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Properties of Cinders from Red Pine, Black Locust and Henon Bamboo

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Introduction

Wood charcoal has approved as one of amendments on "Order for Enforcement of Soil Fertility Enhancement Act" which was amended in 1986 in Japan, and has been commonly used.

Wood charcoal has ability to increase water-holding capacity and permeability of soil because of its porous structure. However, these properties have been examined only on a few kind of wood charcoals. Also, the method of production of wood charcoal has been limited to general one, which is heating a raw material in the space of scanty oxygen then without burning pyrolytic gas and a carbonized product (un-burning method).

The production method of burned wood residue (cinder) is suitable for producing biochar for amendment on small scale production due to a low equipment cost, simple operation and high productivity. The method of producing cinder is to burn raw materials then with burning pyrolytic gas and to stop burning carbonized product (burning product). The simple version of smokeless charcoal kiln called "M series" by Moki Co., Ltd. makes possible to produce cinder efficiently. This series have different size of kilns correspond to the capacity of the production rate of cinder (18 - 505 liter/batch).

In this report, production of cinder from red pine (*Pinus desiflora*), black locust (*Robinia pseudoacacia*) and henon bamboo (*Phyllostachys nigra*) were examined by using charcoal kiln "M50" which is the smallest type of "M series". Then, properties of these kinds of cinder were compared with those of charcoals made by un-burning method and some other amendments.

Materials and Methods

1. Materials

Characteristics of raw materials for cinder are shown in **Table 1**. Blocks (25×25×10 mm) processed from the same raw materials as cinders were used as the materials for making charcoals by un-burning method.

2. Making of cinders (burning method)

Cinders were made from the materials by using smokeless charcoal kiln M50 (Moki Co., Ltd, **Photo 1**). The pilot light was made in the kiln by burning 0.5 kg of materials cut to small pieces. Then, materials divided into 2 kg of fagots each were continuously burned until kiln was filled with carbonized products. When the flame which was made by the fagot on ahead was

Table 1. Raw materials for cinder making.

Raw materials	Shape Length (mm)	Individual mass (kg)	Apparent specific gravity	Moisture (%)	Carbon content (dry basis) (%)
Red pine (*P. densiflora*)	stick 500 - 600	0.04 - 0.25	0.34	11.3	47.48
Black locust (*R. pseudoacacia*)	stick 500 - 600	0.03 - 0.21	0.56	13.0	47.08
Henon bamboo (*P. nigra*)	stick 500 - 600	0.05 - 0.11	0.67	11.1	48.07

Photo 1. Smokeless charcoal kiln Moki M50.

Photo 2. Cinder made from red pine.

Table 2. Cinder making by smokeless charcoal kiln Moki M50.

Raw materials	Mass of material (kg)	Mass of oven-dried cinder (kg)	Yield of cinder * (oven-dried basis) (%)	Yield of carbon *2 (%)	Time for carbonization (min)	Rate of process (material basis) (kg/hr)	Rate of carbon production (kg/hr)
Red pine	26.00	2.99	13.0	24.3	129	12.1	1.24
Black locust	26.00	3.33	14.7	27.0	122	12.8	1.42
Henon bamboo	22.00	3.82	19.5	34.1	88	15.0	2.18

* (mass of oven-dried cinder) / (mass of oven-dried material) x 100

*2 (mass of carbon in cinder) / (mass of carbon in material) x 100

Table 3. Properties of charcoals.

Raw materials	Method of cabonization	Carbonization temperature (℃)	Proximate analysis (dry basis, %) Volatile matter	Fixed carbon	Ash	Moisture	Carbon content (dry basis) (%)	Apparent specific gravity	Water absorption (%) A*	B*2	pH
Red pine	Untreated	-	-	-	-	-	47.48	0.34	77	226	4.6
	Burning(cinder)	-	7.3	91.5	1.2	6.5	88.83	0.20	87	441	9.1
	Un-burning	400	30.1	69.5	0.4	4.4	73.68	0.27	81	301	6.4
	Un-burning	600	11.6	88.2	0.2	3.4	86.98	0.26	82	310	8.4
	Un-burning	800	5.3	94.7	0.0	4.1	91.54	0.31	82	264	8.7
Black locust	Untreated	-	-	-	-	-	47.08	0.56	63	112	6.7
	Burning(cinder)	-	6.3	90.7	2.9	7.5	86.62	0.26	84	324	9.6
	Un-burning	400	26.7	72.4	0.9	4.6	76.57	0.41	62	138	7.3
	Un-burning	600	10.0	88.5	1.4	4.4	87.15	0.45	69	155	9.6
	Un-burning	800	4.5	94.3	1.2	6.8	89.93	0.43	74	171	9.6
Henon bamboo	Untreated	-	-	-	-	-	48.07	0.67	55	83	5.9
	Burning(cinder)	-	7.2	87.6	5.2	5.7	83.78	0.31	79	258	9.6
	Un-burning	400	25.5	72.2	2.3	4.3	73.27	0.52	53	103	8.0
	Un-burning	600	8.1	89.2	2.7	3.3	87.20	0.64	55	88	9.6
	Un-burning	800	2.9	93.7	3.3	3.9	89.02	0.70	59	86	9.8
Mangrove charcoal*3	-	-	35.7	63.0	1.3	5.7	72.89	0.82	42	52	8.5
Rice husk charcoal*4	-	-	3.2	35.3	61.5	4.1	31.98	-	-	352	9.6
Perlite	-	-	-	-	-	-	-	0.08	95	1250	8.3
Vermiculite	-	-	-	-	-	-	-	-	-	349	8.6

* (volume of absorbed water) / (whole volume of material) x 100, equal to porosity

* 2 (mass of absorbed water) / (mass of dried material) x 100

* 3 Primary use : fuel for barbecue

* 4 Trade name : Bio-Tan manufacturer : Aito Eco-Plaza Nanohana-Kan

getting weaker, the next fagot was thrown into the kiln. The time period between the each throw of fagot was 6 to10 mins. After all materials were thrown into the kiln and the flame disappeared, carbonized product was burned for 5 mins. Then, combustion was stopped by sprinkling water on the product (**Photo 2**).

3. Making of charcoals by un-burning method

Materials (50 - 60g) were placed in the stainless steel container with lid and carbonized in a muffle furnace under the atmosphere. The temperature was raised by 1.5℃/mins, and it was held at set temperature for an hour.

Results and Discussion

The results of making cinder are shown in **Table 2**. The yields of cinder and the carbon content of henon bamboo were the highest compared to the others. It is mentioned that this tendency is affected by an apparent specific gravity and individual mass of materials. The properties of charcoals are shown in **Table 3**. The values of fixed carbon and carbon content of cinders were equal to those of charcoal made by un-burning method at the temperature of about 600℃. The cinder had lower apparent specific gravity and higher water absorption. It is considered that the small rate of shrinkage of volume occurred by the rapid carbonization on making cinder, caused the increase of the volume of pore. The cinder had higher level of pH. These results suggested that cinder was suitable for amendment that would enhance water-holding capacity of soil and neutralize acidic soil.