A Preliminary Investigation of Sludge Refuse from Indiana Coal Mines[1]

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Abstract

Seven samples of fine refuse (sludge) were collected from two coal mine refuse pits located in Greene and Sullivan Counties. Particle size distribution was determined. Proximate and ultimate analyses of the sludge refuse were determined and compared to a "whole coal." The data indicated that the British Thermal Unit content of sludge refuse was about 75 per cent of that of the "whole coal" on the moisture-free basis, but was almost similar on the moisture-ash free basis. Based on chemical parameters, sludge refuse should be considered a natural resource for future fuel use and should be reclaimed.

Before coal can be used by industry, it must undergo a preparation process at the mine site. This process consists of crushing, washing, de-watering, and sizing of the coal. During the washing cycle, refuse (pyrite, shale, clay, calcite, rock, high-gravity coal, etc.) is separated from the coal.

Coal preparation produces two kinds of refuse: 1) a coarse particle refuse ("gob") that may be several inches in diameter; and 2) a fine particle refuse ("sludge" or "tailings") that may be 1/8 inch or less in diameter. For brevity the terms "gob" and sludge are used in this paper. Sludge contains larger percentages of coal than does "gob." Total refuse can, periodically, account for as much as 45% of the total daily raw coal (unprepared coal) production. Generally, the average percentage for sludge is 3-7% and for gob 9-15% of total daily raw coal production.

Within the 22 years preceding 1970, Indiana mines produced 370,022,689 tons of salable coal (M. B. Fox, personal communication). Because almost all of this coal underwent the preparation process, the average percentages (sludge—5% and "gob" 12%) may be used to calculate the amount of refuse produced. Calculations indicate that during the 22-year period 136,857,706 tons of refuse were produced of which 40,326,165 tons were sludge.

Sludge produced from the preparation of the following coal members is considered in this paper: 1) Survant Coal (IV), 2) Springfield Coal (V), 3) Hymera Coal (VI), and 4) Danville Coal (VII) (2).

Greene County

The Greene County sludge pit covered an area of 80-90 acres from which Samples #4, 6 and 5 were taken (in that order). The interval between samples was 3,000 feet. Sample #4 was 1,000 feet from the point of sludge entry into the pit. For observational purposes, additional

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[1]Publication authorized by the State Geologist, Department of Natural Resources, Indiana Geological Survey.

samples were taken at 100 feet intervals between Sample Sites #5 and 6. Between these sites there was an apparent change to smaller particle size and to a "dirty gray" color.

Sullivan County

The Sullivan County sludge pit covered a 70-acre area from which Samples #13, 14, 11, and 12 were collected (in that order). Sample #13 was the nearest to the point of sludge entry (about 400 feet). The interval between samples was about 425 feet.

Methods

Seven sludge samples were collected from two sludge storage areas (pits) of mines located in Greene and Sullivan Counties. Before sampling, about 10 inches of sludge surface was removed and then the sample was taken with the use of a post hole digger to a depth of 4 feet. The sample filled a 5 gallon can.

Sample preparation and subsequent chemical analysis followed the procedures and specifications of ASTM-D-271-58 (1). After collection, the samples of sludge refuse were air dried so that their moisture content was in equilibrium with that in the atmosphere. Each sample was thoroughly mixed and then split into four equal parts. Two of the parts (making up 50% of the original sample) were mixed back together to form the sample for the particle size determination. Of the remaining two quarters, one was put into storage for future work and the other was used for chemical analysis.

The chemical analysis consisted of determining moisture, ash, volatile, fixed carbon, total carbon, nitrogen, hydrogen, and sulfur along with the BTU and the CO_2. These data for sludge are compared with the data from "raw coal." The Greene County sludge is compared with Coal V while the Sullivan County sludge is compared with Coal VI.

The screening of the air-dried sample was accomplished with the use of U.S. Standard sieves and a Tyler Ro-Tap sieve shaker. The sieves had square opening sizes of 8, 16, 32, 100, and 200 mesh.

Results and Discussion

On the moisture-free basis the data indicate that sludge from the Greene and Sullivan County pits is inferior to their respective comparative coals (Tables 1 and 2). However, if data on the moisture-ash free basis are considered, it is found that the differences are reduced and that similarity of the materials is emphasized (Tables 1 and 2). Samples #13, 14, and 11 of the Sullivan County pit exhibit the idealistic pattern; that is, higher ash and lower BTU nearer the point of sludge entry into the pit progressing to lower ash and higher BTU farther away (Table 2). Sample #12 appears to be the maverick in the group with its high ash and low BTU; but the data in the particle size histogram of Figure 1 indicates that Sample #12 had a high percentage of fine particles (other data determined on particle size but not presented in this paper indicated that higher ash is located in the finer size).

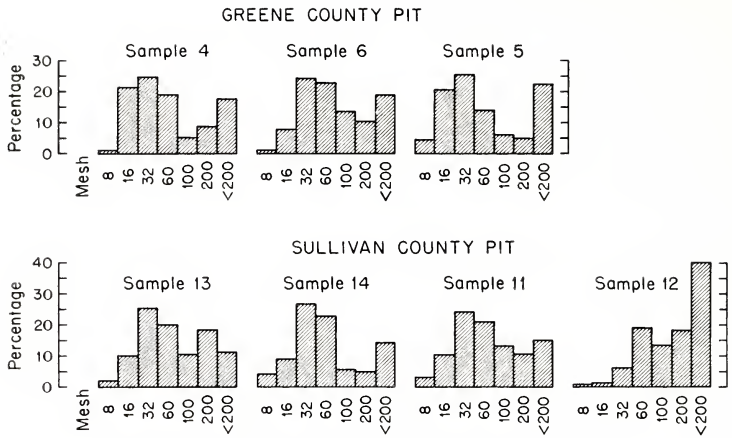

FIGURE 1. *Histogram showing particle size percentages.*

Sample #6, of the Greene County pit, exhibited the same tendencies as Sample #12 except that its (Sample #6) sulfur and CO_2 were very high. These high values were brought about by a secondary washing from run off water of a nearby 100-160 acre farm. The run

TABLE 1. *Proximate and ultimate analysis, Greene County Pit.*

Sample	Coal V	"Sludge" 4	"Sludge" 6	"Sludge" 5
	Moisture Free			
Ash	10.2	29.1	44.7	22.2
Volatile	40.9	29.0	27.4	31.7
Fixed Carbon	48.8	41.8	27.9	46.0
Carbon	71.1	54.3	41.3	61.3
Hydrogen	4.93	3.52	2.91	4.14
Nitrogen	1.54	0.85	0.70	1.07
Sulfur	3.9	3.29	6.97	3.46
BTU	12,670	9,560	7,130	10,880
CO_2	1.33[1]	0.08	2.98	0.12
	Moisture and Ash Free			
Volatile	45.5	41.0	49.6	40.8
Fixed Carbon	54.3	59.0	50.4	59.2
Carbon	79.2	76.6	74.7	78.9
Hydrogen	5.49	4.96	5.26	5.32
Nitrogen	1.71	1.20	1.27	1.38
Sulfur	4.34	4.64	12.6	4.45
BTU	14,110	13,480	12,900	14,000
CO_2		0.11	5.39	0.16

[1]sample only

off water entered the pit just above Sample #6 site resulting with the separation of the lighter particles of coal from the heavier particles of pyrite and calcite.

Because moisture is an erratic variable (on a daily basis) the data for it were not included in the tables; but the moisture percentage ranged from 18.8 to 37% with an average of 25.6% on the "as received" basis.

TABLE 2. *Proximate and Ultimate Analysis, Sullivan County Pit.*

	Coal	"Sludge"			
Sample	VI	13	14	11	12
	Moisture Free				
Ash	13.4	26.6	19.3	18.7	34.3
Volatile	39.6	32.1	31.5	34.6	25.7
Fixed Carbon	47.0	41.3	49.2	46.8	40.0
Carbon	68.6	57.4	61.7	63.6	52.1
Hydrogen	4.76	2.85	4.12	4.50	3.27
Nitrogen	1.55	1.19	1.30	1.35	0.94
Sulfur	3.80	3.09	2.62	2.23	1.81
BTU	12,040	9,950	10,960	11,310	8,950
CO_2	0.16[1]	0.37	0.13	0.13	0.16
	Moisture and Ash Free				
Volatile	45.7	43.7	39.0	42.5	39.1
Fixed Carbon	54.3	56.3	61.0	57.5	60.9
Carbon	79.2	78.2	80.0	78.2	79.3
Hydrogen	5.50	3.89	5.11	5.53	4.98
Nitrogen	1.87	1.62	1.61	1.66	1.43
Sulfur	4.39	4.22	3.25	2.75	2.76
BTU	13,900	13,550	13,580	13,910	13,620
CO_2	0.18[1]	0.15	0.16	0.16	0.25

[1]Sample only

Conclusion

The data bore out some of the visual observations. When considering the BTU on the moisture-free basis, sludge refuse contains about 75% of that of the compared coal (Table 2). If the ash can be eliminated then sludge refuse and coal are very similar, as indicated by the moisture-ash free basis data. Because of the similarity of the chemical parameters, and because of the great quantities available (over 40 million tons), sludge refuse should not be wasted. It should be considered a fuel and should be reclaimed for fuel purposes.

Literature Cited

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