

## Investigating lead amounts in shooting range soil partitioned by particle size

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Soil contamination by lead in shooting ranges has been a critical issue because lead concentrations in soils are often higher than 100 times the concentration of the environmental quality standard in Japan. Tajimi city shooting range is one of the closed shooting range due to the heavy lead contamination. Lead content in soils higher than 10,000 mg kg<sup>-1</sup> were reported at multiple locations in the shooting range. Phytoremediation and immobilization has been studied for lead contamination in the shooting ranges. However, the phytoremediation could not remove lead efficiently, and immobilization remains the land re-use problem. In order to find the effective way to remove lead and to utilize the land, it is necessary to build deep understanding of the lead behavior in the contaminated soil. Mizutani et al. (2016) reported that lead contents and leached lead quantity depend on the soil particle size. This is explained by that soil has large surface area and number of adsorption units in small particle fractions. In this study, we also investigated lead contents and leached lead quantities in/from contaminated soil partitioned by soil particle size. The soil was sampled from Tajimi city shooting range and it is heavily contaminated, i.e., the lead content is close to 100,000 mg kg<sup>-1</sup>.

The soil was divided into six fractions by dry sieving with multiple screen sizes. The sieving was performed with a shaker for 30 minutes. The fractions were smaller than 0.045 mm (A), 0.045~0.074 mm (B), 0.074~0.25 mm (C), 0.25~0.5 mm (D), 0.5~2.0 mm (E), and 2.0~4.75 mm (F). For the lead content exam, 2 mL 12.0M HCl and 5 mL 12.0M HNO<sub>3</sub> were added into 0.25 g soils, and the samples were digested by the microwave sample preparation system. After the digestion, the sample were diluted by pure water and centrifuged. The supernatant was passed through 0.45 μm membrane filter. For the leaching quantity exam, soil and pure water were mixed at 1:10 ratio and equilibrated for 24 h on a shaker. After the equilibration, the samples were centrifuged, and EC and pH of the supernatants were measured. The supernatants were passed through 0.45 μm membrane filter. Lead concentration in each sample was measured by ICP-AES.

There is no clear relationship between pH and particle size but EC decreased as particle size increased. The lead contents in each fraction were 45,000-87,000 mg kg<sup>-1</sup>. The large particle size fractions showed high lead contents, e.g., lead content in 2.0~4.75 mm fraction was 1.9 times larger than that in the fraction less than 0.045 mm. It was expected that the small particles show larger lead contents than those for the large particles. The preceding study reported lead content in that manner. The possible reason is an existence of lead ball and its fragments. Many lead balls were found in the 2.0~4.75 mm fraction. Its fragment cannot be visually observed but probably they exist in the other fractions. The number of the lead ball fragment must decrease as the particle size decrease and, thus, decrease of lead content can be explained. In case we eliminated the visually detectable lead balls in 2.0~4.75 mm fraction, the lead content decreased dynamically from 86,000 mg kg<sup>-1</sup> to 18,000 mg kg<sup>-1</sup>. The leached lead quantity in each fraction distributed between 0.9 and 4.3 mg L<sup>-1</sup>. The small fractions show large leached quantity. This result is also opposite to the preceding study. The existence of lead ball and its fragment can be a possible reason again since the density of lead is higher than that of soil and variety of soil bulk density can affect the leaching quantity. In order to build better understanding of the results, further examinations such as cation exchange capacity, anion exchange capacity, specific surface area, soil particle density are

required.

Keywords: Shooting range, lead, soil contamination