

Beneficial Use of Contaminated Sediment

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Introduction

Contaminated sediments are a problem in many rivers, lakes, and canals. Navigational dredging or environmental restoration requirements may result in large volumes of sediments that require disposal in specially designed landfills. Beneficial use of sediments is being considered to decrease the volume of sediments that require disposal.

Objectives

- Determine if various sediment contaminated with petroleum-like compounds offer some form of reuse or beneficial use
- Determine if particular sediment types can be economically used as a fuel supplement
- Evaluate if combusted sediment results in air emission concerns when used in asphalt plants

Methodology

Task 1. Evaluation of Sediment as a Supplemental Energy Source

- Heating Value Measurement (ASTM 5865-04)
- Elemental Analysis (C, H, N, O, S, Cl, ASTM 5373-02)
- Combustion Off-Gas Measurement (SO₂, NO_x, CO, PICs/POHCs)

Task 2. Evaluation of Air Emissions from Asphalt Plants

- Elemental Analysis (C, H, N, O, S, Cl, ASTM 5373-02)
- Off-Gas Measurement (SO₂, NO_x, CO, PICs/POHCs) at 300–400 °F

Sample Preparation and Analysis

- Dredged sediment was settled and dewatered. Then, three different sediment samples were prepared by drying them in the air for 0, 15, and 30 days.
- These samples were analyzed by using proximate and ultimate analyses for the measurement of heating values and elemental compositions.

Off-Gas Measurement

- 10 g of sediment was placed into a preheated furnace for 2 min at 300 and 400 °F, which are typical residence time and temperature of a dryer for aggregate in the asphalt mixing process.

- The air flow rate used was 1.3 L/min, which is a typical air flow rate of the dryer in hot mixed asphalt plants (0.13 L air/g a mixture of aggregate and asphalt). The furnace system is shown in Figures 1 and 2.
- An online analyzer (Testo 350 M/XL) was used to detect SO₂ (0–5,000 ppm), CO (0–500 ppm), NO (0–3,000 ppm) and NO₂ (0–500 ppm).
- Organic compounds that could be emitted at combustion and asphalt dryer temperatures were measured using EPA Method 5. Organic compounds were captured in an impinger solution containing dichloromethane, and then the concentrated solution was analyzed by GC-MS.¹

Results

- Heating values of 0, 15 and 30 days dewatered sediment were reported in Table 1. The values were lower than those of a typical lignite (low rank) coal produced in the U.S. (–6,000 Btu/lb)², and are not sufficient to be used as a fuel.

- The amounts of sulfur, carbon, hydrogen, nitrogen and oxygen were not significantly different before and after the heating process at 300 °F. Thus, significant emissions are not expected during the drying process.

Table 1. Proximate and Ultimate analyses						
	0 Day		15 Days		30 Days	
	Before heated	After 300 F heated	Before heated	After 300 F heated	Before heated	After 300 F heated
As-received basis						
Moisture (%)	25.39	26.63	6.36	3.07	3.66	3.95
Ash (%)	58.26	55.71	72.34	75	73.78	75.69
S (%)	0.74	0.8	0.94	1.09	1.16	0.88
C (%)	12.97	12.03	13.74	15.47	16.78	17.29
H (%)	1.31	1.18	1.31	1.42	1.48	1.87
N (%)	0.01	0.01	0.04	0.07	0.08	0.1
Cl (%)	-	-	-	-	-	-
O (%)	1.34	3.66	5.25	3.88	2.87	0.22
Heating value (Btu/lb)	1624	1746	2166	2288	2304	2309
Dry basis						
Moisture (%)	-	-	-	-	-	-
Ash (%)	78.09	75.93	77.25	77.38	74.58	78.8
S (%)	0.99	1.09	1.03	1.12	1.2	0.92
C (%)	17.38	16.39	14.67	15.94	17.42	18
H (%)	1.74	1.65	1.4	1.46	1.74	1.95
N (%)	0.01	0.01	0.04	0.07	0.08	0.1
Cl (%)	-	-	-	-	-	-
O (%)	1.79	4.93	5.61	4.01	2.98	0.23
Heating value (Btu/lb)	2177	2380	2313	2360	2394	2404

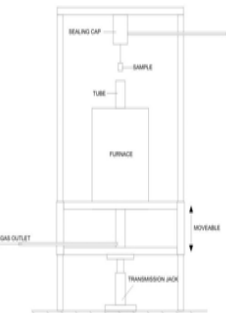


Figure 1. Schematic diagram of furnace system



Figure 2. Furnace system

Off-Gas Measurements at 400 °F

Concentrations of sulfur dioxide (SO₂) emissions from dewatered sediment of 0 and 15 days were not detectable. The concentrations obtained from the 30-day dewatered sediment sample showed a maximum of 0.35 ppm SO₂. A maximum concentration of carbon monoxide (CO) was 4.5 ppm. Nitrogen oxide (NO) and nitrogen dioxide (NO₂) were detected with a maximum concentration of 0.75 and 0.5 ppm, respectively. The figures below show 10-sec moving average of pollutant concentrations.

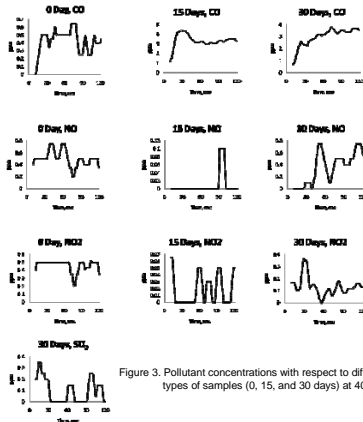


Figure 3. Pollutant concentrations with respect to different types of samples (0, 15, and 30 days) at 400 °F.

The spectra of the organic compounds from GC-MS are shown in Figure 4. A total amount of organic compounds was 204 µg per gram of dewatered sediment. The organic compounds listed in AP-42 were not detected.

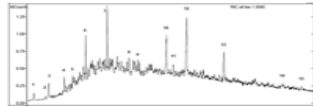


Figure 4. GC spectra of the organic compounds. The peaks in the spectra are: (1) 14-methyl-phenol; (2) 2,4-dimethyl-phenol; (3) benzoic acid; (4) Tridecane; (5) Tetradecane; (6) Pentadecane; (7) Hexadecane; (8) 3-(2-methyl-propenyl)-1H indene; (9) Heptadecane; (10) Octadecane; (11) 1,2,3,4-tetramethyl naphthalene; (12) Nonadecane; (13) Eicosane; (14) n-Hexadecanoic acid; (15) 2-ethyl anthracene.

Total emissions from dewatered sediment at 400 °F are shown in Tables 2–4. The comparison is made based on fuel oil which gives the highest emissions among other fuels (i.e., natural gas, waste oil, and coal). A total amount of each pollutant (lb/ton of sediment) was significantly lower than emission factors reported in Chapter 11 of AP-42.

Table 2. Comparison of total SO₂ and emission factor from AP-42

SO ₂ (lb/ton of hot mix asphalt produced)			
Fuel	AP-42		
Fuel oil	0.088		
SO ₂ (lb/ton of sediment used)			
Sediment	0 Day	15 Days	30 Days
Based on 2-min tests	0	0	1.19 x 10 ⁻⁴

Table 3. Comparison of total CO and emission factor from AP-42

CO (lb/ton of hot mix asphalt produced)			
Fuel	AP-42		
Fuel oil	0.4		
CO (lb/ton of sediment used)			
Sediment	0 Day	15 Days	30 Days
Based on 2-min tests	4.97×10^{-4}	4.22×10^{-3}	3.59×10^{-3}

Table 4. Comparison of total NO_x and emission factor from AP-42

NO _x (lb/ton of hot mix asphalt produced)			
Fuel	AP-42		
Fuel oil	0.12		
NO _x (lb/ton of sediment used)			
Sediment	0 Day	15 Days	30 Days
Based on 2-min tests	6.03 x 10 ⁻⁴	3.59 x 10 ⁻⁵	5.79 x 10 ⁻⁴

^a NO_x was calculated by NO + NO₂

Conclusion

The heating values of dewatered sediment appear to be too low to be used as a supplementary energy source. The emissions from sediment are estimated to be orders of magnitude smaller than those from typical hot mix asphalt plants, and an addition of sediment to aggregate is not likely to increase the emissions from hot mix asphalt plants. According to an asphalt expert, ~80% emissions come from fuels (typically No. 2 fuel oil or recycled oil) and the rest of emissions come from aggregate and/or asphalt in asphalt plants.

Future work

The next phase of the experiment will continue to measure the concentrations of pollutants from exhaust gas. Chemical compositional analysis would be examined by using a combined unit of a thermogravimetric analyzer and a mass spectrometer.

References

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- Annual Coal Report 2005, Energy Information Administration, U.S. Department of Energy, October 2006.