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Rice Crop Application for Humus Bioreactor by Rural Sewage System

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Abstract: In this paper, author will report on the process of rice cultivation in paddy fields using treated water which treated domestic sewage wastewater. Odor problems from sewage treatment plants have been solved by confinement and ventilation, but reducing the color and odor of treated water is economically difficult and is a subject of recycling of discharged water. Humus pellet bioreactors can be attached to existing sewage treatment plants to suppress the odor of the sewage treatment plants as a whole and to prevent sludge from deteriorating and to improve the quality of treated water. The odor and color of the treated water discharged from the sewage treatment plant was reduced. In addition, we were able to obtain performance of treated water with nitrogen 3 mg/L, phosphorus 1 mg/L or less throughout the year. On the other hand, there are many cases of results that cannot be used for paddy rice cultivation and vegetable production etc. by ignoring plant growth and physiology (fertilizer). For that reason, laws and guidance such as having to dilute more than 50 times in order to use processed water for agriculture are being conducted without learning. It is a case of using humus pellets in sewage treatment system and using deodorized wastewater of sewage by adjusting fertilizer when used in paddy field rice production.

Key words: Odor problem, odor reduce, humus pellet, bio-reactor, recycle water, rice production.

1. Introduction

After wastewater treatment, the discharged water is clear but slight coloration and special odor remain [1, 2], and its slight color and smell suppresses recycling. Recycling of treated water has been used in toilets, etc. However, it is not only because of the high cost by physical method, it cannot be said that it has solved the color and smell. Also, since the residual color and odor feels unlikely about sanitation, agricultural use is not diffusion [3].

However, there is a strong demand for agricultural water due to population increase, and agriculture use of water treated domestic wastewater in arid regions and desert areas has been actively taking place.

In Japan, chemical fertilizer, which is a by-product, can be obtained cheaply because abundant water resources and industrial activities are prosperous, so it is difficult to reuse water treated with domestic wastewater for agriculture. Also, because the farmers are concerned about heavy metals and chemical contamination from the image when they were processed together with industrial wastewater in urban wastewater treatment historically, the use of treated water will not proceed. Although there are attempts to change the name and use it as reclaimed water, there is still insufficient use of reclaimed water in Japan due to sufficient and inexpensive water resources and odor and color problems. Although it is used as washing water of toilets in large cities and densely populated areas, it is still in demonstration to enlighten the people and economic efficiency is not obtained.

Author think that many people cannot believe it, but in Japan, if you open a faucet, water that can be drunk safely with almost the same quality as mineral water that enters a plastic bottle is sold. It is transparent and slightly smell of chlorine which does not need to be boiled and sterilized. Unfortunately, hypochlorous acid is added in order to make it possible for anyone to see the state that is safe to drink as it can be confirmed that pathogenic bacteria and bacteria breed in the water pipes by any chance. In other words, since the pool disinfectant is slightly added, chlorine odor will occur. Chlorine odor can be easily removed by boiling or activated charcoal.

And the cost is about 3 dollars at 1,000 liters including the cost of sewage treatment of used water. It is impossible to reach this price even if the current advanced processing is made economical. There is reality that agricultural water is supplied almost free of charge.

There are roughly two standards of treated water in Japan, and there are ten times the opening depending on the quality of the water at the discharge destination. A 5-day BOD different from the standard 7 days in the world is frequently used for wastewater management from many processing plants with oxygen demand of 1 liter for 50 liters. Total nitrogen is less than 10 and 5 to 3 mg for 1 liter.

The agricultural use of water treated on the basis of low wastewater treatment standards continues to fail by using it for fruit trees and trees. In attempting to utilize high-standard treated water for agriculture, failures are continuing in rice cultivation where the demand for nitrogen fertilizer is low. There is a reality that the failure continues against agricultural use which said this, but the report of the failure example does not become a dissertation, so there is a reality which does not gather.

In the 1950s, which included industrial wastewater, when using wastewater treated water for agriculture, there was guidance of the administration saying that it was used after diluting it more than 10 times with river water or the like. Government officials at the time recognized the problem of fertilizer component of wastewater treatment water. However, now farmers think that treated water is clean water that does not contain fertilizer ingredients or freshwater ingredients, and because the wastewater treatment side meets the wastewater standards, we think that it can be used directly as agricultural water. They are repeating the same excessive growth mistake because they believe the results of hydroponic cultivation that nitric acid is not absorbed by rice.

The image that it is not good to use water treated domestic wastewater for agriculture is now being completed in Japan. Even more frighteningly simple attempts have been made to say that it would be nice to use it for rice for livestock to eat. Oil in the bran portion of rice plant has the property of concentrating heavy metals. When people eat, they take rice bran and eat them after eating, so the safety of the rice part is biologically guaranteed. In the case of eating brown rice, it is necessary to eat it after examining the presence or absence of contamination. Since these are only Japanese-language literature, they are not listed here but introduced as an essence of cultural and geographical differences.

This study is a case where cultivation succeeded by considering treated water as liquid fertilizer to connect industrial and agriculture of water treatment industry. Author have been using serial for over 5 years but I will talk about the first 3 years.

2. Material and Methods

In this research, in order to solve the problem of water quality and odor occurrence in a rural sewage treatment plant in the country side of 1,200 people, wastewater treated from a facility laying a humic bioreactor was introduced into adjacent paddy field to carry out rice cultivation. The outline of the performance of the bioreactor and the background to rice cultivation are described below.

3. Humus Pellet Bioreactor

Humus pellet bioreactor can be easily attached to a sewage treatment plant and is a method of supplying soil bacteria without isolation and has a shape and performance suitable for aerobic treatment and anaerobic treatment. Pellets are shown in Photo 1, and components are shown in Table 1. Installation photo is shown in Photo 2. Fig. 1 shows the flow diagram of the bioreactor.

Photo 1 Humus pellet.

Photo 2 Installation reactor tank (Rear of right) Humus pellet.

Table 1 Composition of humus pellet for aerobic treatment.

Shape	Cylindrical
Dia meter	15 mm
length	15-30 mm
Apparent density	1.05 g/mL
True density	1.50 g/mL
pH (disolved 10 g/100 mL)	3.0
Moisture	17%
Total organic carbon	13%
Total nitgogen	12%
SiO_2	44%
Al_2O_3	11%
Fe_2O_3	7%
MgO	0.3%
CaO	0.5%
Other Analytical estimation	
Organic matter	37%
Humic acid (HCl-NaOH method)	16%

The diameter of the pellet is 15 mm and the length is 15 to 30 mm and it supplies the humic substances by gradually dissolving. This specification is not fixed, but by adjusting the hardness and size, it is possible to respond to the supply amount of humus and the interval of addition and the size of bioreactor tank etc. that can be installed. Humus is a residue obtained by

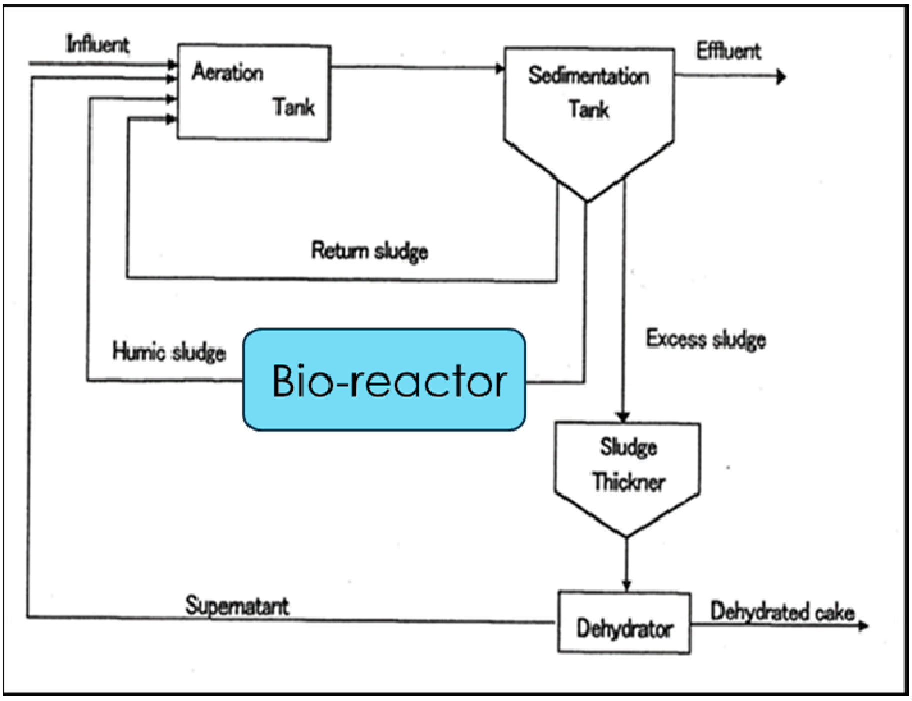

Fig. 1 Flow diagram of bioreactor.

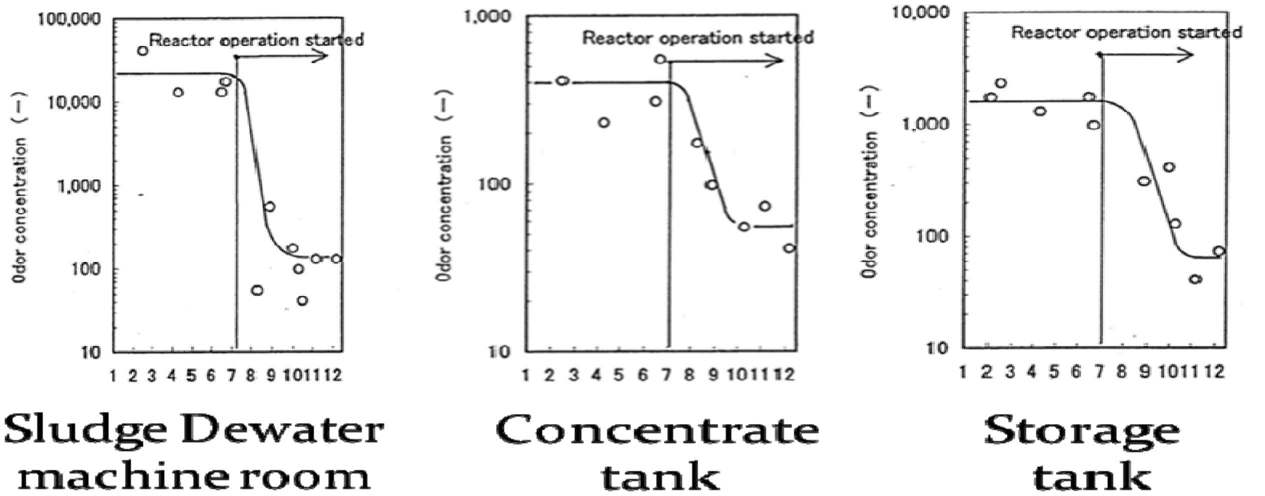

Fig. 2 Odor reduction effect of dehydrating machine room, concentrating tank, storage tank with many malodor problems in water treatment. The horizontal axis is the day. Flow diagram of bioreactor.

decomposing plants obtained from soil by the action of microorganisms and also contains cellulose and the like. It also contains silica in the ingredients and contains clay minerals that are prone to soil sedimentation and it is easy to separate in the sedimentation tank and has a specific gravity that is difficult to precipitate in the aeration tank and can float when there is a flow of water. The cause of the odor peculiar to water treatment is thought to be due to the composition of microorganisms that can grow with mere aeration of water and the composition of microorganisms that can grow only at the interface with water in the fixed microbial membrane method or the floating carrier microbial membrane method [4, 5].

Author thought to control the odor by giving the water treatment mechanism a property that it is resistant to a shock of aeration and rotation of water and makes it easy for various microorganisms to float and form flocks.

The place where microorganisms play an active part in the soil deodorization method is a part with a lot of humus and cellulose in plant bodies, which led to the possibility of improving by making such an environment in the water.

The characteristics of these humic pellets are different from artificial contact materials such as plastics and exist in the natural environment and can be expected to promote the diversity of microorganisms. Microorganism flocs are easy to break due to aeration and microorganisms that can grow on the biological membrane need adhesion. Components supplied from humic pellets provide an environment in which various microorganisms can grow as flocks, and by breeding various microorganisms, the odor peculiar to water treatment is alleviated.

We tested the completed bioreactor in Miyagi prefecture. It became famous for the tsunami. The sewage treatment at that time was stalled due to the problem of odor. In particular, the odor intensity of the dewatering chamber of sludge exceeded 40,000 (Fig. 2), and it was not working in an environment where people can work, and it became a labor problem. When opening the window for ventilation it was a condition that the odor problem comes out from the living environment of the surrounding residents. The odor intensity of 40,000 is measured by sensory method by more than ten odor judges, saying that it will not smell when diluted to 40,000 times. Sludge dewater machine room in Photo 3 is 40,000 to 100, concentrate tank is 400 to 70, storage tank is 2,000 to 80. Author think it is very good and surprised results.

This bioreactor uses humus which is not nutritious for plants denied by Liebig. In other words, it provides a part of the nutrients necessary for soil bacteria to

Photo 3 Belt press dewater machine. Work was difficult due to the bad odor at work.

decompose organic matter and gives a residence work, and makes an environment where bacteria are easy to propagate in the aeration tank.

Bacteria propagate when all three nutrients are present, but they are not in adequate nutritional status.

Studies on humic substances are mainly conducted in drinking water. Brian R. Eggins, et al. [6] decompose humus using photocatalyst. Michael R. Collins, et al. [7] conducted on molecular weight and carboxylic acid amount in drinking water. However, no examples of utilizing humus as a wastewater treatment have been found.

3. Treated Water Quality

The performance of treated water in rural areas in this study was BOD 5, nitrogen 3, phosphorus 1 mg/L or less. On the other hand, standard municipal sewage is less than BOD 50, nitrogen 10, phosphorus 5 mg/L or less in Japan. There is a problem of contamination of harmful metal elements and some contamination in municipal wastewater, and high nitrogen and phosphorus are limited to tomatoes, cucumbers etc. which require high fertilizer requirements. It cannot be used for rice and leafy vegetables with low fertilizer requirements.

Attempts to utilize treated water have been done in various places. When the nitrogen content is high, plants grow long and weak stems are formed. In rice, not only the length of stems but also the number of branches was reduced, so the number of panicles is small and the leaves become larger as time passes.

Photo 4 Rice collapsed using treated water.

In the field which does not know agriculture, the growth of early stems of rice is good and the leaves are increased, and it is pleased that growth is good. However, like the Photo 4, the stem grows too much before harvesting and it collapses. If it collapses with wheat the same as germination and rot, it cannot be harvested. Although decades have already passed since the water treatment began, it is still repeated in various places that the use of treated water in rice cultivation will not be generalized due to different fields. Various studies on nitrogen-rich pre-harvest have been done and are carried out comprehensively in the study of Consuelo M. Perez, et al. [8].

4. Physiological Characteristics of Rice and Use of Treated Water

When using treated water for rice cultivation, it is important to understand the physiological characteristics of the accumulation of heavy metals and hazardous chemicals in bran as an important characteristic of rice. Domestic animals eat rice bran together, but rice human eat is polished and they eat only white starchy part.

When rice is eaten by livestock, researchers and administrative authorities have begun to be used for rice for livestock feed for ideas that people do not eat directly because it is safe. However, chemical properties of heavy metals are strongly liable to be concentrated in fat. Unfortunately, it is not taken into consideration that heavy metals and bioaccumulation of harmful components are liable to occur in adipose tissue.

Japanese soils contain a lot of cadmium, they have been rice milled from olden days and eaten white rice. Since the bran portion contains a lot of vitamin B group, we ingest vegetables by transferring vitamins by fermenting the bran and picking the vegetables. Since vegetables have no oil, cadmium dissolved in oil has come to utilize the property of not moving to vegetables. Recent organic farm booms may be harmful to health.

5. Design of Fertilizer and Yield of Paddy Rice

A quality is the top priority for rice cultivation in Japan. As the harvest amount is increased, the decline in quality is a matter of course, so it is impossible to think of increased sales by using treated water. Production of delicious rice with sweetness and chewy response involves producing 20% rice of garbage. Garbage rice feeds livestock.

Plant physiology of Japanese rice (Japonica) requires nitrogen nutrition especially during tillage from rice planting, but it becomes unnecessary at the time when panicles are made and floral buds can be formed. After pollination, nitrogen nutrition is necessary. Therefore, when the nitrogen content is high, the plant grows quickly and large, but it has the property of not adding rice. Also, because of typhoon and rice weight, it falls before harvesting and the roots come out from the ears, so it gets rotten. Rice production fails when using treated water for conventional fertilizer design. The image of fertilizer design is shown in Table 2.

When the nitrogen concentration T in treated water is added to the fertilizer concentration N shown in Table 2, plants grow greatly in May and June because nutrients are doubled. If we use treated water in July, August, when the rainy season with a unique Japanese climate passes and the summer water runs short, the nitrogen fertilizer becomes excessive and the taste quality becomes worse and it cannot be sold. In other words, treated water in paddy rice cultivation is not water quality that can be used when water shortage occurs. It was concluded that it could be used with aggressive use to save water by using treated water in advance and saving the excess fertilizer used in the environment.

6. Results and Discussion

Photo 5 shows a wastewater treatment facility at a rural settlement with a population of 1,250 people subject to wastewater treatment. Since there is an image in the odor problem of the wastewater treatment facility, we decide the design of the facility which does not give the image which is performing wastewater treatment as the standard in Japan.

Photo 6 shows the drainage from the wastewater treatment plant into the paddy fields. The size of the paddy field is 20 meters by 100 meters in size and it is the standard area in Japan. In order to equally supply wastewater to the front of paddy field, six water supply ports were prepared and a water gauge was installed.

Table 2 Rice fertilizer application image.

Month	Standard fertilizer (chemical)	Plus treated water (excess N)	Controlled fertilizer plus treated water
April	NNNN	NNN T T	NNTT
May	NN	NN T T	TT
June	N	N T T	T T = slightly over, excess
July	NNNNNNNNNN	NNNNNNNNNN T T	NNNNNNNNTT
Aug	NNNN	NNNN T T	NNTT
Sep	N	N T T	T T = slightly over, excess

N: Rice required nitrogen concentration using chemical fertilizer;

T: Treated water nitrogen concentration; T: = OVER amount.

Photo 5 Whole view of the rural sewage treatment plant at experimental field.

Photo 6 Treated waste water drawn into the paddy field next to the wastewater treatment plant (Photo 5).

Photo 7 Rice and paddy fields just before harvest.

Photo 8 From the left of the rice plant after harvesting Akita komachi, Koshihikari, Koshihikari of standard chemical fertilizer cultivation.

Paddy rice cultivars using treated water were able to obtain standard yields. The standard harvest in this area is 480-560 kg, compared to 1,000 square meters (= a). The quality of rice was the highest quality, there was no quality degradation due to the use of treated water. There was no biodiversity in cultivation using agricultural water, but various kinds of organisms occurred when treated water was used. Photo 7 shows rice and paddy fields before harvesting. As shown in Photo 4, when leaves grow too large, they lie down, but in Photo 7 leaves cannot be seen on the panes. Also, it is a healthy growth where the spikes are hanging down.

As shown in Photo 8, there was a difference in the growth of the stem at the entrance and the exit of the rice paddy, there was no big difference in harvesting amount between the exit and entrance part. On the other hand, in Koshihikari of standard chemical fertilizer cultivation, the stem extends from treated water. This indicates that the initial concentration of chemical fertilizer used was high, but there is no fear of lodging in this length. There is one who suggests the use of a lodging-alleviating agent, but farmers cannot accept a lodging alleviating agent from the aspect of cost increase because reduced pesticide and proper cultivation are agriculture.

Koshihikari and Akitakomachi rice varieties are famous varieties in Japan that can be produced in the northern part of the country in Japan, but the species of Sasanishiki is also produced in California in the United States but it is a conformable species in the south, so it cannot be grown in north of Osaka or Nagoya. However, the impact of climate change fortunately has made it possible to cultivate Sasanishiki in the northern part, and even in the high latitude of Hokkaido it is becoming possible for rice cultivation Koshihikari and Akitakomachi. Various types that meet high latitude have been developed.

Fig. 3 shows the mechanism of decreasing stem length. In paddy fields, a phenomenon different from the result of hydroponic culture occurs. In agriculture, we assume that the nutrient of paddy rice is ammonia nutrient so it will not absorb nitric acid after wastewater treatment. On the surface of paddy fields, nitric acid which contains oxygen easily is absorbed by algae and microorganisms and life activities are carried out. Denitrification is done by microorganisms that absorb oxygen from nitric acid and turn into nitrogen gas through nitrite, hydroxylamine or ammonia is famous, but the root of rice is present when the microorganisms are active. Algae and small animals that eat it also breed in paddy fields. They metabolize ammonia. Ammonia quickly adsorbed as the clay mineral in the paddy field is negatively charged. It is thought that it will be absorbed by rice as ammonia by the exchange reaction with the root acid metabolized from the root of rice. Research using tracer in paddy field soil has not been done yet. It is impossible to handle the fact that nitric acid is not absorbed by hydroponic cultivation that does not involve microorganisms using tracer and paddy fields where microorganisms are involved and cannot be handled in the same way.

Table 3 shows the cultivation result and the amount of treated water used and total nitrogen content. The amount of inflowing water in this treatment plant is about 7,500 cubic meters/month, the N of discharged water discharged after treatment is 3 mg/L, P is about 1 mg/L, and the regional conditions of the most severe discharged water. If N/P in wastewater from this treatment plant is converted into per month, it translates N 22.5 kg and P 7.5 kg each month. The wastewater from the field shown in Table 3 was shown to have been reduced to an N concentration of about 0.5 mg/L or less, which was reduced to about 1/6 or less. Since the cultivation period of rice is from the middle of March to the beginning of September, removal of N from discharged water by paddy rice cultivation was done during the cultivation period of about 6 months.

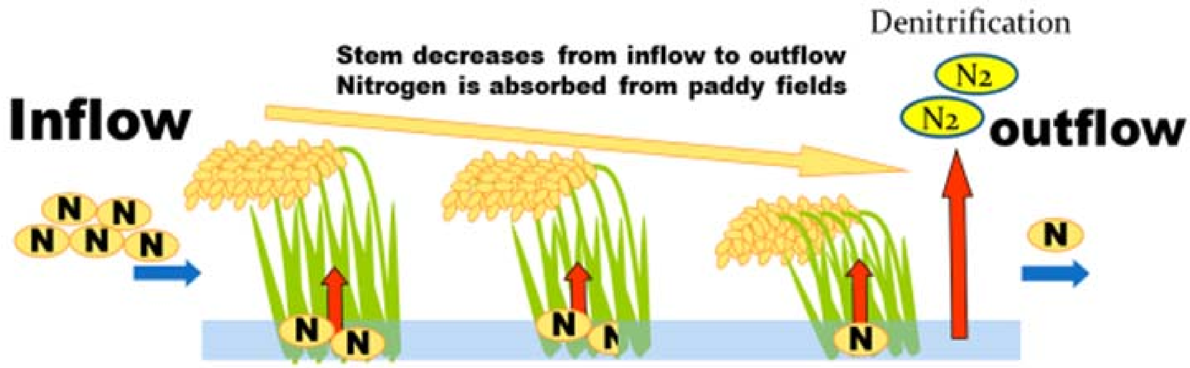

Fig. 3 Mechanism of stem length reduction in rice.

Table 3 Result of cultivation and amount of treated water and total nitrogen content.

Year	Harevest volume (kg/1,000 m^2) Akitakomachi	Use of treated water per cultivation term	Harevest volume (kg/1,000 m^2) Koshihikari	Use of treated water per cultivation term	Total nitrogen mg/L (average of 2 to 4 measurements per month) May June July August
1st	520	2,420	540	2,023	0.3 < 0.1 < 0.1 0.3
2nd	505	2,120	580	2,230	0.6 0.2 < 0.1 0.6
3rd	545	2,585	530	2,145	0.4 < 0.1 < 0.1 0.2

Photo 9 Aerial photograph of cultivated land. The small circle in the center is the experiment paddy field. Wastewater from the surrounding private houses gathers at the wastewater treatment plant next to the experimental paddy field and is treated with wastewater and discharged to the upper tributary.

For P, the result (not shown) was less than the detection limit of 0.5 mg/L or less from the accuracy of analysis. About 1 mg/L for discharged water from the treatment site, it is considered that there was a removal rate of about 50% or more. It is estimated that 37.5 kg of N was used for rice or denitrification during the six months of cultivation period. For the entire treatment facility, five months of the one-year emissions are calculated by paddy rice cultivation.

If we use discharged water of about 2,500 m^3 for 20 a, we can accept all of the discharged water by using 360 a (18 paddy fields: Photo 9. Square area). One side of the paddy to the river in the back of Photo 6 is sufficient enough, and in the rice cultivation area it is sufficiently large enough to use a small amount of paddy fields (about a part of the area of idle fields).

In addition, it is possible to reduce N of 337.5 kg when all the discharged water at this treatment plant is accepted for rice cultivation, converted to 4,218 kg in terms of home farming fertilizer (all 8 types: NPK each 8%), 420 bags in 10 kg bag. It is a corresponding amount of reduction. On the other hand, the concentration of each component of the effluent water from the paddy field decreased by more than 90% compared to the treated water. That is, using paddy fields has been shown to be effective in reducing the use of fertilizer and removing residual components of treated water. Removal of phosphoric acid in water treatment is the only method of recovering it as sludge, and an increase in generation amount is essential to recover phosphoric acid as sludge. Since phosphorus in the environment exerts the effect of eutrophication as the total amount, the limitation of phosphorus discharge to lakes and oceans accompanying population increase is strengthened.

Photo 10 is a truck loaded with 4,500 kilograms of chemical fertilizer. Author think that it is a necessary photograph to get a sense of realism. This amount is the actual condition of treated water released by river etc. after treatment of wastewater issued in only one year by 1,250 people, but the drainage standard for municipal sewage is more than 10 times loose, so urban sewage treatment, the same number of people are discharging ten times the amount of rural areas. It is equivalent to 36 kg per year for one person. In other words, it is 2 bags of chemical fertilizer containing about 20 kilograms per one population.

By multiplying the urban population by 36 kilograms of chemical fertilizer value, the load can be estimated from the area and average depth of the harbor in countries such as Southeast Asia. If we introduce it from the splendor of the equipment in the city of

Photo 10 Truck loaded with 4,500 kilograms of chemical fertilizer.

Japan's wastewater treatment it is easy to think that damage such as red tide of the port can be prevented but the quality of treated water is low although the processing capacity of municipal sewage is high. It is an unavoidable economic compromise because it processes large amounts of water. It is not known that environmental conservation has been accomplished by reducing the total amount of nutrients flowing into the port by strictly reducing the drainage of rural communities dispersed around the city. Therefore, it is not known that even if municipal wastewater treatment alone is done, it can not sufficiently suppress harbor eutrophication.

7. Heavy metal Cd and Zn

Fig. 4 shows the cadmium content of brown rice in three years of cultivation. Cadmium rice content standard value was less than 400 micrograms per kilogram, but after cultivation analysis up to 80 micrograms averaged 60 micrograms. The food standard of brown rice in Japan is generally white rice to eat while removing bran, but brown rice is used as a stricter regulation. The idea that the act of using treated water after wastewater treatment is dangerous because it involves heavy metals and does not take into account the adsorption properties of soil cations (heavy metals cations) and the elimination effect of rice on physiological bran. Unlike upload rice, paddy rice does not have aerobic conditions, so heavy metals are difficult to elute from anaerobic paddy field soils. However, if the task of harvesting paddy fields before harvest lasts long to put in a heavy harvesting combine and the paddy field is brought into contact with the aerobic condition, heavy metals are transferred to rice,

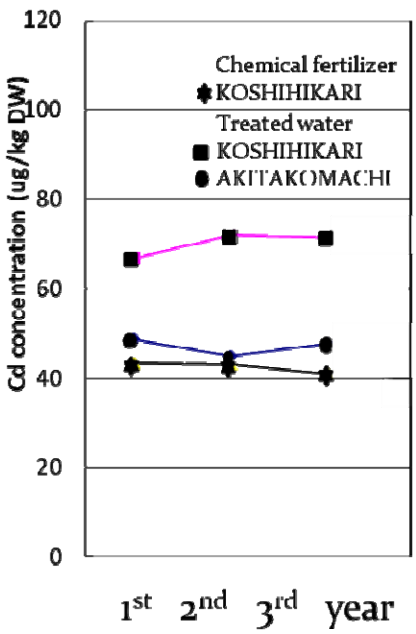

Fig. 4 Cadmium content of brown rice in 3-year cultivation.

though slightly. Regarding the absorption and transfer of soil and heavy metals, pH dependence has also been reported in studies by Nanthi Bolan, et al. [9].

Considering the accumulation of heavy metals in rice, there is a problem of taste and harvest time. Combine is used in modern agriculture but in order to work in paddy fields it is necessary to dry the state of the muddy and harden it. If a person cuts by hand, it is sufficient to lightly dry for several days but to enter the machine it will take days from 10 days to several days. This work is called "Doyou-Bishi" in mid summer time, but when water is extracted and the cracks are cracked in the rice fields, cadmium changes from the soil to a form that is absorbed by plants when aerobic conditions are reached. There is cadmium in the whole soil of Japan, and various activities to prevent it from moving to food are being carried out. Consumers strongly demand leaving sweetness in rice, so harvesting is done earlier and good rice can be made by making inferior rice to 30%, but at the same time it is difficult to balance with high cadmium content.

Write again it was less than a fifth of 400 micrograms per kilogram which does not affect health. It was less than twice as much as the chemical fertilizer area. Brown rice with cadmium concentration close to the regulated value of less than 400 micrograms per kilogram at much higher concentration than this empirical research is distributed normally. As a result of experiments, cadmium concentrations of less than 1/5 of that of ordinary commercially available brown rice were obtained. However, there are people who are afraid of having a small amount due to emotional anxiety or those refusing to use it only by being treated water of human waste. Not only in Japan but also in natural soil is a trace amount of heavy metals such as cadmium and mercury are present.

The rice to be eaten by humans further reduces the content of cadmium by removing the bran portion of brown rice. However, feed rice given to domestic animals is eaten as unpolished rice. Heavy metals are concentrated in the fat of domestic animals if it is said that it is safe if feed rice given to livestock is safe because people are uneasy. People who eat it further concentrate heavy metals. It is difficult to evaluate bioaccumulation, but it is uneasy that easy-thinking and actions are increasing, saying that foods of livestock that human beings cannot eat are all right.

8. Conclusion

This sewage treatment plant has a scale of 1,250 people. When the whole amount of treated water is used in rice paddy rice production, a paddy field of 360 a (a = 1,000 square meters) is necessary. The amount of nitrogen fertilizer reduced is 337.5 kg, which corresponds to 4,218 kg as a fertilizer with a general component quantity of 8%. By conducting sewage treatment in rural areas in pairs with agricultural production, we achieved a reduction of 337 tons of fertilizer when converted to a population of 100,000 people, and a reduction effect of nitrogen load of 26 tons to lakes and oceans. The contamination of paddy rice with heavy metals in 3 years was slight, indicating that the wastewater from wastewater treatment in rural area is very likely to be used for agriculture.

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