Effect of Surfactant on the Index Properties of Clayey Soils Contaminated with Naphthalene

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Abstract

Effect of adding surfactants to naphthalene contaminated kaolinite and bentonite was investigated. All of the surfactants at 10 CMC decreased the surface tension of water less than 35 dynes/cm. Biosurfactant was basic (pH=10.5) at 10 CMC. Biosurfactant at 10 g/L (pH=10.5) increased the solubility of naphthalene from 32 mg/L to 600 mg/L. SDS (anionic) surfactant substantially decreased the plasticity indices from 18 to 7, and from 386 to 288 for kaolinite and bentonite clays, respectively. Whereas, the biosurfactant and Triton X-100 (nonionic) surfactant did not affect the plasticity of the test soils. The effect of naphthalene on the index properties was negligible.

Introduction

Remediation of contaminated soils by soil flushing is one of the emerging and innovative techniques, specifically for the DNAPLs (Dense Non-Aqueous Phase Liquids) sorbed onto soil particles by physicochemical interactions. Surfactants can be properly used to enhance the desorption and solubilization of organic contaminants into water. However, surfactants may become sources of secondary contamination, and furthermore, they may also change the engineering properties of soils into undesirable state. This adverse effect should be carefully studied for the adequate application of soil flushing for the remediation of organic contaminated soils in situ.

Objectives and Testing Program

This paper focuses on the investigation of the change in the index properties of contaminated clayey soils due to the addition of surfactants. The interactions between clay-surfactant-naphthalene were studied with three types of surfactants. Atterberg limit tests were performed on kaolinite and bentonite clays before and after naphthalene contamination, with and without the addition of biosurfactant, SDS (anionic), and Triton X-100 (nonionic) surfactants at the concentration of 10 CMC. Surface tension and pH changes were also measured before and after the addition of surfactants. As a dispersing agent, NaPO3 was also tested and the changes in soil properties were compared with surfactants.

Results

Test results are summarized in Tables 1, 2, and 3.

Table 1. LL, PL, and PI Changes Before/After the Addition of Naphthalene into Kaolinite and Bentonite

	DI Water	4% $NaPO_3$	Biosurfactant	Triton X-100	SDS
LL(Kaolinite)	47(46)	28	47(46)	48(48)	30(32)
PL(Kaolinite)	29(28)	27	33(30)	31(24)	23(26)
PI(Kaolinite)	18(18)	0.3	15(15)	17(24)	7(5)
LL(Bentonite)	420(445)	241	403(405)	448(375)	338(360)
PL(Bentonite)	34(48)	47	43(100)	43(61)	50(75)
PI(Bentonite)	386(397)	193	359(305)	405(314)	288(285)

Numbers in ( ) were obtained with 32 mg/L of naphthalene solution at room temperature.

Table 2. Surface Tension Before/After the Addition of Naphthalene (Unit: dynes/cm)

	DI Water	4% $NaPO_3$	Biosurfactant	Triton X-!00	SDS
Before Naph. Addition	77	56	29	30	33
After Naph. Addition	76	51	31	32	35

Table 3. pH Changes Before/After the Addition of Naphthalene at Max. Solubility

	DI Water	4% $NaPO_3$	Biosurfactant	Triton X-100	SDS
Before Naph. Addition	7.7	6.7	10.5	8.0	8.5
After Naph. Addition	7.7	6.6	10.6	8.0	8.4

Conclusions

All of the surfactants at 10 CMC decreased the surface tension of water less than 35 dynes/cm. Biosurfactant was basic (pH=10.5) at 10 CMC.SDS substantially decreased the plasticity of both kaolinite and bentonite clays, as the dispersing agent reduced the plasticity of bentonite to approximately half of the value obtained with DI water (PI=386). The dispersing agent turned kaolinite into almost non-plastic soil (PI=0.3). Biosurfactant and Triton X-100 (nonionic) surfactant did not affect the plasticity of the test soils. The effect of naphthalene on the index properties was negligible.

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