Advocacy of Positive Environmental Assessment using Soil Microbial Diversity and Its Vitality Value

As an Index for Environmental Preservation Effects in Environmental Accounting

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***Abstract*—We advocate the soil microbial diversity and its vitality value as a positive environmental assessment in the environmental accounting to show the result of the approach to the environmental friendly agriculture. It is considered to be important information to specifying the effort of the soil-making. The diversity of soil microbial community and its vitality value is an index that shows biological richness of the soil. This index doesn't pay attention to the species and the number of microorganisms but is measured only by the speed and the diversity of the degradative reaction to 95 different organic compounds and the rapidity in response. In general, the index of the soils enriched by the soil-making with the compost and the organic fertilizer indicates remarkably high compared with soil that amended with the chemical fertilizers. Moreover, it is known to decrease a value remarkably in the soil that causes soil-borne diseases by continuous cropping.**

Keywords-Environmental Accounting; Soil Biodiversity; Accountability; Complex System; Evaluation

I. Introduction

The environmental destruction in the global scale keeps becoming severer, and promotion of environmental conservation activities is required strongly. The Ministry of Agriculture, Forestry and Fisheries has defined that "The environmental conserving agriculture is sustainable agriculture that reduces the negative environmental impact of the chemical fertilizer and the pesticides, etc. with the soil-making, best use of the matter cycle function of agriculture, and noting harmony between environmental conservation and productivity. " and is promoting it nationwide. Moreover, the conservation of biodiversity is emphasized worldwide as an environmental preservation. The ministry also shows that "Conservation of biodiversity at the agricultural eco-system is essential to maintain and promote agriculture, forestry and fishery as industries and rural areas supplying good quality products of agriculture, forestry and fishery."

Many of research about the environmental conserving cost and its effect at the view point of the environmental accounting had also been promoted. However, most of the effects are not measured directly about the efforts of harmonization between agriculture and environment such as soil-making and positive use of organic composts, but about reduction of use of chemical pesticides and fertilizer. Investigations of biodiversity are mainly focused on microscopic organisms.

In this paper, we are advocating a new index, "Soil microbial diversity*vitality value" calculated by measuring both of biodiversity of soil microbial communities and their organic matter utilization activity as an alternative assessment of positive effect of the environmental conserving agriculture.

II. Problem in Environmental Assessment

A. Environmental assessment in agricultur

Recently, the life cycle assessment (LCA) is well known as a method of the environmental assessment [1][2]. The LCA is a method to realize environmental impact of a certain products through the all steps in its life cycle from production, transportation, sales, use, discard to reuse (recycle). Although the LCA is very important, there are many problems in the manipulation as follows.

1) In case of data acquisition about environmental impact of each material for agricultural production, we need to correct all information of environmental impact of every step from raw material to production to discarding. It is unrealistic to achieve the data acquisition in each material. To solve this difficulty, thus, we correct the impact data from the inter-industrial relations table, and the negative environmental impact data is summed up by a big bundling (ex. chemical pesticides and the fertilizers). In the calculation, it is possible to measure gross amount of reduction of the chemicals but impossible to realize the reduction of negative impact due to changing chemicals from high impact to low impact.

For instance, in case of change in material for plant protection, change of amount, reduction in pesticides is detectable, but changing pesticide from chemical to biological with no reduction in amount sprayed, is not detectable in the LCA. Change from chemical fertilizer to organic compost cannot be detected as reduction of impact either.

2) Many kind and various units in the environmental impact makes comparison between different production

procedures changed for environmental preservation very difficult.

For example, in case of change in method for plant protection, changing chemical insecticide to physical barrier such as anti-bug net, or chemical herbicide to mechanical weeding, it is not possible to measure and compare the environmental impact of the chemical insecticide, anti-bug net, chemical herbicide and mechanical weeding totally. Alternatively, amount of CO2 emission is now used as a universal unit to measure the environmental impact in the LCA, but result may be reversed by the estimation with CO2 emission between the impact of chemical pesticide and non-chemical protection, such as physical net and mechanical weeding due to higher CO2 emission in steps of production and transmission and application, etc. compared to the chemicals.

These examples are showing that the LCA itself is important conceptually, but is unrealistic to evaluate the efforts and trials by farmers to reduce use of chemicals to non-chemical materials for the environmental conserving agriculture.

B. *Effect of environmental conservation in the environmental accounting*

The environmental accounting is a method to measure effectiveness of management in environmental conservation compared to the LCA that measure every impact of management to environment [3][4]. In the guideline presented by the Ministry of the Environment in 2005 defined that the environmental accounting is quantitative indication of environmental conservation activity of enterprise with unit of currency or physical superiority as much as possible.

In the guideline, the effect of the environmental conservation is defined as "Quantitative measurement of effect of approach to prevent, control or evade generation of the environmental impact, removal of the influence and recovery of the damage, and approach to contribute these activities with unit of physical superiority ". And an example of method to calculation, "Effect of environmental conservation = Gross amount of negative environmental impact at standard period - Gross amount of negative environmental impact at this season" is shown in the guideline. From this example, we may assume that the guideline means tacitly that the effect will be indicated as decrease of negative environmental impact. In the agriculture, however, we considered that increase of positive environmental impact resulted by soil-making in an approach of environmental conserving agriculture should be evaluated much more positively on the environmental accountability view point.

Although the new formula to calculate the positive environmental conservation effect, "Effect of environmental conservation = Gross amount of positive environmental impact at this season - Gross amount of positive environmental impact at standard period " advocated in this paper is reversal from the conventional formula to calculate the negative environmental conservation effect shown above, the fundamental concept does never deviate the definition of the environmental effect of the guideline.

Additionally, we advocate a new index to measure the positive environmental impact resulted by approach of the environmental agriculture, "Soil microbial diversity*vitality value" as one of display item in the environmental accounting.

With this index, we are able to indicate biological richness of the soil microbial community enriched by reducing agricultural chemicals such as fertilizer and pesticides and promoting soil-making, plant protection as positive effect of environmental impact.

Compared to the LCA, we will not emphasize the steps of production and discarding of management resources in this approach, so we can prevent to be trapped in difficulty in negative impact estimation for the LCA shown previously, and can push the positive approach of the management forward as an advantage of the positive assessment.

An idea, putting the positive environmental impact on the effect of the environmental conservation may already exist in the basic concept of the environmental accounting. However, technique to evaluate the soil-making as the positive environmental conserving impact has never examined. It is, therefore, considered that connecting the "Soil microbial diversity*vitality value" as a valuable information to the environmental conservation effect is the most important and novel point of this paper.

III. "SOIL MICROBIAL DIVERSITY*VITALITY VALUE"

Soil microbial diversity*vitality value is an index indicating level of biological richness based on diversity, rapidity and speed of degradative reaction of organic matters (carbon sources for the microorganisms). The index does not focus on the number of species and microorganisms, but translate diversity and richness of degradative activity of the microbial community to diversity and richness of biological function of the soil.

To measure the index, soil suspension tested is injected in 96 small walls (about 150 micro litter in volume) on a plastic panel (Biolog GN2 [5]), having 95 different kinds of carbon sources such as sugars, its derivates, amino acids, organic acids, polymers, nucleotides, etc. in each well except 1 negative control well. Degradation reaction of each carbon source on the plastic panel is observed as coloring reaction by an indicator dye mixed in each carbon source 192 times for 48 hours (every 15 minutes). The coloring reaction is numericalized by imaging with CCD camera and image analysis programs "Omnilog-PM [5]" supplied by the Biolog Inc.. The index is calculated by integrating the color values of all 96 carbon sources through the whole of 192 time observations.

With this index, soil having microbial community composed of microbes having higher diversity, rapid responding and high speed carbon source degradation activity should be scored high. High index means that the soil is biologically enriched by soil-making in environmental conserving agriculture.

The soil-making is understood as activity to enrich biological function of soil empirically. Soils amended with organic compost and pig manner indicate higher diversity compared to soiled amended with chemical fertilizer [6]. At soil synthesis, increase of soil microbial diversity in soil maturation was reported [7]. In contrast, dumping off of diversity level of the soil microbial communities in the soil causing sever monoculture soil-borne diseases was reported [8].

A. *Example of surveillance of Organic agricurlture*

Following examples are results of surveillance of the "Soil microbial diversity*vitality value" in collaboration with the Japan Soil Association.

1) Example 1: We compared the "Soil microbial diversity*vitality value (value)" in rice paddy fields between soil of organic agriculture and soil changing from conventional to organic (TABLE I). The result shows that the soils of organic had higher values compared to the conventional soil, furthermore, soil of longer organic agriculture had higher value than soil of shorter organic agriculture.

TABLE I. COMPARISON OF THE "SOIL MICROBIAL DIVERSITY*VITALITY VALUE" IN THE EXAMPLE 1

Site	Value
Organic agriculture for 8 years #1	1,092,095
Organic agriculture for 8 years #2	1,086,078
Organic agriculture for 6 years	917,846
Conventional agriculture but changing to organic for 2 years	724,817

Japan Soil Association

2) Example 2: We compared the "Soil microbial diversity*vitality value (value)" in rice paddy fields between soil of organic agriculture and conventional agriculture neighboring each other at Ogawa-machi in Saitama Prefecture (TABLE II). The result shows that the soil of organic agriculture for 10 years had approximately double score compared to the soil of conventional agriculture.

TABLE II. COMPARISON OF THE "SOIL MICROBIAL DIVERSITY*VITALITY VALUE" IN THE EXAMPLE 2

Site	Value
Organic agriculture for 10 years	1,371,983
Conventional agriculture	634,099

Japan Soil Association

3)Example 3: In Saitama Prefecture, we also compared physical hardness and the "Soil microbial diversity*vitality value" between soils of tea tree of organic agriculture for 30 years, organic agriculture for 5 years and conventional agriculture neighbored each other (Table 3).

The result shows that the soil of organic agriculture for 30 years has low physical hardness from 10 to 20 cm in depth compared to soil of short organic agriculture (for 5 years) and conventional agriculture. This means the soil having longer organic agriculture have developed softer and better soil for growth of root system of tea than soils having shorter experience of organic agriculture and conventional agriculture.

TABLE III. COMPARISON OF THE "SOIL MICROBIAL DIVERSITY*VITALITY VALUE" IN THE EXAMPLE 3

	Organic for 30 years	Organic for 5 yeas	Conventional
	Physical hardness of soil		
Depth 5cm	12	7	6
10cm	10	13	13
15cm	12	17	15
20cm	17	20	19
25cm	19	17	18
30cm	17	16	16
	Value		
	1,363,414	1,108,226	946,853

Japan Soil Association

In the "Soil microbial diversity*vitality value", there was the same tendency as the physical hardness of soil. The soil had longer experience of organic agriculture than the soil had shorter experience of organic agriculture and conventional agriculture.

4) Example 4: We compared the "Soil microbial diversity*vitality value" between soils having different severities in occurrence of soil-borne disease of Tomato by collaboration with Dr. Masayuki Maeda of Niigata Prefecture Agricultural Experimental Station. This surveillance was conducted for examine usefulness of the "Soil microbial diversity*vitality value" in plant protection against the soil-borne diseases.

Fumigation of soil to control the soil-borne diseases caused by mono culture is thought one of the most sever negative impact to the agricultural eco-system. The fumigation is used to prevent serious damage in yield and management of farming caused by the disease in mono culture. However, many soils evaded from the diseases with suitable care with amendment of organic compost without the fumigation were empirically known as "Suppressive soil".

The Figure 1 is showing the suppressive soil against the bacterial wilt disease of Tomato plant (no diseases occurred for 6 to 20 years under mono culture) had much higher value compared to soils having medium occurrence of disease, and almost double score of the value compared to sever occurrence of the disease.

This means that the more effective and efficient soil-making may be able to be designed by checking the "Soil microbial diversity*vitality value".

In addition, we have discovered remarkable decrease of the value after spraying of chemical pesticides (fungicide, insecticide, and herbicide) for certain period (data not shown). This is suggesting strongly possibility to usage of this value for checking a kind of hidden spray of chemical pesticide and a proof of exact organic agriculture.

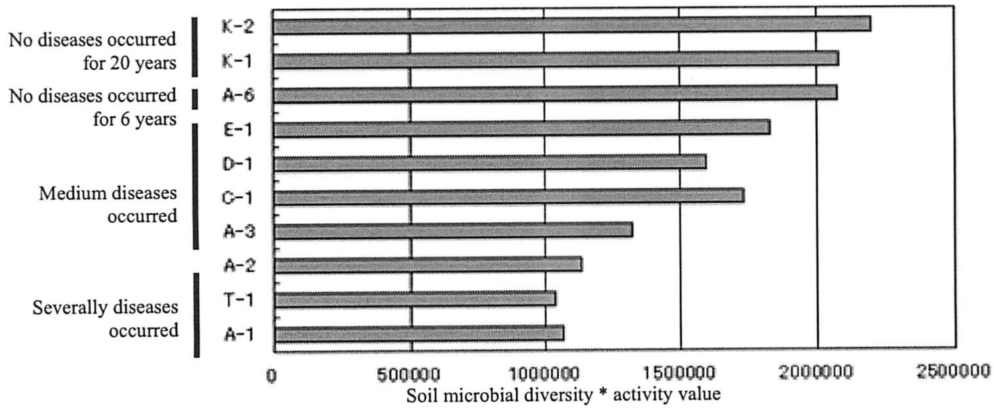

Figure 1. Comparison of the "Soil microbial diversity*vitality value" between the suppressive and the condusive soil against the bacterial wilt of Tomato plant

B. Example of making active compost

The recycling of waste using the living organisms is an important subject in the environmental preservation, and, for instance, a lot of trials that making environmental safe compost from industrial waste work as part of environmental conservation activities. Therefore, the measurement of the environmental conserving effect is also essential to support the trials and the use of the" Soil microorganism diversity*vitality value" is given as thought of the techniques.

An example is shown as follows. The table 4 is showing a comparison of the "Soil microorganism diversity*vitality value" in the waste of agricultural production (mixture of the sawdust medium for brown mushroom cultivation and the cow excrement) between before and after digestion by earthworm of the Hotoku Co. Ltd. [9] in Tokushima Prefecture. We can understand easily that biological richness and activity in the compost (after digestion) is remarkably amplified from the numerical value through the digestion by earthworm in the table. It is assumed that the compost can work to amplify the biological richness of the agricultural field as an economically valuable resource in the environmental accounting, but the waste (before digestion) will work as a negative impact against the eco-system in agricultural field in contrast.

TABLE IV. COMPARISON OF THE "SOIL MICROBIAL DIVERSITY*VITALITY VALUE" IN MAKING THE ACTIVE COMPOST

Waste of agricultural production	Value
Before digestion	273,270
After digestion	1,880,240

Hotoku co. ltd.:DGC co itd

IV. CONCLUSION

Although, until recently, we have recognized harmony with nature and preservation of landscape as positive environmental effect of agriculture, it is very difficult to measure directly these effects. This difficulty is now generating suspicion about the positive environmental effect of the agriculture.

We conclude that evaluating positively approach of soil-making as a biodiversity conserving activity of soil eco-system by farmers should be essential to avoid the difficulty (effort to making clear makes it more unclear) in measuring the environmental positive effect of agriculture.

We believe that the "Soil microbial diversity*vitality value" and introducing it into the environmental accounting must be one of the important breakthrough to solve the big difficulty.

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