



## **The environmental consequences of the oil shale utilization in Jordan: The effect of combustion processes**

Tayel El-Hasan

Mutah University, Faculty of Science, Chemistry, Jordan (tayel.elhasan@gmail.com)

The geochemical analysis of the upper Cretaceous organic rich oil shale of El-Lajjoun revealed that it contains considerable concentrations of trace element when compared to the average world shale. The aim of this study was to deduce the effect of various combustion processes on the geochemical and mineralogical characteristics of the produced ashes. The oil shale powder samples were burned under Aerobic Combustion Process (ACP) at 700°C, 850°C and 1000°C respectively, beside the anaerobic (pyrolysis) combustion process (PCP) at 600, 650, 700, 750 and 800°C respectively. The ashes produced from the (ACP) caused almost all major oxides contents to increase with increasing burning temperature, particularly SiO<sub>2</sub> and CaO were nearly doubled at temperature 1000 °C. Moreover, trace elements showed the same trend where ashes at higher temperatures (i.e. 1000 °C) have doubled its contents of trace elements such as Cr, Ni, Zn, Cu and U. This was reflected through enrichment of calcite and quartz beside the anhydrite as the main mineral phases in the ACP ashes.

As for the PCP ash show similar trend but relatively with lower concentrations as evident from its lower Enrichment Factor (EF) values. This might be due to the higher organic matter remained in the PCP ashes compared with ACP ashes. However, PCP is more likely associated with toxic Cd and As gases as evident from their lower concentrations in the ashes. Moreover, recent results using the synchrotron-based XANES technique confirm that toxic elements are found in higher oxidation state due to ACP. The investigation was concerned on As and Cr. The chromium in the original shales was in the form of Cr(III) and then it was converted to Cr(VI) in the ashes due of the ACP. Similarly, As(III) the XANES results showed that it was converted into As(V) too. These findings are alarming and should be taken seriously. Because elements with higher oxidation states became more mobile, thus they can easily leached from the ash tailing into the nearby water resources. The most important species is Cr(VI) because it is easily leachable and very harmful species. It could cause pollution to surface and ground water resources. Therefore, a lot of concerns should be paid on the ongoing oil shale utilization enterprises due to its pollution potential. Further investigation regarding the speciation of vanadium and cadmium are on the way.