Recycle Technology of Sewage Sludge by Carbonization Process

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This study has been conducted for the purpose to develop a new technology using the carbonization process for establishing the resources circulation system for sewage sludge and enabling the sludge amount and volume to be reduced sanitarily and safely. Besides, it is thought that the effective value of the carbonized sludge is much greater even though there is any limitation to its applicable fields or use since it is not a product that is intentionally produced like any existing materials for conventional uses.

Key Words : Carbonized Sludge, Sewage Sludge, Adsorbent

1. Introduction

Sludge from sewage treatment plants is traditionally disposed by ocean dumping and landfilling, but this has been causing increasing environmental concerns in many countries, especially where land is scrace as in Korea. In Korea, as the population and development have grown, the production of sewage sludge has risen rapidly and amounted to 1,740× 10^3ton per year in 2000. Disposal of Sew-age sludge on reclaimed land is no longer a viable solution. While farmland applications of sewage sludge are limited by the uptake capacity of the soil and potential pollution by the heavy metals, incineration can provide a large volume reduction and result in energy recovery. The residue of incineration has potential for use in road surfacing, building materials and metal reclamation. However, the scrubbing costs of incinerator flue gases are high.

Alternatively, research has been focused on the pyrolysis of sewage sludge in an oxygen-free atmosphere in which the organic matter is transformed into liquid oil and gases containing hydrocarbons. The heavy metals, except mercury, are safely enclosed in the solid residues. In addition. the residues solid, i.e the carbide, can be used as an adsorbent and soil conditioner if pyrolysis under controlled conditions [1]. The carbonization is the link of the pyrolysis technique. But the carbonization does for the generation of the carbide[2].

This study has been conducted for the purpose to develop a new technology using the Carboniza- tion process for establishing the resources circula-tion system for sewage sludge and enabling the sludge amount and volume to be reduced sanitary-ily and safely[3].

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2. Experimental Methods

2.1 Sewage sludge

Anaerobically digested and dewatered sewage sludge was used. The sewage sludge sample was obtained from Okcheon Sewage Treatment Works, Korea.

2.2 Carbonization

The carbonization delimited to the electric furnace and carbonizing furnace. The carbonization temperature and the sample hold time varied from 400 to 800℃ and from 15 to 60min, respectively. After the carbonization process. the reacter was cooled to room temperature before the sample was removed for weighing and charac-terization.

2.3 Characteristic of pore structure

The equipment used for surface area and pore structure characterization is an accelerated surface area and porosimetry system(ASAP 2010, micro- meritics).

2.4 Absorption characteristics

The absorption characteristic examination follows KSM 1802.

3. Results and Discussion

3.1 Composition characteristics

Also, an experiment for development of use thereof was conducted for showing the availability thereof as floricultural soil and an adsorbent by using the final optimum carbide(Fig. 1).

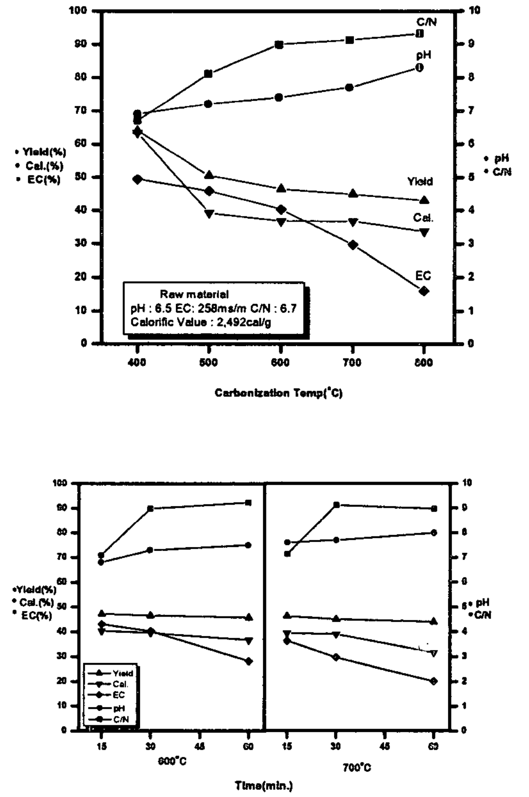

Fig. 1. Characteristics of Yield, Calorific value, EC, pH and C/N according to carbonization temperature and time.

Among characteristics of change in properties of sewage sludge, production yield, heating value, EC, pH and C/N depending upon carbonizing temperature and time were indicated. It was shown that as the temperature went higher and the time was more lengthened, carbonizing yield was more decreased. Also, it was found that the heat-ing value was equivalent to 63.4% of 2,492 cal/g of the raw specimen at 400℃, and 33.7% thereof at 800℃ so that as the carbonizing temperature and time was more increased, the heating value was more decreased.

Characteristics in change of EC were more decreased as the carbonizing tem-perature and time was more increased. The C/N ratio and pH had a tendency to be more increased as the carbonizing temperature and time was increased, and particularly, it was identified that pH was increased to 6.9 at 400℃, and 8.3 at 800℃ in comparison of 6.5, pH of the raw speci-men. The C/N ratio was increased along with the carbonizing temperature, and it showed a value below 10 in all conditions. Consequently, the car-bonizing yield, the heating vale and EC had a ten-dency to be more decreased as the carbonizing temperature and time was more increased, and pH and the C/N ration showed the result that they were more increased as the carbonizing tempera-ture and time was more increased.

As for behavior of heavy metals, Cd began to be volatilized at 600℃ or higher and volatilized upto 53% at 700℃ for 60 minutes(Fig.2).

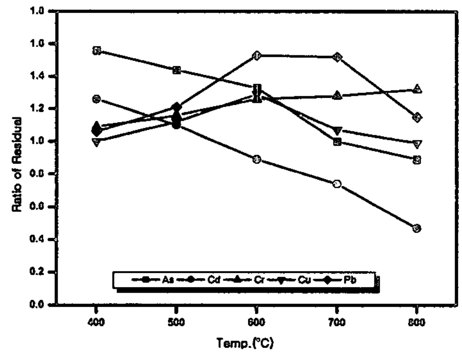

Fig. 2. Heavy metal behavior according to carbonization temperature(TS basis)

As was volatilized to 22% at 700℃ for 60 minutes and other heavy metals (Cr, Cu and Pb) were found not to be volatilized. And, as a result of conducting an elution test for eluting fixed heavy metals, the eluted values were found to be adequately within the allowable standard values (Fig.3).

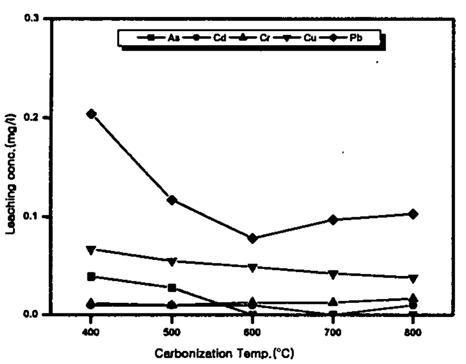

Fig. 3. Heavy metal leaching behavior according to carbonization temperature

3.2 Absorption characteristics

Gererally, the adsorption capacity of carbonized sludge increased with temperature and hold time(Table 1 and 2). In this study, the optimum temperature and hold time for maximum surface area and adsorption capacity development of carbonized sludge were found to be 700℃ and 30min, respectively. The highest iodine adsorp-tion capacity was achieved 123.5mg/g.

Table 1. Effect of Carbonization Temperature on Yield and Iodine Adsorptivity(Carbonization Time : 30min)

Carbonization temp. / Item	400℃	500℃	600℃	700℃	800℃
Iodine number (mg/g)	116.9	99.5	113.9	123.5	86.4
Yield (%)	64.0	50.5	46.5	45.0	43.0

Table 2. Effect of Carbonization Time on Yield and Iodine, Adsorptivity (Carbonization Temperature: 700℃)

Carbonization time / Item	15min	30min	60min
Iodine number(mg/g)	109.4	123.5	104.6
Yield(%)	46.3	45.0	44.0

3.3 Characteristic of pore structure

It was shown that the specific surface area of the carbonized sludge as generated in an electric furnace (E.F) was 43.8 ㎡/g and the average pore diameter thereof was 58.4 Å. On the other hand, it was shown that the specific surface area of the carbonized sludge as generated in a carbonizing furnace (C.F) was 14.3 ㎡/g and the average pore diameter thereof was 89.0Å(Table 3).

Table 3. Specific Surface Area, Volume and Pore Size of Carbonized Sludge(700℃, for 30min)

Item / Condition	BET (㎡/g)	Average pore size (Å)	Pore volume (㎤/g)		
			micro	external	Total
E.F	43.8	58.4	0.0073	0.0567	0.064
C.F	14.3	89.0	-	0.032	0.032

This result indicated that the carbonized sludge processed in the carbonizing furnace had such mesopore as developed better than the carbonized sludge processed in the electric furnace. Also, the pore volume of the carbonized sludge processed in the electric furnace was found to be 0.064 ㎤/g, and macropore was found to account for 88.6% thereof.

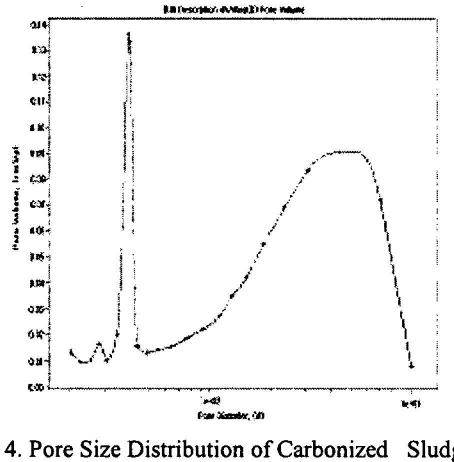

Fig. 4. Pore Size Distribution of Carbonized Sludge (E.F)

The whole pore volume of the carbonized sludge processed in the carbonizing furnace was 0.032 ㎤/g, which was smaller than the pore volume of the carbonized sludge processed in the electric furnace.

But, the rate of mesopore and macropore was found to account for 100% therein. In the carbonized pore distribution diagram as indicated, it was shown that mesopore and macro-pore were mostly well developed(Fig. 4).

3.4 Absorption of organic matters and color

As a result of adsorbing organic substance and chroma contained in dyed wastewater and thereby removing them from it by using carbonized sludge, the efficiency of removing organic sub-stance was found to be lower than the case of using powered activated carbon. Such efficiency of adsorbing organic substance was shown to be equivalent to 69~87% of the efficiency in the case of using powered activated carbon available in the market(Fig. 5).

The carbonized sludge used for removing chroma showed a removing efficiency equivalent to 70~97% of the efficiency in the case of using powered activated carbon, which was relatively high(Fig. 6).

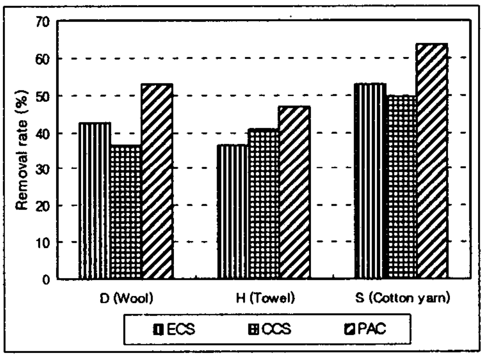

Fig. 5. Removal efficiency of COD on carbonized sludge and powder actiavted carbon

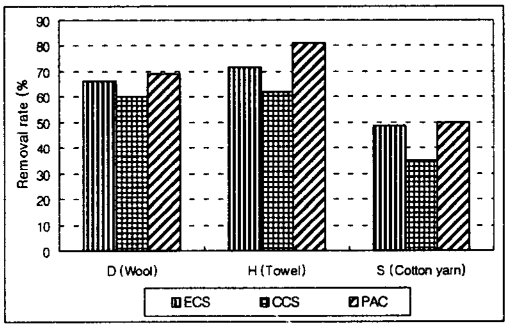

Fig. 6. Removal efficiency of chromaticity on carbonized sludge and powder actiavted carbon.

4. Conclusion

The carbonized sludge produced in the carbonizing furnace is similar in properties to charcoal and activated carbon, and has the following characteristics.

1) It is odorless and preservable because no organics are contained.
2) It is porous and light.
3) It has a water holding capability, air Permeability and a good fertilizer holding capability.
4) It helps, like charcoal, microorganisms in soil reproduce and breed.
5) It has high solar heat absorption efficiency.

The carbonized sludge, which has the above characteristics, will be effectively used as a supplemental dehydrator for a hydro-extractor in our prefecture.

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