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PLANT NUTRIENTS IN FLYASH FROM BARK-FIRED BOILERS

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ABSTRACT

Flyash from bark-fired boiler plants was found to be a low strength fertilizer, having a beneficial combination of essential micro- and macronutrients. Analysis shows the nutrient level to be low but also of long duration, which enhances the use of flyash as a source of plant nutrients.

KEYWORDS: soil nutrients, wood residue utilization,
flyash utilization.

Gradual prohibition of open refuse burning and increasing prices and intermittent supplies of fossil fuels, particularly natural gas, have prompted many forest products plants to use bark as fuel. Burning logging residues or grasslands to release nutrients to the soil has been practiced for a long time. Flyash from forest products boiler plants produces similar residues! Why not use flyash for a soil amendment? Are these residues suitable as a nutrient supply? Might there be some additional favorable qualities as a soil amendment? What limitations are there on the application of this material?

Flyash is produced when burning gases contact the relatively cool surface of the firebox or burning chamber wall. The gas then changes to a solid ash which is then removed in precipitators or scrubbers. Dirty bark causes the formation of volcanic glass which can help to improve tilth of heavy soils. A rule of thumb is--bark from 1 million board feet of logs will provide 1 ton of flyash. This rule suggests that in western Montana more than 1,000 tons of flyash are disposed of per year. At this time an indeterminate amount of bark is still burned in tepee burners. It is logical to assume that eventually much of this bark will be utilized for firing boilers. Consequently, the supply of flyash will increase proportionately.

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The following analysis was obtained for a boiler plant fired with bark residues. About 17.5 tons of wet hog fuel produces 121,000 pounds of steam per hour for 24 hours which also produces 622 pounds of ovendry flyash. Because this boiler plant is fired with a traveling grate feed system, the flyash contains some unburned carbon. This amounted to 3.02 percent by weight of the material obtained from the stack precipitator. One boiler plant operating 350 days per year will generate 86 to 90 tons of flyash per year. Another plant, with a much larger boiler installation, generates more than 260 tons of flyash per year.

This Research Note reports on preliminary analysis of flyash from bark-fired boilers. The work is part of a research effort directed toward increasing utilization and product alternatives from forest and processing plant residues.

FLYASH RESEARCH

Literature pertaining to flyash from boiler plants is quite abundant. However, most of it deals with coal-fired powerplants. Plass and Capp (1974) determined that alkaline flyash, rich in some plant nutrients, can be used to help reclaim acidic mine spoils. Before treatment the spoils were extremely acidic, and after treatment pH and soil phosphorus increased significantly. Infiltration rates were improved, soil porosity was increased and percolation was increased to a depth of 4 feet (Plass and Capp 1974).

SAMPLING, ANALYSIS, AND RESULTS

Three flyash samples were taken from each of four boiler plants in the Missoula, Montana, area. Ash samples were taken from different sources at each plant such as (1) below the cyclone that captures the ash, (2) at the conveyor before it is dumped for pickup, and (3) at the dump site. These boilers are fired with sawmill and plywood residues. This residue is mainly bark because sawdust and planer shavings are used in pulp or particleboard.

Flyash material was prepared by sieving through a 1-mm sieve to make all samples of uniform texture and get rid of unburned material. Two 5-gram samples were randomly picked from each collection for analysis. They were then placed in funnels lined with filter paper and leached. One of the paired 5-gram samples was leached four times with 100 ml of water at 31°C, and the other leached four times with ammonium acetate at 30°C, and one normal concentration. Each leaching was analyzed individually.

An atomic absorption unit was used to analyze leachate samples for calcium, copper, magnesium, manganese, potassium, sodium, and zinc. The water-leached samples were additionally analyzed for nitrate with a nitrogen meter, phosphate with a calorimeter, and pH with an electronic pH meter.

WATER LEACHATE

Table 1 shows the average of water soluble materials in the four leachings. Lower concentrations were noted with each successive leachate. (Tables 4 and 5 in the appendix show the results of each successive leaching.) The figures in table 1 are the means for four water-leached samples from each source. The extremely high sodium content in the source A sample was later traced to contamination from boiler blowdown effluent. The $\overline{x}$ source is the mean of samples A-D for all the various elements tested.

Recalling that 1,000 parts per million is the same as 0.1 percent, these figures indicate low concentrations of all elements compared to regular commercial fertilizers. Elements destructive to plants are low in concentration; potassium, a beneficial element, is comparatively high in concentration.

Table 1.--Mean flyash nutrient concentration--water leaching[1]

Source	Ca	Cu	Fe	K	Mg	Mn	Na	Zn	pH	NO3	PO4
	Parts per million									P/m	Mg/ℓ
A	1,250	2.3	7.0	1,280	235	4.6	[2] 1,755	0.10	9.5	4.3	6.6
B	1,250	1.4	1.0	1,848	5,100	2.5	74	0.04	8.5	8.7	2.0
C	2,200	0.9	0.6	1,056	4,065	0.7	26	0.01	8.6	6.5	0.6
D	107,200	3.1	2.9	6,168	268	2.5	58	0.57	12.2	82.3	0.4
Grand Mean	27,975	1.9	2.9	2,588	2,417	2.6	[3] 535	0.18	9.7	25.5	2.4

[1] Table 1A in the appendix gives the results of each leaching.
[2] Extremely high sodium content. Subsequent investigation determined this source to be contaminated from water clarification process effluent.
[3] Excludes contaminated source A.

ACETATE LEACHATE

Table 2 shows the average element availability when leached four times with ammonium acetate. The purpose of this procedure is to provide a basis for determining the availability of nutrient elements through successive moist periods. That is, ammonium acetate was used to test the residual elements that would be available over a longer period of time than suggested by water leaching. Ammonium acetate was chosen for its known ability to flood the exchange and replace the nutrients available in the exchange. In this way the residual elements can be analyzed. The relatively high concentration of calcium agrees with previous findings (Metz and Wells 1965).

Statistical Analysis

In many cases, one or more sources for a fixed element have variances differing from the rest (tables 4 and 5 in the appendix). This causes the F-test of analysis of variance to give significant results too often. Therefore, the t-statistic (or an approximation when variances were significantly different) was used to detect differences between sources for selected elements. All tests were performed at the 5 percent level.

Table 2.--Mean flyash nutrient concentrations by ammonium acetate leaching[1]

Source	Ca	Cu	Fe	K	Mg	Mn	Na	Zn
	Parts per million							
A	5,313	2.3	3.3	1,138	245	26	1,109	7.8
B	14,069	2.0	3.9	1,682	697	199	52	19.3
C	14,669	2.5	3.2	3,418	1,015	186	2,994	23.0
D	3,860	3.0	3.0	2,362	528	38	233	4.1
Grand Mean	9,478	2.5	3.4	2,150	621	112	1,097	13.6

[1] Table 2A in the appendix gives the results of each leaching.

Table 3.--T-test results for selected elements

Type of leaching	Elt.	Sources					
		A vs. B	A vs. C	A vs. D	B vs. C	B vs. D	C vs. D
Water	Ca	0	-2.36	-8.62*	-3.45*	-8.63*	-8.55*
	K	- .51	.27	-1.15	.71	-1.00	-1.20
	NO_3	- .73	- .55	-6.19*	.31	-5.34*	-5.79*
	PO_4	2.23	3.08	3.12	2.33	2.37	.44
Acetate	Ca	- .96	-4.44*	1.01	- .07	1.12	5.08*
	K	- .33	- .69	- .53	- .49	- .26	.27

* Indicates significant difference between sources at the 0.05 probability level.

The results of these t-tests appear in table 3. For the water leachings, source A is not significantly different from either source B or C in mean flyash nutrient concentrations of Ca, K, NO_3, and PO_4. And, except for a difference in Ca concentration, source B is no different from source C. Sources A, B, and C each differ from source D in mean concentrations of Ca and NO_3.

In acetate leachings, the average concentration of Ca for source C significantly differs from both sources A and D. Other sources exhibit no statistical differences for Ca and K.

For the water leaching, 55 percent of the time there is a decrease in the parts per million from leaching 1 through leaching 4. In acetate leaching, the decrease in each leaching occurs 48 percent of the time.

DISCUSSION AND CONCLUSIONS

The current practice of using flyash as a landfill is becoming increasingly costly. Available landfill areas are becoming more distant from the boiler plants. A solution to the problem is utilization rather than disposal.

Wood is a very low component of processing plant residues. However, the inner bark contains nutrients. Hence, flyash from bark can be expected to be a better fertilizer source than wood ash.

Chemical analyses suggest that flyash could serve as a fertilizer or soil amendment. Flyash can be added to pulverized bark for physically improving heavy clay soils.

Present farming practices tend to overfertilize, which reduces water quality and wastes nutrients. Generally, fertilizer application has to be increased each year to get the same result as the previous year because organic material is lacking as a water-nutrient reservoir. Flyash appears to be superior because of its natural timed release of nutrients over an extended period of time. Preliminary field testing shows growth response still evident 3 years after application. A low-grade fertilizer meets plant needs over time better than a high-concentrate fertilizer.

Flyash is high in potassium, which enhances its value as a fertilizer since plants absorb more potassium than any other element. Furthermore, the ash has a fairly good balance of nutrients, that is, the macronutrients and micronutrients are favorably proportioned in large and small quantities.

A low-grade fertilizer can be effective if plant nutrients are available in quantities needed by plants and not in such excess amounts as to pollute the soil or damage the plant. Also, where soil fertility is not fully depleted, a low-grade fertilizer can be a better supplement than a potent fertilizer that will overfertilize.

Fertilizer prices will follow rising petrochemical prices. One response of fertilizer users will be to seek alternative sources for fertilizer. Flyash can provide a new source, and perhaps, provide additional revenues to wood products industries. Although further work must be done on application rates and specific uses, the prospect of using flyash as a fertilizer warrants serious consideration.

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Table 4.--Water leaching--sample data

Source	Leaching	Ca	Cu	Fe	K	Mg	Mn	Na	Zn	pH	NO3	PO4
		- - - - - Parts per million	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -			P/m	Mg/ℓ
A	1	1,800	6.0	10.4	3,060	200	7.0	3,460	.22	10.0	8.4	11.8
	2	200	1.4	5.8	760	40	3.6	1,700	.10	9.7	4.0	7.4
	3	1,400	1.2	6.2	721	300	4.0	1,100	.06	9.2	2.8	4.5
	4	1,600	.6	5.6	580	400	3.6	760	.02	9.1	1.9	2.8
	$\bar{x}$	1,250	2.3	7.0	1,280	235	4.6	1,755	.10	9.5	4.3	6.6
	s	718.8	2.5	2.3	1,189.0	153.5	1.6	1,201.3	.09	.42	2.9	3.9
B	1	1,000	2.0	2.0	4,600	3,000	4.0	186.4	.16	8.3	25.9	3.6
	2	800	1.8	1.0	1,620	4,400	2.0	74.0	0	8.7	4.8	2.4
	3	1,600	1.0	.9	750	6,400	2.0	24.2	0	8.7	2.3	1.1
	4	1,600	.6	0	420	6,600	2.0	12.0	0	8.4	1.6	1.0
	$\bar{x}$	1,250	1.4	.98	1,848	5,100	2.5	74	.04	8.5	8.7	2.0
	s	412.3	.66	.82	1,903.5	1,716.6	1.0	79.3	.08	.21	11.6	1.2
C	1	1,800	2.0	1.6	2,800	3,300	2.0	68.0	.04	8.8	17.9	1.0
	2	2,400	1.2	.4	820	4,400	.2	21.2	0	8.6	4.0	.5
	3	2,600	.2	.2	382	4,600	.2	8.0	0	8.2	2.3	.4
	4	2,000	.2	0	221	3,960	.4	5.0	0	8.6	1.9	.3
	$\bar{x}$	2,200	.9	.55	1,056	4,065	.70	26	.01	8.6	6.5	.55
	s	365.1	.87	.72	1,109.1	575.8	.87	29.2	.02	.25	7.6	.31
D	1	128,400	4.2	3.4	18,500	363	2.2	176.0	.40	12.3	115.5	1.3
	2	118,600	3.8	3.8	4,600	291	3.6	40.0	.86	12.3	79.5	.2
	3	109,600	2.2	2.4	950	274	2.2	8.4	.60	12.2	79.5	.1
	4	72,200	2.0	2.0	620	144	2.0	6.2	.42	12.1	54.7	.04
	$\bar{x}$	107,200	3.1	2.9	6,168	268	2.5	58	.57	12.2	82.3	.40
	s	24,563.9	1.1	.84	8,417.1	91.2	.74	80.5	.21	.10	25.0	.61

Table 5.--Acetate leaching--sample data

Source	Leaching	Ca	Cu	Fe	K	Mg	Mn	Na	Zn
A	1	7,650	2.7	6.0	3,225	291	27	2,905	11.3
	2	6,250	2.5	3.0	794	284	30	935	9.2
	3	4,050	2.1	2.0	316	207	24	351	4.8
	4	3,300	1.9	2.0	216	196	21	245	5.7
	$\overline{x}$	5,313	2.3	3.3	1,138	245	26	1,109	7.8
	s	1,998.9	.37	1.9	1,414.2	49.9	3.9	1,235.2	3.0
B	1	40,000	4.6	5.8	6,087	938	365	158	49.0
	2	12,700	1.1	2.5	394	933	224	28	12.0
	3	2,750	1.2	3.5	145	515	122	13	9.0
	4	825	1.0	3.7	100	400	86	10	7.0
	$\overline{x}$	14,069	2.0	3.9	1,682	697	199	52	19.3
	s	18,053.8	1.8	1.4	2,939.8	279.9	125	70.9	19.9
C	1	18,250	3.3	3.8	13,125	1,013	104	11,200	17.6
	2	16,500	2.2	2.6	296	1,450	245	388	26.0
	3	14,250	2.4	3.2	146	905	222	222	26.0
	4	9,675	1.9	3.0	105	690	172	165	22.4
	$\overline{x}$	14,669	2.5	3.2	3,418	1,015	186	2,994	23.0
	s	3,709.9	.60	.50	6,471.9	319.9	62.4	5,471.7	4.0
D	1	1,265	5.2	6.0	8,950	798	47	846	6.6
	2	6,075	2.7	2.0	285	447	40	43	4.0
	3	4,850	2.2	2.0	127	188	33	23	3.2
	4	3,250	1.7	2.0	87	677	32	20	2.7
	$\overline{x}$	3,860	3.0	3.0	2,362	528	38	233	4.1
	s	2,081.1	1.6	2.0	4,392.7	269.1	7.0	408.8	1.7

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