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# Feasibility of Washing/Extraction Treatment for the Remediation of Deep-Sea Mining Trailings

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**Abstract :** Importance of deep-sea mineral resources is dramatically increasing due to the depletion of land mineral resources corresponding to increasing human's economic activities. Korea has acquired exclusive exploration licenses at four areas which are the Clarion-Clipperton Fracture Zone in the Pacific Ocean (2002), Tonga (2008), Fiji (2011) and Indian Ocean (2014). The preparation for commercial mining of Nautilus minerals (Canada) and Lockheed martin minerals (USA) is expected by 2020. The London Protocol 1996 (LP) under International Maritime Organization (IMO) and International Seabed Authority (ISA) will set environmental guidelines for deep-sea mining until 2020, to protect marine environment. In this research, the applicability of washing/extraction treatment for the remediation of deep-sea mining tailings was mainly evaluated in order to present preliminary data to develop practical remediation technology in near future. Polymetallic nodule samples were collected at the Clarion-Clipperton Fracture Zone in the Pacific Ocean, then stored at room temperature. Samples were pulverized by using jaw crusher and ball mill then, classified into 3 particle sizes (> 63 µm, 63-20 µm, < 20 µm) by using vibratory sieve shakers (Analysette 3 Pro, Fritsch, Germany) with 63 µm and 20 µm sieve. Only the particle size 63-20 µm was used as the samples for investigation considering the lower limit of ore dressing process which is tens to 100 µm. Rhamnolipid and sodium alginate as biosurfactant and aluminum sulfate which are mainly used as flocculant were used as environmentally friendly additives. Samples were adjusted to 2% liquid with deionized water then mixed with various concentrations of additives. The mixture was stirred with a magnetic bar during specific reaction times and then the liquid phase was separated by a centrifugal separator (Thermo Fisher Scientific, USA) under 4,000 rpm for 1 h. The separated liquid was filtered with a syringe and acrylic-based filter (0.45 µm). The extracted heavy metals in the filtered liquid were then determined using a UV-Vis spectrometer (DR-5000, Hach, USA) and a heat block (DBR 200, Hach, USA) followed by US EPA methods (8506, 8009, 10217 and 10220). Polymetallic nodule was mainly composed of manganese (27%), iron (8%), nickel (1.4%), cupper (1.3 %), cobalt (1.3%) and molybdenum (0.04%). Based on remediation standards of various countries, Nickel (Ni), Copper (Cu), Cadmium (Cd) and Zinc (Zn) were selected as primary target materials. Throughout this research, the use of rhamnolipid was shown to be an effective approach for removing heavy metals in samples originated from manganese nodules. Sodium alginate might also be one of the effective additives for the remediation of deep-sea mining tailings such as polymetallic nodules. Compare to the use of rhamnolipid and sodium alginate, aluminum sulfate was more effective additive at short reaction time within 4 h. Based on these results, sequencing particle separation, selective extraction/washing, advanced filtration of liquid phase, water treatment without dewatering and solidification/stabilization may be considered as candidate technologies for the remediation of deep-sea mining tailings.

**Keywords :** deep-sea mining tailings, heavy metals, remediation, extraction, additives
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