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A study on the materials of smart barrier for selectively blocked TCE and TPH

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Abstract. Many barrier materials are used around industries, construction areas, livestock dump sites, waste landfills, and underground oil storage tanks. In the case of barriers, even if there is no inflow of contaminants, they do not provide selective permeability, develop water barrier properties, and hinder groundwater flow when contaminants encounter groundwater. Recently, contaminated sites that are difficult to resolve with current purification technologies continue to emerge. Pollutants flow into groundwater through the advection and diffusion by leaking. The pollutants introduced in this way cause pollution to the surrounding environment, and various types of severe underground environmental pollution problems occur depending on the type of pollutants leaked. Therefore, using a material that has the property of adsorbing organic contaminants and gelling them is harmless to the environment by penetrating groundwater under normal conditions. It has the property of selectively adsorbing the pollutant and gelling it upon contact with it underground. Therefore, the authors aim to study the applicability of polynorbornene and polyolefin as components of smart barrier materials that make barrier materials impermeable through the adsorption of pollutants, swelling, and coagulation behavior in this study. The components of smart barrier materials include Ottawa sand, organo-bentonite, polynorbornene, and polyolefin. Polynorbornene and polyolefin adsorb only organic pollutants selectively. Before applying polynorbornene and polyolefin to the barrier material, TCLP was performed to evaluate environmental hazards. As a result of heavy metal analysis, it was determined that there was no environmental hazard. The pH results are 7.27 for polynorbornene and 7.31 for polyolefin, indicating that both materials are slightly alkaline. In addition, as a result of testing with TCE (stock solution) and TPH (diesel crude oil) to confirm the swelling effect when in contact with organic pollutants, the efficiency of pollutant adsorption and swelling was found to be high when the ratio of polynorbornene: polyolefin = 6:4. Therefore, when using the material used in this study, it is expected that it can be applied as a component of a smart barrier material that selectively blocks pollutants.

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1 Introduction

Organic pollutants and inorganic pollutants enter groundwater through advection and diffusion. Pollutants cause various underground environmental pollution. NAPLs (non-equivalent phase liquid), one of the soil pollutants, are representative organic pollutants that are not easily dissolved in water and do not mix, so they exist as a fluid separated from water when introduced into the ground. NAPLs are divided into DNAPLs, heavier than water, and LNAPLs, lighter than water. DNAPLs such as TCE (Trichloroethylene) and PCE (Perchloroethylene) are toxic pollutants that can cause cancer even in minimal amounts. It is heavier than water, so once it leaks underground, it acts as a groundwater pollutant for a long time. LNAPLs include TPH (Total Petroleum Hydrocarbons), and BTEX is lighter than water, so when it enters the ground, it moves with groundwater and pollutes the surrounding soil and streams. Sites such as railway and gas stations are difficult to apply the excavation method, so new measures are needed. In addition, remediation after contamination consumes high costs and causes social conflicts such as pollution neglect or disputes between interested parties. Therefore, preventing the advection and diffusion of pollutants is essential to prevent environmental pollution. Technologies that prevent the diffusion and transfer of pollutants include slurry walls and geomembrane barrier walls. The slurry wall has a low cost and low water permeability. Barrier materials are used around industries, factories, livestock dump sites, waste landfills, and underground oil storage tanks. In the case of general water barriers, even if there is no inflow of contaminants, they do not provide selective permeability, so when they encounter groundwater, they develop water barrier properties and hinder groundwater flow. There is a problem in that the water level of the upper class rises by completely blocking the groundwater flow. Therefore, there is a need for advanced technology that can block only pollutants. In the end, we aim to study the applicability of polynorbornene and polyolefin as components of smart barrier materials that make barrier materials impermeable through the adsorption of pollutants, swelling, and coagulation behavior in this study.

2 Materials and Methods

2.1 Materials

The materials used in this study include the Ottawa sand, organo-bentonite, polynorbornene, and polyolefin. Figure 1 shows each material.

2.2 Method

Toxicity Characteristic Leaching Procedure (TCLP; EPA SW-846 Test Method 1311) was performed to evaluate the environmental hazards. Furthermore, to evaluate the swelling effect when contacting organic pollutants, the swelling test with TPH and TCE was conducted by varying the ratio of polynorbornene and polyolefin. Table 1 shows the ratio of polynorbornene and polyolefin in this study. The measurement time was measured over a maximum of 72 hours from contact to 1, 5, 30, 120, 1440, and 4320, and the swelling effect was sensibly evaluated by photographing the sample surface at each measurement.

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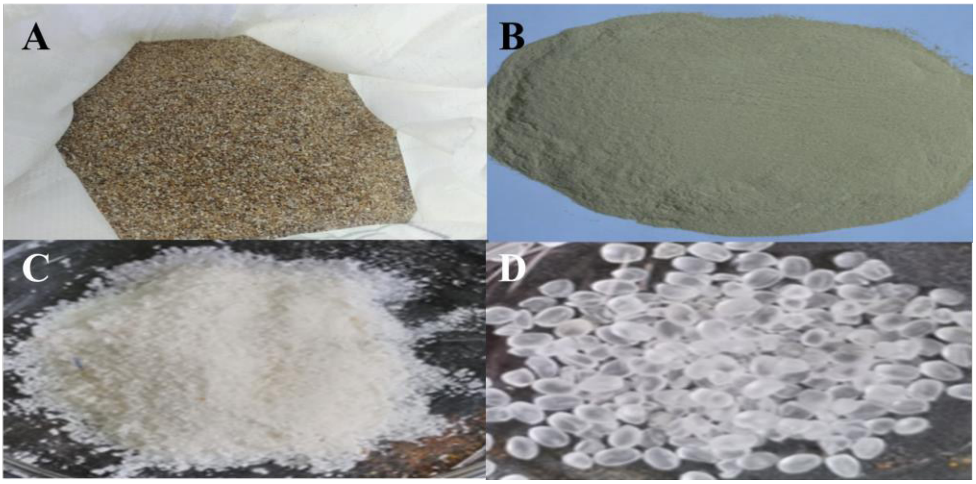

Figure 1. Materials used in this study; A: Ottawa sand, B: Organo-bentonite, C: Polynorbornene, D: polyolefin

Table 1. Mixing ration of polynorbornene and polynorbornene in this study

Case No. \ Materials	Polynorbornene	Polyolefin
Case 1	10	0
Case 2	9	1
Case 3	8	2
Case 4	7	3
Case 5	6	4
Case 6	5	5
Case 7	4	6
Case 8	3	7
Case 9	2	8
Case 10	1	9
Case 11	0	10

3 Results and Discussion

3.1 Environmental hazards

Table 2 shows the results of the environmental hazards of each material used in this study. As a result of TCLP, heavy metals were not detected, so it was determined that there was no effect on environmental hazards.

Table 2. The result of the TCLP

Materials / Heavy metal	Ottawa Sand	Organo-bentonite	Polynorbornene	polyolefin
Pb(mg/L)	0.069	0.042	0.026	0.486
Ni(mg/L)	0.014	2.694	0.350	0
Zn(mg/L)	0.697	4.995	0.446	0.312
Cd(mg/L)	0.001	N/D	0.001	N/D
Cr(mg/L)	0.226	3.482	0.686	0.143

3.2 Physico-chemical Characteristics

3.2.1 Chemical Characteristis

Table 3 shows the results of the chemical characteristics of each material. All materials show weak alkalinity.

Table 3. The results of chemical characteristics

Materials / Item	Ottawa Sand	Organo-bentonite	Polynorbornene	polyolefin
pH	7.59	9.25	7.27	7.31
EC(um/cm)	40.76	476.5	43.26	25.96
ORP(mV)	245.77	205.7	330.9	646.4

3.2.2 Sieve Analysis

Figure 2 shows the Particle-size distribution curve of each material. Organo-bentonite has much more clay than other materials.

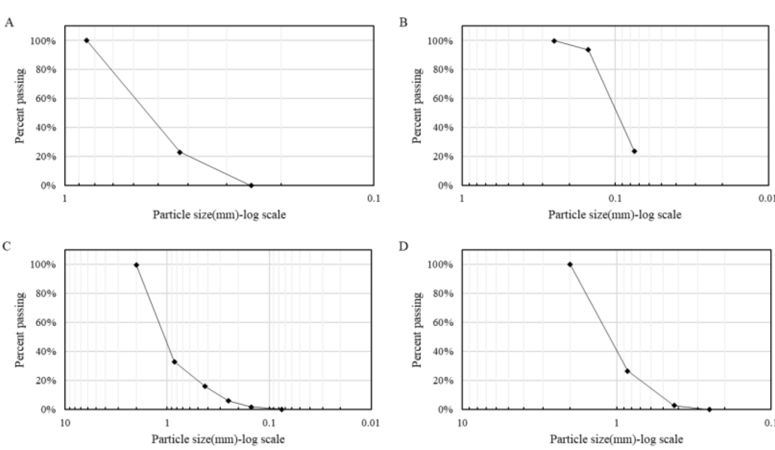

Figure 4. Particle-size distribution curve of each material (A: Ottawa sand, B: Organo-bentonite, C: Polynorbornene, D: polyolefin

3.3 Swelling test

Figure 5 and 6 show some of the results of the swelling test. As the ratio of polynorbornene increases, the swelling effect tends to increase. However, as the ratio of polyolefin increases, the swelling effect decreases, and it is judged that polyolefin alone is unsuitable as a constituent material of a smart barrier material. When considering economic feasibility, it is necessary to determine an appropriate mixing ratio of the two polymers, and the ratio of Case 5 is considered appropriate considering the swelling effect.

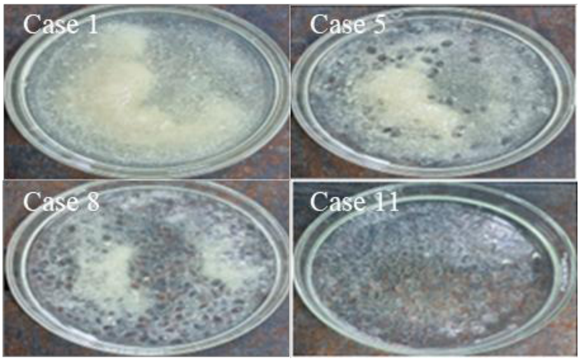

Figure 5. The swelling effect of the polymer 1 minute after contact with TPH

Figure 6. The swelling effect of the polymer 120 minute after contact with TCE

4 Conclusion

This study aims to evaluate the applicability of polynorbornene and polyolefin as components of smart barrier materials that make barrier materials impermeable through the adsorption of pollutants, swelling, and coagulation behavior. To this end, the physicochemical analysis, TCLP, and swelling effects were evaluated. As a result of heavy metal analysis, it was determined that there was no environmental hazard. The pH results are 7.27 for polynorbornene and 7.31 for polyolefin, indicating that both materials are slightly alkaline. The efficiency of pollutant adsorption and swelling was found to be high when the ratio of polynorbornene: polyolefin = 6:4. Therefore, when using the material used in this study, it is expected that it can be applied as a component of a smart barrier material that selectively blocks pollutants.

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