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Research article

The suitability evaluation of dredged soil from reservoirs as embankment material

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A B S T R A C T

We assessed the suitability of soil dredged from reservoirs as embankment material and investigated its physical and geochemical properties and strength parameters, as well as its environmental stability. The dredged soil samples were taken from the Ansung, Jechon, and Mulwang Reservoirs in Korea. To evaluate their environmental stability and geochemical properties, we examined their levels of heavy metal contamination, pH, and electrical conductivity. We also conducted X-ray fluorescence and X-ray diffraction analyses. Furthermore, we determined the geotechnical characteristics, such as the compaction characteristics, and permeability coefficient, and we performed consolidated undrained triaxial compression tests to evaluate the recycling potential of dredged soil as embankment material. The concentrations of heavy metals in the sediment samples were lower than those of the standard samples. The pH value of the soil samples ranged from 4.25 to 5.39, and the electrical conductivity ranged between 83.3 and 265.0 μS/cm, indicating suitability for use as construction material with steel and concrete. Based on the values of the mechanical properties of the dredged soil, analysis of slope stability was performed for various cases and water level conditions. Our results indicate that the dredged soil has sufficient stability for substitution of embankment material and also as new embankment material for expansion.

1. Introduction

The siltation of rivers, marine areas, and reservoirs represents a major problem in water management, mainly due to the reduction of water storage capacity, sediment in the navigation channel, and accumulation of contaminants (Chandrajith et al., 2008; Junakova et al., 2015; Koç, 2011; Singh et al., 1998). To avoid these problems, large amounts of soil have been dredged from rivers, marine areas, and reservoirs. However, the dredged soil has generally been disposed of as waste in landfills or disposal sites at sea. In recent years, this has become difficult due to increasing concern about the environmental impacts, which has promoted demand for recycling the dredged soil. A number of studies have been conducted on the recycling of such material as a construction material such as lightweight soil, air-foam stabilized soil and composite geomaterial with bottom ash (Kim et al., 2008, 2011; Park and Vo, 2015; Yoonz et al., 2004).

Chiang et al. (2008) assessed the feasibility of using reservoir-dredged soil to produce bricks. They conducted experiments on soil/clay mixtures (0–20% clay content) over temperatures ranging from 1050 °C to 1150 °C and showed that all specimens complied with the criteria for building bricks. Junakova et al. (2015) demonstrated the potential use of dredged soil from reservoirs as a secondary raw material in concrete production. Soil-containing concrete specimens were pressed and cured for 2, 7, 28, and 365 days, and the end products were similar to those made from standard concrete mixtures. They also performed freeze–thaw resistance tests, which showed that the specimens met the standard requirements for frost-resistant concrete class XF2. Grubb et al. (2006) conducted a laboratory evaluation of crushed glass and dredged material mixture. They found that the mixture can significantly improve the engineering properties of the dredged material with the addition of above 20% crushed glass. Grubb et al.

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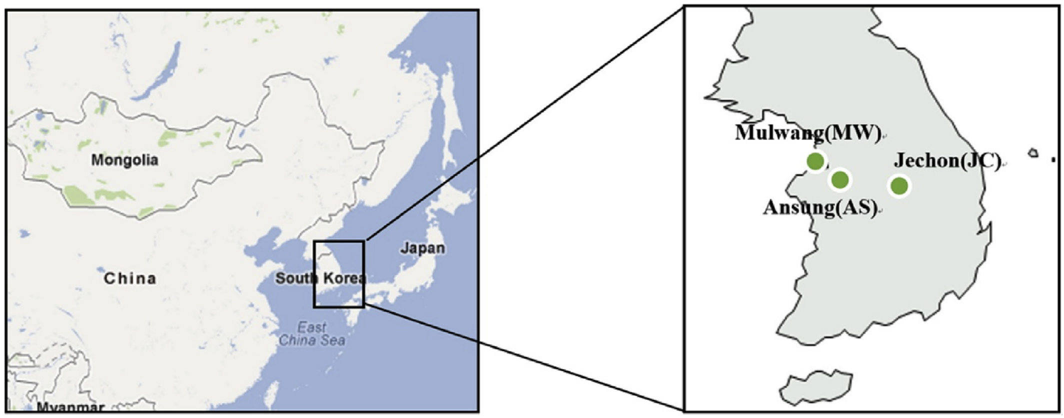

Fig. 1. Location of sampling sites in this study.

Table 1
Physical properties of dredged reservoir soil samples.

Sample	Specific gravity (Gs)	Cu	Cg	LL (%)	PL (%)	USCS
AS	2.60	5.88	1.30	43.7	37.6	ML
JC	2.56	44.89	0.23	47.6	37.0	SM
MW	2.56	14.00	1.41	33.6	25.6	ML

Cu: Coefficient of uniformity.
Cc: Coefficient of curvature.

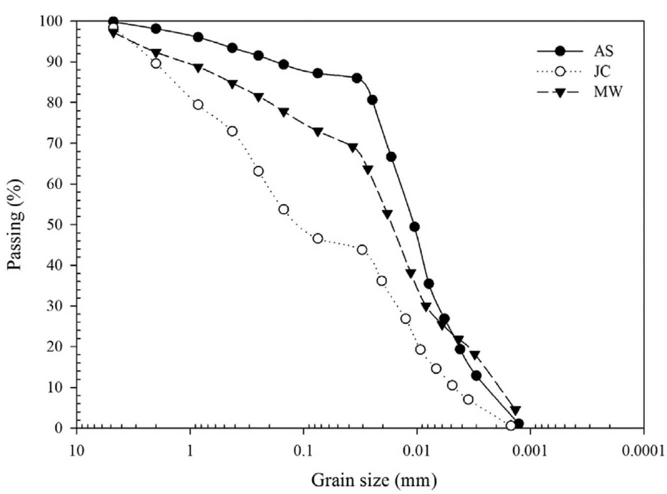

Fig. 2. Particle size distribution curves of dredged soil samples.

Table 2
EC and pH values of samples dredged from three reservoirs.

Sample	pH			EC (μS/cm)		
	Max	Min	Mean	Max	Min	Mean
AS	4.41	4.25	4.35	176.7	155.5	164.1
JC	5.39	5.35	5.37	100.5	83.3	93.9
MW	5.23	5.20	5.22	265.0	242.2	253.3
Average			4.98			170.4

(2008) performed an aging effect evaluation of crushed glass and dredged material mixture and concluded that the effective friction angle of the aged blend material increased by up to 8° due to silica cementation processes. A number of studies have been conducted on geotechnical properties of biosolids such as water treatment

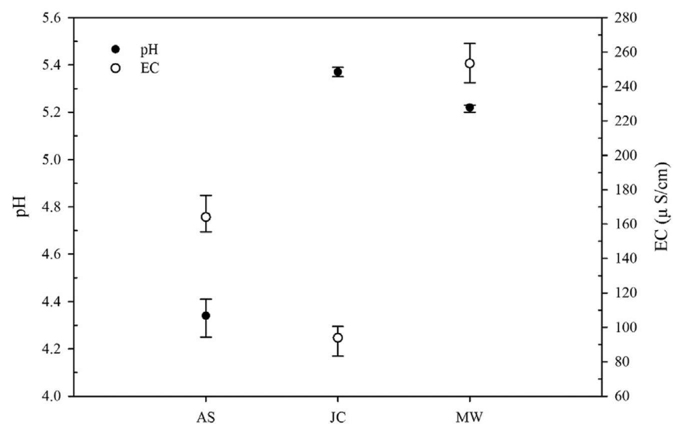

Fig. 3. EC and pH values of soil dredged from three reservoirs.

sludge which are very similar behavior with dredged soil (Arulrajah et al., 2013; Disfani et al., 2013; O'Kelly, 2008, 2013).

Sediment accumulates continuously in reservoirs, and is deposited upstream, which not only results in the reduction of the water storage capacity but also increases environmental contamination. For these reasons, studies have calculated the amount of dredged reservoir sediment necessary to maintain stable irrigation water capacity (Jang et al., 2012), have assessed management strategies for reservoir sedimentation (Haregeweyn et al., 2011; Lee et al., 2013b; Noh et al., 2013; Noh et al., 2015), and have analyzed sediments from an environmental safety viewpoint, considering factors such as heavy metal and phosphorus (P) contamination (Chandrajith et al., 2008; Cheng et al., 2012; Lee et al., 2013a; Sinolungan et al., 2008). Other studies have investigated remediation strategies for contaminated dredged sediments (Kim et al., 2015, 2016; Oh and Cho, 2013).

In particular, there are about 18,687 agricultural reservoirs in Korea, most of which experience rapid vertical accretion and contaminant loading (KME, 2007). Despite their primary purpose being to provide a stable supply of water for farming, the land can suffer from drought from winter to early spring, while floods occur in summer because of the distinct seasonal difference in rainfall. Therefore, the Ministry of Agriculture of Korea has implemented the dredging of reservoir sediment amounting to about 1.5 million m^3 per year.

However, most of the dredged soil is transferred to nearby uplands or rice paddies, and only about 2% of the total amount of soil is recycled as construction material (RRI, 2005). For this reason,