Potential of carbon sequestration by carbonizing wood residue from industrial tree plantation as a Clean Development Mechanism project in the Kyoto Mechanism

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1. Effective sequestration of CO2 in atmosphere and its inactivation

Photosynthesis by plants

Carbohydrate (Cellulose, Hemicelluloses, Lignin)

Harvesting for timber, pulp etc.

Carbonization

Wood charcoal

Carbon in a tree shall be left at 20 - 50%

Reduction of CO2 emission and Carbon-sink expansion are a pair of wheels
2. Carbon sequestration project by forestation and charcoal use

CFC-scheme (Carbon sequestration by Forestation and Carbonization) Ogawa.M, 2001

Logging & replantation of Acacia

- Harvesting
- 8-year Rotation
- Charcoal application in replanting

- Logs
- Oilpalm, Coconut-palm, Rubber, Paddy

- Stems branches
- Agriculture waste

- Chips
- Bark, chipdust

Carbonization

- Flat kiln
- Charcoal wood & powder

- Compost with charcoal
- Improving soil, Raising fertility

Agriculture, Agroforestry

- Fuel
- Water purification

- Electrification in rural region
- Agriculture, Agroforestry

Power generation

- Electric supply
- Pulp

Urban region

- Sewage
3. Charcoal properties (1)

General property of charcoal (Fagus tree)

- Volatile: 11.0%
- Ash: 1.6%
- Carbon: 87.4%

Surface area: 440 m²/g
pH: 9.9

Relationship between Temperature and Carbon of charcoal (Tanaka, S. 1968)
4. Charcoal properties (2) : Porous structure

- Habitat for Symbiotic microbe : mycorrhizal fungi, a filamentous fungus, an actinomyces, etc.
- Water holding capacity, etc.
5. Development of charcoal use
(source: Japanese Charcoal New-use Association)

- **Consumption**
- **Import**

**The amounts of consumed and imported charcoals in Japan**

**Charcoal use for non-fuel in Japan (1999)**

- **Agriculture**: 30.6%
- **Humidity conditioning**: 4.0%
- **Animal husbandry**: 22.3%
- **Water purification**: 20.0%
- **Greening/gardening**: 3.6%
- **Cleaning bath water**: 0.5%
- **Other industries**: 3.6%
- **Golf course**: 0.5%
- **Live stock industries**: 0.5%

**Year**
- 66
- 70
- 75
- 80
- 85
- 90
- 95
- 2000

**Units**
- (1000 ton)
South Sumatra Province:
- 110,000 sq km as same as Ohio, Tropical humid climate
- Population: 7.6 million, density: 70 /km²

**Industries:** Mining resources is rich such as petroleum, coal, etc. Agriculture plantation such as rubber (peasants), oil palm (estate).

Concession: 270,000 ha
Plantation area: 190,000 ha

6. Location of study site

- Concession: 270,000 ha
- Plantation area: 190,000 ha
7. Requirements for CDM project

**Boundary**
- Region: Plantation concession 270,000 ha, and Pulp mill site
- Activities range:
  1) Use of forest residue
  2) Use of wood waste in pulp mill

**Baseline**
- 1) Socioeconomy: Are there any similar projects?
  2) GHG emission from Forest residue and Wood waste in pulp mill

**Leakage**
- GHG which would occur outside the boundary due to the project (only negative effect)

**Impact for environments**
- for Nature and Socioeconomy with negative and positive factors

**Monitoring**

**Sustainability**
8. Plantation forestry of Musi Hutan Persada (MHP)

- Start of plantation in 1991
- Start of harvest in 1999

- Growth rotation in 8〜10 years
- Mean Annual Increment: 20〜35 m³/ha
- Harvest/replantation: 10,750 ha/yr
Small stems and branches with D< 8cm

Avg. 56.4 t/ha x 10,750 ha/yr = 606,300 t/yr

by Hardiyanto, et al. (2000, 2001)
10. Wood waste in Pulp mill of Tanjungenim Lestari

Craft pulp production 450,000 t/yr

Waste = Bark, Woodloss, Chip dust

180,000 t/yr

115,000 t/yr

Power boiler

65,000 t/yr

Landfill (unused)
11. Method of charcoal making

Charcoal production can roughly be classified into two categories.

1) Carbonization by the auto thermal process, which includes many traditional and simple methods (FAO 1987).
2) Carbonization represents industrial mass production methods utilizing external heating, which requires fossil fuel (FAO 1985).

Taking into account applications in developing countries, and the participation of the local people; --> a low cost, easier and simpler method is preferable.

Tin drum, Hume pipe and Built-up brick kiln: forest residue
- The furnace materials are inexpensive, conveniently purchased.
- To enable the participation of local people, preventing fires at forest sites.

Flat kiln: Pulp mill - Bark, woodloss, chip dust
- Often adopted in barks and wood from chip mills and sawmills in Japan and also in Indonesia.
- Easily operated and maintained, But careful control is required to prevent the outbreak of fire.
12. Charcoal-making test of Forest residue (1)

Drum method

Capacity: 0.254 m³

Hume-pipe method (Gorong2)

Capacity: 5 m³
13. Charcoal-making test of Forest residue (2)

![Image of charcoal-making process]

**Graph:**

- **Axes:**
  - Y-axis: Temp (Celsius)
  - X-axis: Time after heatup (hrs)

- **Lines:**
  - Chimney: ○
  - Inside: □

The graph shows the temperature progression over time for both the chimney and inside of the charcoal-making process.
14. Charcoal-making test of Forest residue (3)

Nutrient in forest: 606,000 t-dw/yr

- 50% moisture: 303,000 t-dw/yr
- X 0.80 (moisture 20%): 242,400 t-dw/yr
- X 0.25 (efficiency): 60,600 t-Char/yr (48,500 t-C/yr)
15. Charcoal-making test at Pulp mill (1)

Waste = bark, woodloss, chip dust

Flat kiln

Capacity : 14 m³/kiln
16. Charcoal-making test at the Pulp mill (2)

One cycle: 7 - 10 days

65,000 bdt/yr

16,000 t-Char/yr
(13,000 t- C/yr)

X 0.25 (efficiency)
17. Biomass/Carbon balance in tree plantation and pulp industry

- **Forestry Company**
  - 270 ha: Concession
  - 190 ha: Acacia plantation
  - 10.75 ha/yr: Harvest area

- **Timber production**
  - Forest residue
    - 600 t/yr (-300 t-C/yr)
    - 50%

- **Pulp production**
  - 450 t/yr
  - Bark, wood loss, chipdust
    - 180 t/yr (-30.5 t-C/yr)
  - 115 t/yr
    - Power generation
      - 95 MWh
      - Recovery boiler 327 MWh

- **Power generation**
  - 422 MWh
  - 20 t-C/yr

- **Carbonization**
  - Charcoal: 61 t/yr (48.5 t-C/yr)
  - Local community
  - Employment
  - Farmland
  - Soil improvement
  - Water purification

- **B**
  - Powder charcoal: 16 t/yr (12 t-C/yr)
  - Carbonization: 65 t/yr (-32.5 t-C/yr)

- **CDM**
  - Fuels for sale
  - Figures of (ha) and (t) indicate x1000

- **A + B = Charcoal 77 t/yr (62 t-C/yr)**

- **Vehicle fuel**
  - -0.7 t-C/yr
18. CO2 reduction potential by carbonization from wood residue/waste

Carbon reduction: 62,000 t-C/yr, 1.24 million t-C in total
(CO2 equivalent: 228,000 t-CO2/yr, 4.56 million t-CO2 in total)
19. Cost efficiency and local job opportunity by the project

Forest residue (1) -> Drums: 25,000 units
Facilities, operation, personnel expenses, etc. = 3.4 million $

Workers (full/part time) 2,500 men

Forest residue (2) -> Brick kilns: 4,900 units
Facilities, operation, personnel expenses, etc. = 3.6 million $

Workers (full/part time) 2,000 men

Wood waste in pulp mill -> Flat kilns: 225 units
Facilities, operation, personnel expenses, etc. = 0.56 million $

Workers (full/part time) 140 men

CO2 reduction: 223,000 t-CO2

Cost efficiency in 20 years
17.1 to 17.7 $/t-CO2
20. Charcoal application test (1) on Acacia (by Yamato)

To spray powder charcoal to 2-year-old Acacia

To spray on the surface

Increase of fine roots (12 months later)
21. Charcoal application test (2): for crops (by Yamato)

- Long bean
- Corn

![Graph showing the effect of charcoal application on crop yield.]

- Total amount of harvest in each ridge (fresh weight)
- Fertilizer NPK (15-15-15) 50g/m²
- Amount of charcoal application:
  - con
  - 5L/m²
  - 10L/m²
22. Coexistence with local community (1) in/near the project

- Local Sumatran people
- Settlers from other islands of Jawa, Bali.
- 265 villages, 13,000 people
- Livelihood: Rubber resin collection
23. Coexistence with local community (2) Efforts of MHP

Technical/financial support of MHP to local people for encouraging the cultivation of crop and fishery.

Local people's expectation to income increase besides Rubber resin collection:
--> Food production for self-support and sale in local market.

Charcoal application for raising agricultural production
24. Proposal of integrating charcoal carbon into the carbon accounting system

It is required to establish the method of accurately monitoring the carbon sequestered in charcoal in the course of charcoal production from biomass material to the end use of charcoal.

1. Restriction on the source of biomass: Not come from natural forest

2. Identification of biomass and residue/waste: the chemical composition (heavy metal, a toxic substances), etc.

3. Accurate estimation of the input amount of biomass into the carbonization kiln

4. Charcoal production
   - carbonization method: mechanical kiln or manual handling, external heating or internal heating
   - charcoal yield, carbon composition, energy consumption of fossil fuel in charcoal production

5. Application methods of charcoal for non-fuel use
   - Soil amendment: to clarify the use of some media or soil substances
   - Charcoal compost: to identify kinds of livestock compost and its composition
   - Method of application spraying: to clarify mechanical application or manual application
   - Water purification agent: to clarify the treatment after use

6. Impact and risk for environment
   - Prediction of impact on natural environment like soil and water
   - Risk of fire in grassland and forest if charcoal making is carried out in the field.

7. Monitoring of different uses of charcoal
   The end use of charcoal should be classified either into non-fuel use (soil conditioner, water purifier, etc.) and fuel use. Some kind of monitoring system is required to make a balance sheet between charcoal production sites and markets.