

# Toward the establishment of biorefinery industrial system by the right material at the right place - Proposal from agricultural scientists -

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## Standing point:

“Biomass Nippon Strategy” decided at the Cabinet meeting, Government of Japan, on 27 December 2002 estimates annual quantity of residual biomass in Japan as about 68 million ton (dry weight), which calculate as 27.3 million carbon ton, and set the effective utilization of 80% of such residual biomass with cascade-type the goal of doing. It is quite important to obtain information of regional distribution of such residual biomass because of collection and transformation of them as industrial resources.

It was not available reliable database for the localization of residual biomass in the world. A database for local distribution of residual biomass in Japan is going to be opened to the public from the New Energy and Industrial Technology Development Organization (NEDO) at following Internet home page;

[http://www.nedo.go.jp/informations/other/171116\\_1/171116\\_1.html](http://www.nedo.go.jp/informations/other/171116_1/171116_1.html)

We estimated the quantities of residual biomass for major agricultural products (59 kinds of products) and animal excrement using FAOSTAT data base and “residual production ratio (RPR)” reported by Sajjakulnukit B. et al. (2005) and Matsumoto, S. & Hakamada, T. (1994) (Table 1 & 2). Total quantity of the residues was 11.3 billion ton/y in the world, which is 124EJ and equivalent to 2.5 billion kL of crude oil. If all of the residues are used as energy source, the value would be calculated as about US\$900 billion (residual woody biomass is not included).

Such residues and animal excrements are partially utilized as energy source, organic fertilizer, paper making and so on, but it would be limited only 30-40% of them. Mankind has strongly great expectations

Table 1. Estimated quantities of agricultural residues (10<sup>3</sup> fresh ton)

Residue, 10 <sup>3</sup> ton	Crops	Plantation	Vegetable	Fruit	Others	Total
Number of scanned species	10	11	13	18	7	59
Cambodia	7,500	600	0	100	14	8,200
Indonesia	86,000	240,600	1,800	2,000	2,500	332,900
Laos	4,400	300	0	100	24	4,800
Malaysia	3,500	237,300	100	600	0	241,500
Myanmar	37,300	6,100	0	0	1,300	44,700
Philippines	23,000	39,300	300	3,500	48	66,100
Thailand	40,600	63,500	700	2,900	300	108,000
Viet Nam	57,600	15,100	500	1,000	600	74,800
China	504,400	267,500	95,700	54,100	22,500	944,200
India	325,800	192,500	25,100	6,800	11,500	561,700
Japan	20,800	4,500	3,700	600	100	29,700
World	2,362,000	2,948,000	243,000	118,000	57,000	5,729,000
%	41.2	51.5	4.2	2.1	1.0	100.0

**Crops:** paddy rice, wheat, barley, rye, oats, sorghum, millet, potatoes, sweet potatoes, **Plantations:** oil palm, rubber, coconut, sugar cane, coffee, tea, cocoa, cassava, maize, soybeans, sugar beets, **Vegetables:** cabbages, lettuce, tomatoes, onion, cucumbers, carrots, spinach, pumpkins, eggplants, cauliflower, asparagus, rapeseed, castor beans, **Fruits:** bananas, pineapples, papayas, mangoes, apples, oranges, peaches, pears, grapes, watermelon, melons, lemons, plums, persimmons, strawberries, apricots, kiwi fruit, avogados, **Others:** groundnuts, pigeon peas, broad beans, canary seed, caster beans, chestnuts, beans (not specified).

**Production data:** FAOSTAT (2004), **Residual products ratios:** Sajjakulnukit B. et al. (2005) and Matsumoto, S. & Hakamada, T. (1994)

Table 2. Number of animals and estimated quantities ( $10^3$  head) of excrement ( $10^3$  dry ton).

	Cattle $10^3$ Head	Buffaloes $10^3$ Head	Sheep $10^3$ Head	Pig $10^3$ Head	Chickens $10^3$ Head	Horse $10^3$ Head	Excrement $10^3$ dry t
Indonesia	10,878	2,459	20,533	6,151	1,238,173	413	71,100
Thailand	5,048	1,650	220	7,059	197,114	9	20,700
Vietnam	4,394	2,835	780	24,885	247,010	113	27,700
China	103,468	22,729	316,714	469,809	4,641,091	20,783	766,400
India	187,382	96,616	181,886	14,142	441,900	1,838	4,477,200
Japan	4,523	0	45	9,725	284,298	25	17,700
Asia	371,127	163,037	673,239	569,040	7,973,507	25,432	2,051,000
World	1,335,769	170,122	1,809,308	945,987	17,179,333	109,300	5,648,000

**Number of animals:** FAOSTAT (2004), **Excrement and N content:** Matsumoto, S. & Hakamada, T. (1994)

on further effective utilization, such as production of high value add materials from the residues. The development of effective utilization technologies based on the exact knowledge of their scientific and social natures would be essential to realize the expectations, because of huge varieties of their nature and the regional situation. They should be involved chemical, physical, biological (cultivation condition including the state of soil, production yields, harvesting season and so on) characteristics of residues, and social, political, cultural, economical and educational (for training of employee) situation, to fit into “the right material” and “the right place” policy. In addition, the establishment of biorefinery system, which links systematically many factories, is required from the view points of production cost and the preservation of regional and global environment.

#### “The Right Materials”

Biomass would be classified as “Hard lignocellulose” (woody lignocellulose), “Soft lignocellulose” (herbaceous lignocellulose and dried excrement), “Starchy biomass” (rich in starch), “Liquid biomass” (oils, black liquor and waste water rich in organics). “Hard lignocellulose” is further grouped on coniferous and non-coniferous woody biomass, and others (barks and so on). The major component of woody biomass is cellulose, non-cellulosic cell wall polysaccharides (hemicellulose) and lignin. It should not be ignored for the development of effective utilization the difference in not only chemical structural feature, but also in covalent associations between cell wall polymers, which are due to tissue construction (tracheids in coniferous wood and wood fibers in non-coniferous wood), between coniferous and non-coniferous woody biomass. Especially coniferous wood has high resistance to enzymatic modification.

“Soft lignocellulose” would be the most valuable resource for the biorefinery system due to the wide varieties for effective utilization such as board formation and paper making with low energy input, production of many chemicals (furfural, levulinic acid, lactic acid and so on). “Starchy biomass” such as starch of cassava is attracting as not only a resource of energy, ethanol production, but also a resource of future C1 chemistry, which because of biologically easy modification. The C1 chemistry would be constructed using water-gas composing of CO and H<sub>2</sub> generated by the high temperature reaction between charcoals which are produced from “hard” and “soft” lignocelluloses and water. Energy would be recovered from waste water containing high level of organics (“liquid biomass”) by anaerobic fermentation. Biodiesel can be produced from palm oil without external energy supply, if biodiesel factory is placed side by side with palm oil factories.

#### “The Right Place”

The biorefinery system has to be established at the right place, considering not only cultivation area, ideal transport distance for collection (would be 50-100km), but also political security, legal system, economic situation, human resources, technical situation, education and cultural situation (especially religion). The most suitable place for the establishment of biorefinery system would be around of various tropical plantations and agricultural region with various productions.

#### References

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