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Oil & gas (O&G) has bee linked with water quality changes in freshwater streams from the permitted discharge of treated wastes. These discharges lead to increased concentrations of strontium, barium, and radium in waterways and sediments that could pose risks to human and environmental health [1-4]. Elemental concentrations measured in sediments downstream of O&G wastewater discharge facilities identify intervals with higher alkali earth metals in both surficial sediment transects and sediment cores downstream of multiple facilities that discharge treated O&G wastewater. Isotopic tracers ($^{226}Ra/^{228}Ra$ and $^{87}Sr/^{86}Sr$) indicate upstream disposal of O&G wastewaters is the source of the elevated concentrations. Isotopic ratios can also indicate the source of the wastewater (i.e., unconventional versus conventional) and help identify the time of the waste disposal. While sediments appear to preserve the unique chemistry of O&G wastewater that can be used as forensic tools to record discharges of effluent over time, little is known about the potential accumulation and/or long-term risks of these contaminants for freshwater species. Similar to sediments, bivalve shells record the water chemistry of streams and may be used to evaluate changes in water quality through time and preserve unique chemical signatures of O&G wastewater as well as changes in watershed energy development. Bivalve shells collected downstream of discharge facilities , recorded Sr/Ca ratios and $^{87}Sr/^{86}Sr$ ratios consistent with changes associated with a time period when the greatest volumes of O&G wastes were disposed to surface water (2009-2011). Feathers are commonly used for sampling exposure to pollutants. Bird feathers collected in areas of O&G development also reveal $^{87}Sr/^{86}Sr$ ratios consistent with O&G wastewaters. Analyses of biomonitors will help quantify risks human health and environmental risks that can guide future O&G wastewater management strategies.

[1] Warner, et al., *ES&T* (2013) **47**, 11849–11857. [2] Ferrar, et al., (2013) *ES&T* **47**, 3472–3481. [3] Skalak, et al., *In. J. Coal Geo*. (2014) **126**, 162-170. [4] Burgos, et al., *ES&T* (2017) 51, 8851-8860.