ザンビア共和国カブウェ地区廃石場における鉛のassisuted natural remediation
Assisted natural remediation of leads at a dumping site in Kabwe, Zambia

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Kabwe mine area has adversely affected by heavy metal contaminations which is attributed to past mining activities. Lead (Pb) poisoning especially in children is becoming a serious public health concern in the whole world today. To help determine which method is the most suitable to remediate contaminated soil and groundwater in Kabwe, we focused on secondary phases of lead. This study clarified the extent of pollution within dumping site in Kabwe and the achievement in immobilization of lead by generating phosphate mineral (chloropyromorphite: $Pb_5(PO_4)_3Cl$).
Firstly, slag, boring core and groundwater samples were collected and analyzed by XRD, XRF, SEM/EDS for solids and ion chromatograph, alkalinity titration, ICP-AES, ICP-MS for liquids. Water samples from three boreholes KA-01, KA-02 and KA-03 shows a significant amount of lead in the area. The lead concentration for KA-01, KA-02 and KA-03 were 2.29ppm, 0.026ppm and 0.010ppm respectively. KA-01 had highest lead concentration in groundwater which is being attributed to leaching of lead minerals from the slag dump. The slag dump is waste after chemical leaching of sphalerite (ZnS) by sulfuric acid and this contain sulfate of various metals like anglesite ($PbSO_4$) which is considered a primary phase but according to SEM/EDS observation, anglesite and cerussite ($PbCO_3$) were regenerated as secondary minerals during interaction of slag with the environment. A natural attenuation due to formation of secondary phase of lead was observed and because this attenuation is not enough to reduce lead mobility in water. Lead immobilization can only be achieved with human assist to form a secondary mineral which is stable and resistant to leaching. This remediation method needs minimum treatment to support only shortfall of natural remediation mechanism and it is called assisted natural remediation. If we can understand how much shortfall in achieving natural remediation, then we can easily remediate soil and groundwater in Kabwe using economically and environmentally friendly method. Secondly, in this study, thermodynamics was considered as a tool to remediate pollution in Kabwe. The geochemical reaction modeling showed a reduction in dissolved lead concentration and formation of lead secondary phases by using geochemical code “Act2” and “React” in the Geochemist’s Workbench 11.0 (Bethike, 1996) based on the field sampling and laboratory synthesis experimental analysis. According to thermodynamic calculation, dissolved lead concentration of groundwater in Kabwe is controlled by solubility of anglesite. The solubility of anglesite and cerussite were very high compared with the environmental standard set by WHO (0.01 mg/L) while that of chloropyromorphite was very low below WHO environmental standard. Generating chloropyromorphite as a new secondary mineral phase of lead in Kabwe which has the lower solubility will however only be defined when the system reaches equilibrium. In most cases the mechanisms of retention and release of soil contaminants are time-dependent processes. Therefore, we clarified whether chloropyromorphite can be generated in a short time at room temperature or not by synthesis experiment. The formation of chloropyromorphite was observed by SEM/EDS, and that the

dissolved lead concentration was reduced to below the WHO environmental standard. This intel’ s that chloropyromorphite can be generated at room temperature, hence contribute effectively to remediate lead contamination in Kabwe.

キーワード：鉛汚染修復、自然浄化、リン酸塩、沈殿
Keywords: Lead remediation, Natural attenuation, Phosphate, Precipitation

