FAO European Cooperative
Research Network

RAMIRAN

Recycling of Agricultural, Municipal and Industrial Residues in Agriculture

Network Coordinator: José Martinez, Cemagref, Rennes (France)

RAMIRAN 2002

Proceedings of the 10th International Conference of the RAMIRAN Network

General Theme: Hygiene Safety

Štrbské Pleso, High Tatras, Slovak Republic
May 14 - 18, 2002

Edited by Ján Venglovský and Gertruda Gréserová

ISBN 80-88985-68-4

University of Veterinary Medicine
Research Institute of Veterinary Medicine
Hlinkova 1/A
040 01 Košice
Slovak Republic

CHARACTERISTICS OF THE SEWAGE SLUDGE PROCESSED BY NEW DEHYDRATION SYSTEM AND USE FOR CONSERVATION AGRICULTURE OF PADDY

Nakaji, K., S. Yamanaka, S. Nakazono*, E. Nakazono* and N. Tokutome*

Faculty of Agriculture, Kyushu University, Kasuya-cho, Fukuoka 811-2307, Japan
Prorex, Co. Ltd., Inc., 430-32 Oazayoshikuma, Keisen-cho, Fukuoka 820-0609, Japan

ABSTRACT

Firstly, we have developed a new drying system of the sewage sludge cake, which is rapidly dehydrated using waste edible oil as a heating medium (100C) under a reduced pressure (-370mmHg) in a cooker. Secondly, using the dried sewage sludge produced by this system, the experiments on rice growing which aim to realize conservation agriculture have been carried out at the same paddy field for three years. It was obtained that the dried sewage sludge was almost equal to the chemical fertilizer on yield and quality of the rice by appropriate fertilization and ecological weed control using *Pomacea canaliculata.*

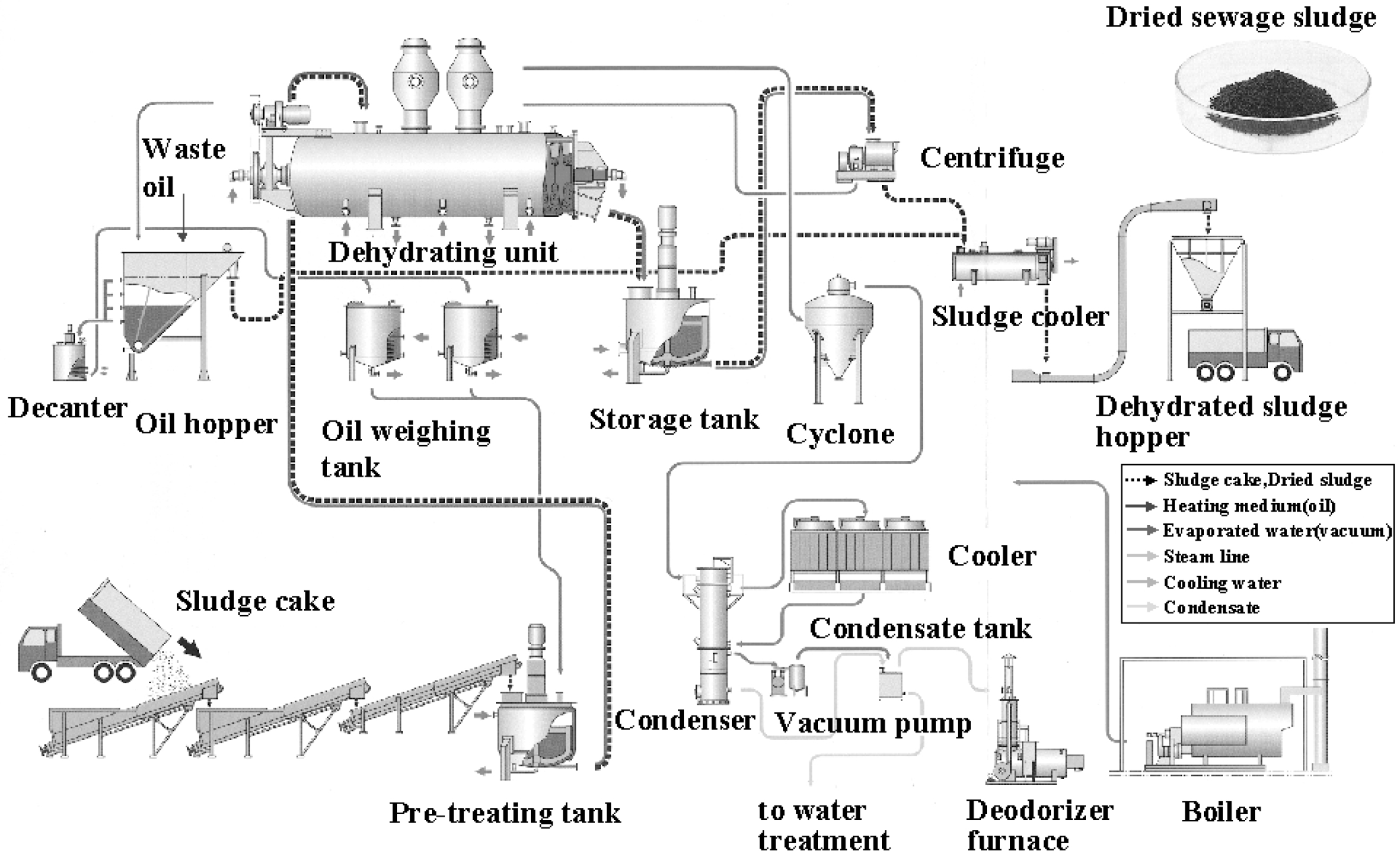
INTRODUCTION

It is essential to reduce the generation amount of the sewage sludge for the ecosystem conservation. However, the generation amount of the sewage sludge increases more and more with expansion of various sewerage systems such as a regional sewerage system and increase in advanced treatment plant and processing system. In Japan, the amount of the municipal sewage sludge reached 85.5 million tons and the 30% of it were recycled in 1996. As a farmland utilization of the sewage sludge, composting use and direct use are mainly carried out. The distribution quantity of the only dried sewage sludge as fertilizer or soil improvement material is more than that of the sewage sludge compost. However, it is somewhat difficult to use the dried sewage sludge because of instability for the crop growth. The purpose of this study is to construct rice cropping for conservation agriculture in using the dried sewage sludge produced at the high efficiency for the fertilizer.

MATERIAL

The authors have developed a new drying system of the sewage sludge cake as shown in Fig.1, which is rapidly dehydrated using waste edible oil as a heating medium (100C) under a reduced pressure (-370mmHg) in a cooker (Nakazono *et al.*, 1999). The volume and weight of sewage sludge decrease in about one-fifth of the initial dehydrated sludge cake. The dried sewage sludge using the system has following advantages; granular material with the easy handling, the stable water content of 3 to 6%, disappearance of raw sludge smell, sterilization, preservation of nutrients and organic matter, and the remarkable oil content of 25 to 30% due to the adsorption of edible oil. A practical plant with the capacity of 90t/day was constructed in Fukuoka Prefecture in 2001.
Main components of the drying sewage sludge produced by this system are shown in Table 1. The components satisfy the recommended limits in the standard for sludge manure in Japan presented as a reference. The concentration of organic toxic substances

Fig. 1. Flow diagram of the sludge drying system.



in the leachates obtained from elution tests and the mass concentration of heavy metals were less than the tolerable limits in the regulated standard for manure. The physical and chemical properties of the soil which mixed the dried sewage sludge have already been reported (Chikushi *et al*., 2000, Ohtsubo *et al*., 2000).

METHODS

Using the dried sewage sludge produced by this system, the experiments on rice growing which aim to realize conservation agriculture has been carried out at the same paddy field of Kyushu University Farm since 1999. Paddy rice (*Oryza sativa* L. cv. Hinohikari) was cultivated by the standard method in northern Kyushu, Japan. Three groups of treatments, i.e. the cultivation with chemical fertilizer (CF), the dried sewage sludge containing the equivalent nitrogen (SS), and the multiple use of the dried sewage sludge (2SS), were designed and duplicate plots were prepared for each group. No agricultural chemicals such as herbicide and insecticide were used for each plot over the cultivation period every year. The ecological weed control using the habit of *Pomacea canaliculata* (Fig.2) recognized as vermin against paddy rice was adopted. *Pomacea canaliculata* was made to eat only the weed by the water depth control after rice transplanting. By this method, it was possible to carry out the weed control almost perfectly. Only in 1999, the production of the rice was considerably low, since the sunshine hours were insufficient.

Table 1. Chemcal analysis of the dried slewage sludge used

Constituent	Mean value	Recommendation for sludge manure*
Water content [%]	3.04	<50
Oil content [%]	29.10	-
pH	7.0	<(8.5)
C [%]	42.84	-
N [%]	4.53	>2(1.5)
C/N	9.50	<10(20)
P_2O_5 [%]	5.22	>2
K [%]	0.40	-
Organic matter [%]	77.90	>35
Low calorific value [kJ/kg]	20962	-

* Recommemded standart for organic manure quality (Notification by Ministry of Agriculture, Forestry and Fisheries, Japan.

Fig.2. Pomacea canaliculata eating small paddy plants.

RESULTS AND DISCUSSION

The rice yields with their components of 1999 to 2001 rice cropping are shown in Table 2. On brown rice, the yields were heavy in order of CF, SS, 2SS. Though the crop situation of SS was good, the yield of it did not reach that of FC. On the yield components, the percentage of ripened grains and the thousand-kernel-weight of FC were a little bigger than those of SS, and considerably bigger than those of 2SS, respectively. In the typical case of 2SS, the superfluous nitrogen component caused the non-bearing tiller, the percentage of ripened grains lowered, and the growth of the grain was prevented. Therefore, it is very important to consider the quantity and timing of the fertilization of the dried sewage sludge.

Table 2. Yield of paddy rice in 1999 to 2001

	Year	Number of ear [/m^2]	Number of unhulled rice [/ear]	Percentage of matured rice [%]	Thousand-kernel weight of brown rice [g]	Yield of brown rice [kg/10a]	Number of hill [/m^2]	Number of culm [/hill]	Top weight [g/hill]	Total weight of unhulled rice [g/hill]	Plant length [cm]	Culm length [cm]
CF*1	1999	286.9	87.4	83.0	21.9	455.5	20.4	13.6	60.5	29.0	105.3	80.7
SS*2	1999	275.4	88.0	80.7	21.4	416.5	20.4	13.7	56.3	27.9	102.3	79.4
2SS*3	1999	327.7	92.4	63.3	21.4	406.7	20.5	16.5	57.9	30.7	108.6	79.7
OC*4	1999	299.6	80.9	89.5	21.0	456.5	21.0	14.3	59.8	30.3	99.8	77.8
CF*1	2000	319.2	95.6	74.8	22.4	511.3	20.9	15.3	66.5	33.1	100.4	78.3
SS*2	2000	416.5	85.1	69.7	21.0	513.7	20.7	20.1	76.4	37.3	101.6	78.2
2SS*3	2000	475.2	82.8	48.7	20.0	391.5	20.6	23.1	76.6	33.6	107.9	81.5
OC*4	2000	381.5	87.7	76.5	21.1	537.3	20.5	18.6	79.5	44.6	102.8	76.4
CF*1	2001	417.6	78.3	84.6	22.3	615.9	20.6	20.3	80.2	39.4	104.6	85.2
SS*2	2001	435.3	75.6	81.1	21.3	569.9	20.8	20.9	79.1	37.2	103.3	85.3
2SS*3	2001	444.3	72.4	56.0	21.1	378.9	20.9	21.3	65.1	30.3	106.5	87.4
OC*4	2001	377.7	75.3	85.3	21.3	515.6	20.2	18.7	77.7	35.3	102.6	83.3

CF*1 : Chemical fertilizer.
SS*2 : Application amount of sewage sludge equal to nitrogen content of CF.
2SS*3: Application amount of sewage sludge is two times as much as SS.
OC*4: Organic cultivation.

Table 3. Chemical analysis and quality of rice in 1999 to 2001

	Year	Brown rice											Milled rice	
		Moisture content [%,w.b.]	Protein [%]	Amylose*1 [%]	Taste value*1	High quality rice	Unmatured rice [%]	Damaged rice [%]	Chalky kernels [%]	Colored rice [%]	Cracking rice [%]	Whiteness degree [%]	Amylose*2 [%]	Taste value*2
CF	1999	14.7	7.7	17.6	75.5	70.7	11.9	8.2	1.4	0.4	7.6	19.5	17.8	73.5
SS	1999	14.6	7.7	17.4	74.0	71.4	15.6	6.7	1.3	0.1	5.1	19.4	17.8	73.0
2SS	1999	15.0	9.3	17.3	61.0	63.5	17.4	13.1	1.2	0.8	4.2	18.5	16.8	64.5
OC	1999	14.0	7.2	17.8	79.5	76.0	9.7	7.5	1.0	0.3	5.6	19.5	17.2	77.5
CF	2000	15.9	7.2	17.9	73.5	67.0	23.7	1.5	2.7	0.3	4.9	19.4	18.2	72.0
SS	2000	15.4	6.9	17.6	73.5	64.9	25.6	0.9	5.0	0.4	3.3	18.8	18.1	75.0
2SS	2000	15.4	7.9	17.5	62.0	52.1	30.3	2.4	13.9	0.6	0.8	18.5	17.7	65.5
OC	2000	15.4	6.5	18.3	79.0	70.5	22.7	2.7	2.3	0.2	1.8	19.1	18.1	76.5
CF	2001	16.4	6.6	18.6	79.5	83.9	11.1	1.9	0.8	0.2	2.2	19.0	18.1	74.5
SS	2001	16.3	6.6	18.6	79.0	81.9	11.9	2.8	1.5	0.2	2.0	18.7	18.1	73.5
2SS	2001	16.5	7.7	18.2	68.5	72.2	16.9	3.4	6.1	0.2	1.4	18.8	17.7	63.0
OC	2001	16.4	6.3	18.8	83.0	87.6	8.1	1.6	0.5	0.2	2.2	19.0	18.1	77.0

*1: Reference data.
*2: The taste value was measured by the taste analyzer based on the near-infrared analysis.
Taste analyzer: K-AS100(Kubota Co.), RS-2000(Shizuoka Co.), and C-300(Kett Co.).

The quality indices of the brown and milled rice of 1999 to 2001 annual productions are shown in Table 3. Several external and internal qualities of rice were determined using three kinds of measuring instruments, K-AS100 (Kubota Co.), RS-2000 (Shizuoka Co.) and C-300 (Kett Co.). The following were measured by the near infrared analysis: Moisture content, protein, and amylose, which seriously affect the taste and food feeling of the rice. The taste value was calculated by the multiple regression using these measured values. Generally, the taste and food feeling of the rice are better, as both the protein content and the amylose content are lower. As an index of total evaluations, the taste values of the milled rice were almost same for CF and SS. On the other hand, the value was low for 2SS. It is considered that the low value was occurred due to the increase in the protein content by the nitrogen overdose. As a reference data, the taste values of the rice in organic farming are shown in Table 3. The taste value of the rice in the organic fertilizer cultivation was the highest of all, and the value in the dried sewage sludge fertilizer of equivalent nitrogen was almost equal to the value in the chemical fertilizer. It was proven that the dried sewage sludge was useful for the cultivation of the rice plant by the experiment for three years.

CONCLUSIONS

It was obtained that the dried sewage sludge processed by the developed system was useful as an organic fertilizer for the paddy rice growing by considering the quantity and timing of the fertilization. By the ecological weed control using the habit of *Pomacea canaliculata*, furthermore, it was possible to realize the paddy rice cultivation without chemical fertilizer and agricultural chemicals.

REFERENCES

Chikushi J., Nakaji K., Kawanobu S., Nakazono S., Nakazono E., and Tokutome N. (2000): Agricultural use of oily and dehydrated sewage sludge. *The CIGR Electronic-Journal*:1272-1277.

Nakazono S., Nakazono E., Tokutome N., Nakaji K., Okano K., Yamanaka S., Chikushi J., and Ohtsubo M. (1999): Drying of sewage sludge by using wasted edible oil under heating and decompression. *Geoenvironmental Engineering, Thomas Telford Ltd, London*: 551-558.

Ohtsubo M., Nakaji K., Nakazono S., Nakazono E., and Tokutome N. (2000): Physical properties of soil with addition of sewage dried with heated edible oil. *Sci. Bull. Faculty of Agriculture, Kyushu University*, 55(1): 71-75 (in Japanese).