The environmental consequences for the utilization of oil shale products using the Aerobic Combustion Process

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The El-Llajjoun oil shale of Jordan was investigated for the fate of toxic elements contained within the shale, including Cr, As and V in the ashes produced through aerobic combustion. The study was done using Synchrotron-based X-ray absorption near-edge structure (XANES) analysis. The study was done at BESSY II/Berlin. The oil shale powder was burned aerobically at different temperatures (700 − 1000°C).

The chemical analysis shows that ashes produced from aerobic combustion processing (ACP) significantly increases the concentrations of all major oxides due to high loss on ignition (LOI) resulting from both calcium carbonate and organic carbon degradation. The concentrations of SiO_2 and CaO in the ashes nearly doubled. Moreover, trace elements such as Cr, Ni, Zn, Cu and U showed a similar enrichment trend. For example, the LOI leads to enrichment in the Cr concentrations from 480mg kg^{-1} in the original oil shale up to 675 mg kg^{-1} in the $\geqslant$850 ° C (ACP) samples.

The XANES results show that toxic elements were converted to higher oxidation states, including Cr(VI), As (V) and V(V), during the APC with increasing burning temperatures. The leaching experiment following the European compliance leaching test CEN/TC 292 EN 12457-1 (1:2 solid/water ratio, 24 hours shaking) shows that leachates from APC samples showed Cr release in the order of one mmol L^{-1}. The leachable Cr content is dominated by chromate Cr(VI) as revealed by catalytic adsorptive stripping voltammetry (CAdSV). This is an alarming conclusion because Cr(VI) is more mobile and harmful than Cr(III) and thus could cause pollution to scarce surface and groundwater bodies of Jordan. This result raises concerns regarding ongoing oil shale utilization projects in Jordan due to pollution potential and precautionary measures should be implemented to monitor leachates originating from ash piles in addition to the solidification of ash piles.