ASSESSMENT AND UTILIZATON OF SYNTHETIC SOIL AGGREGATES DEVELOPED BY USING COAL FLY ASH AND PAPER WASTE

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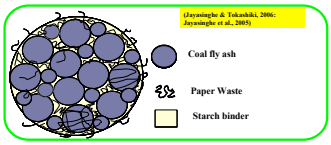
●INTRODUCTION

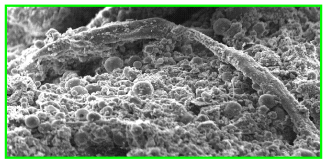
➢ Coal has been a major energy source since the industrial revolution. Coal accounts for around 25% of total global primary energy. However, utilization of coal as an energy source involves the generation of a great amount of coal fly ash, and the recycling rate of the ash is rather low. The global amount of coal fly ash emitted from thermal power plants is over 500 million tons per year (Manz 1997). And the global recycling rate of coal fly ash is about 15% (Claus 1994). Japan is one of the major coal importing countries in the world. As a consequence of its use, it is estimated that approximately 9.9 million tons of coal fly ash is produced every year. (Center for coal ash utilization 2005). Furthermore, few uses exist for the tonnages produced and the disposals of coal fly ash become a significant problem. In present context, paper industry faces a growing solid waste problem as environmental regulations, which become increasingly stringent and land fill space grows scarcer. Additionally, paper factory waste is a rich source of carbon ,which improves soil organic matter contents, water holding capacity, soil structure and bulk density (Zhang et al.1993:Simard et al.1998). Therefore, an attempt was done to develop and study the utilization avenues for unconventional coal fly ash–paper waste synthetic aggregates by using coal fly ash and paper waste with starch waste as a binder.

● OBJECTIVE OF THE STUDY

To evaluate the characteristics of the coal fly ash–paper waste synthetic aggregates and their different possible utilization ways in agriculture to improve crop production.

Idea and the structure of the aggregate

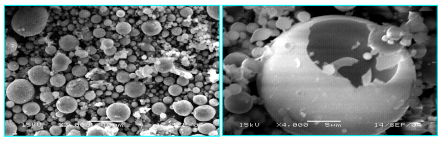




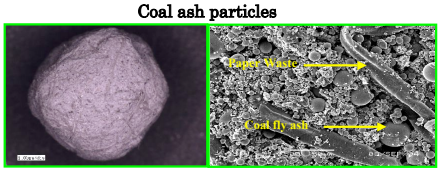
Scanning Electron Microscopic Image

➢Rigid coal fly ash particles are embedded into the fibrous paper matrix with the help of the starch binder

Scanning Microscopic Images of coal fly ash and aggregates



Coal ash particles



Synthetic aggregates

(A) Aggregate production and property assessment

Materials utilized to produce aggregates

Materials	Quantity
Coal fly ash (g)	500
Used paper (g)	50
Starch paste (ml)	250

Selected properties of coal fly ash

Bulk Density (g/cm³)	pH	EC (mS/m)	C (g/kg)	N (g/kg)	P (g/kg)	Na (g/kg)	K (g/kg)	Mg (g/kg)	Ca (g/kg)
0.92	10.92	92.70	43.26	0.52	0.07	1.02	1.68	0.87	3.45

Chemical and Physical properties of synthetic aggregates

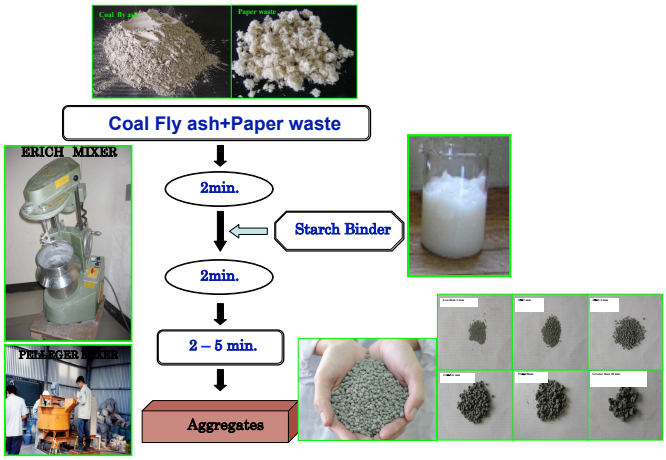
Bulk density (g/cm³)	EC (mS/m)	Water holding capacity (kg/kg)	Hydraulic conductivity (cm/s)	C (g/kg)	N (g/kg)	Aggregate stability (kg/cm²)
0.61	73.67	0.61	2.20×10^{-2}	110.02	0.60	3.58

Heavy metal concentration in aggregates

	Cd (mg/l)	Pb (mg/l)	Cr (mg/l)	As (mg/l)	Hg (mg/l)	Se (mg/l)	Cu (mg/l)	Zn (mg/l)
Aggregates	<0.003	<0.003	<0.01	<0.005	ND	<0.005	<0.01	0.19
EQS*	0.01	0.01	0.05	0.01	0.005	0.01	3.0	5.0

EQS: Environmental Quality Standards ND: Not Detected

Aggregate production Process



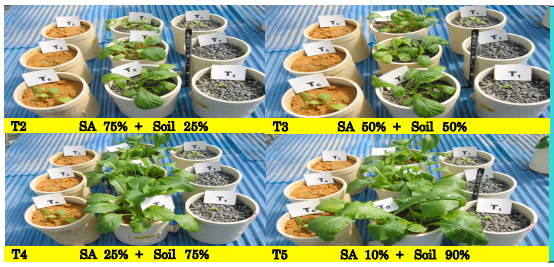
◆Developed synthetic aggregates had an alkaline pH,high EC,high cation concentrations, low bulk density, high water holding capacity, low heavy metal content, higher aggregate strength, and larger mean weight diameters.

(B) Different utilizations of developed aggregates

➢Utilization as a soil amendment to low productive acidic red ("Kunigami Mahji") soil

✓Pot experiments

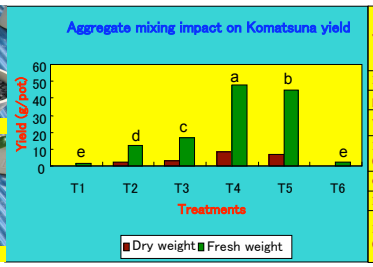
(i) Komatsuna production



SA: Synthetic Aggregates

Comparison of different treatments

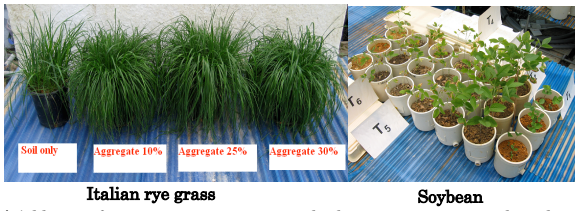
Influence of aggregates addition on the Komatsuna growth and the physical and chemical properties of the acidic red soil



Treatments	T1 (Aggregates only)	T2 (75% of Aggregates)	T3 (50% of aggregates)	T4 (25% of aggregates)	T5 (10% of aggregates)	T6 (Soil only)
EC (mS /m)	73.67^{a}	55.24^{b}	39.64^{c}	18.57^{d}	10.06^{e}	3.27^{f}
pH (water)	9.26^{a}	8.37^{b}	7.86^{c}	6.25^{d}	5.78^{e}	4.62^{f}
WHC (kg/kg)	0.612^{a}	0.585^{b}	0.569^{b}	0.541^{c}	0.528^{cd}	0.512^{d}
Permeability (cm/s)	2.20×10^{-2a}	6.22×10^{-3b}	2.24×10^{-3c}	2.94×10^{-4d}	2.73×10^{-4d}	6.62×10^{-5e}
Carbon (g/kg)	110.2^{a}	83.1^{b}	55.9^{c}	28.8^{dc}	12.5^{e}	1.6^{f}
Nitrogen (g/kg)	0.6^{a}	0.5^{a}	0.5^{a}	0.4^{a}	0.4^{a}	0.4^{a}
Bulk density (g/cm^3)	0.61^{c}	0.87^{d}	0.98^{c}	1.05^{bc}	1.12^{b}	1.23^{a}

◆Addition of 25% of aggregates to acidic red soil gave the best maximum growth and yield parameters of komatuna and enhanced the soil physical and chemical properties.

(ii)Italian Rye grass and Soybean



Italian rye grass Soybean

◆Addition of aggregate 10-30 % gave the best maximum growth and yield parameters of Italian Rye grass and Soy bean and enhanced the physical and chemical properties of the low productive acidic red soil in Okinawa, Japan.

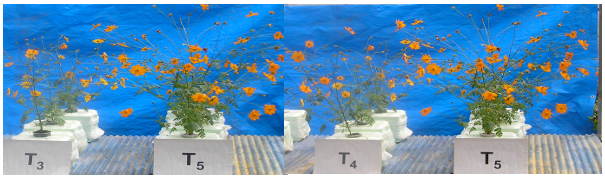
✓Field experiments

Sweet potato Sugar Cane

◆Addition of aggregate 15% at field level gave the best maximum growth and yield parameters of sweet potato and sugarcane and enhance the physical and chemical properties of the soil.

➢Utilization as a potting media with oil palm waste

French Marigold

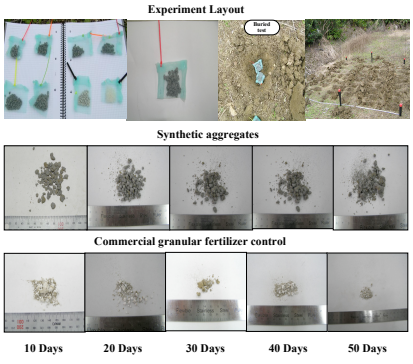


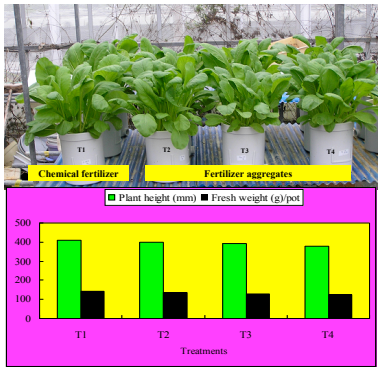
Cosmos

◆A mixture of synthetic coal fly ash – paper waste aggregates with oil palm waste at the ratio of 1:10 as a container substrate gave the best maximum growth and yield parameters of ornamental plants such as French Marigold and Cosmos. Aggregates palm waste 1:10 mixture gave best physical and chemical parameters, which were in the range of ideal substrate.

➢ Utilization of synthetic aggregates as a fertilizer

✓Decomposition test (buried under soil)





✓Komatsuna cultivation using fertilizer aggregates

◆Synthetic fertilizer aggregates can be developed by using coal fly ash and paper waste with ammonium sulfate, which is resulted from the process of entrapping carbon dioxide originating from coal combustion. These aggregates remained longer time period under the buried soil with out degrading much compared with the commercial granular fertilizer. At the end of the 50 days of buried time 60% of aggregates were still remained while the that amount in commercial granular fertilizer was 6%. In addition, synthetic coal fly ash – paper waste aggregates can be successfully utilized as a chemical fertilizer replacement, which also enhanced the physical and chemical properties of the soil.