H-063 Evaluation and alleviation of environmental burden associated with economic development in several Asian regions – a policy-related research（Abstract of Final Report）

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[Abstract]

Most of the rural regions in Asia-Pacific countries undergo a very rapid transition from traditional subsistence to cash-economy agriculture. Such transition entails introduction and release-accumulation of chemical substances, such as pesticides and food additives, into the local ecosystem, which in turn would affect not only the health and survival of the inhabitants, but also the safety of local produce. In this project, choosing six Asia-Pacific countries, we will describe such transition and its environmental consequences in detail and, through systematic analyses, reveal the interrelationship between the transition and the changes of local chemical environments. Final goal of the project will be to make a policy recommendation to minimize unnecessary adverse consequences of such transition.

Sub-group 1 (Evaluation of environmental and body burden and analyses of chemical flow) and sub-group 3 (Evaluation of biomass/biodiversity and collection of basic data for subsistence transition) have collected samples of over 5500 individuals and the information on the driver and descriptor of subsistence transition from Indonesia, Nepal, Viet Nam, Papua New Guinea, Bangladesh and China (Hainan) and analyzed them with various procedures. The results of analyses revealed that 1) within-country difference appeared to be larger than between-country difference; 2) the effects of a subsistence transition may be different between sexes, which may have some biological background; 3) the relationship between the policy and subsistence/health appears to have a unique aspect in each community with unique context only applicable to that society. Sub-group 2 (Exploratory analyses for potential chemical contaminations in environmental and biological samples) developed a protocol that enables the measurement of conjugated components in the urine samples. In addition, SBSE-absorbed samples were eluted from the stir bar and subject to GC/MS, which enabled the analyses of small volume samples.

1. Introduction

In many rural communities in Asian countries, subsistence transition, rapid transition from the traditional agriculture to cash-oriented agriculture, has been taking place during the last couple of decades. Such transition brought about environmental impacts, ranging from loss of forest resources due to land-opening activity for new crop fields, loss of traditional man-made landscapes such as paddy field or slush-and-burn plots, introduction and in-flow of man-made chemicals like pesticides and non-degradable plastics from urban/cities to local environments and their vicinity. The final component would result in discharge/release and accumulation of the chemicals, and hence, the local chemical environment will be changed. In addition, subsistence transition would result in the change of life style of the people in such rural communities, especially regarding their food habit and agricultural labor, which in turn would change the nutritional status and health condition of the residents. As such, environmental and health impacts of the subsistence transition need to be examined to assure the sustainability of rural Asian communities, which also has a huge impact on global environmental issues considering the number of the people inhabiting such communities.

Previous attempts to evaluate such impacts of subsistence changes, such as made by political ecologists, may not have wide impact because of their "case report" nature, while attempts to examine the health status in such communities, such as conducted by international health researchers, tended to be merely descriptive or superficial. In the present study, we tried to delineate the process that mechanistically connects the "drivers" of the transition, such as governmental policy, infrastructure, or "psychology" of the people to the consequences of the transition including both the health and environmental aspects.

2. Research Objective

The major purpose of this study is to describe the [functional] relationship between the transition and environmental/health impacts. By examining many of such communities, we expect a wide variation of the cause/pathway of transition, which we hypothesize, will give different impacts on local environment and health of the people. Thus, to examine such difference closely, we may find a "better" pathway of such transition.

For describing the relationship, we will collect the data, which would be classified into three categories of variables; X = drivers, Y= descriptors, and Z= consequences of the transition, respectively. Variables in X categories were already described above, and Y variables include type of traditional agriculture, the extent of the introduction of cash-income, while Z variables include the impacts. By elucidating the functional relationship among X, Y, and Z, we might be able to find "optimal" pathway of Z with various combinations of X and Y. In the final step, we will be translating such optimal pathway into policy recommendations for environment as well as for food.

3. Research design

The project has three "sub-themes", each of which was pursued by corresponding "sub-groups" (SGs). SG1 is in charge of evaluation of chemical exposures, health effects, and

environmental burden (mainly related with Z variables), SG2 is in charge of developing and conducting exploratory analyses for multiple chemicals in environmental and biological samples (also Z variables). SG3 is in charge of collecting basic community-level information regarding policy, subsistence, and general environmental impacts of the subsistence transitions. Thus, the overall flow of the project will start with a) field observations and interviews at selected communities, interview regarding the subsistence transition; b) examining the changes of food consumption and labor hours due to a); c) examining the impacts of a) and b) on natural environment; d) evaluating chemical exposure as a consequence of a) and b) by chemical analyses of biological samples; e) elucidating the health consequence of the chemical exposure; f) to elucidating the potential influences of environmental policy and food policy on the processes outlined above; and g) by scrutinizing the positive/negative effects of subsistence transition, we will make a recommendation for policy makers.

The subject areas include Indonesia, Bangladesh, Papua New Guinea, Viet Nam, China (Hainan), and Nepal. We chose 4-7 communities preferably representing various ecological for each of these areas, where SG1 and SG3 conduct health-related surveys.

* SG1 … focusing on Z variables, collecting the information for nutritional status and food consumptions, and the biological samples, which were analyzed in laboratories in Japan. This was conducted for 32 communities in total (Indonesia: 5, Bangladesh: 7, Papua New Guinea: 7, Nepal: 5, Vietnam: 4, and China: 5). Samples of urine, saliva, filter-paper blood were collected from over 5500 individuals (four individuals from a household: household head and his/her spouse, with two children preferably of different sex). Only those who gave written informed consent participated in the survey. The survey included an interview for basic information, anthropometry, sampling of biological specimen, another interview with food frequency questionnaire (FFQ). The collected specimens were immediately frozen, and analyzed for elements and pesticides later in Japanese laboratories. Part of the specimen was sent to SG2 for the exploratory analyses as described below.

* SG2 ….. This group focused on the development and validation of a rapid and highly sensitive, multi-chemical species analyses applicable for biological samples. Major improvement compared to the conventional methods was the extraction step, in which SG2 utilized so called SBS extraction method, which avoids the labor and time-consuming condensation step. After the extraction, the obtained samples will be analyzed by GC/MS connected with enhanced data-handling software, enabling the identification and semi-quantification of more than 500 environmental chemicals. Apart from this, an EIA procedure for DDT in biological samples has been developed.

*SG3 …. This group focused on the reconstruction of past ecological history of each community by doing interviews for several “leaders” of each community. The interview was semi-structured one and information associated with the X and Y variables was collected.

4. Results

(SG1)Evaluation of environmental and body burden and analyses of chemical flow

This subgroup aims at apprehending the influences of chemical substances accompanying subsistence transitions through the assessment of environmental as well as body burden of such chemicals. The results showed that there existed substantial between-community differences among the samples for each country, enabling us to evaluate the relationship between subsistence and chemical burdens through inter-community comparisons. Also suggested was that inter-community difference within each country appeared to be greater than inter-nations differences.

Apart from such "inter-"comparisons, we could identify several potential problems, which were peculiar to some of the target communities. For example, in some communities in Bangladesh, not only arsenic contamination of drinking water but also high cadmium exposure as well as low selenium intake was suggested through the analyses of urine samples. Potential modification of arsenic toxicity by these factors should be examined with further data analyses.

We have also tried to generate composite scales for the "effect" variables using the data for the Indonesian samples. As a starting step for this goal, we applied principal component analyses (PCA) for 18 "effect" variables for adult males in the five Indonesian communities. As the results, we could extract four principal components (PCs), which could account for more than half of the total variances. We then plotted each of these five communities onto PC#2 and PC#4 plane, obtaining a clear segregation of mountainous communities and lowland communities on this plane, suggesting such type of analyses could be used to visualize the potential integrated difference among the communities and to identify the underlying causes of such differences. In addition, when the PCA was applied to males and females separately, the resultant pattern for each sex appeared different.

We have also started a survey of material flow in an Indonesian community. Twenty households were arbitrarily chosen, visited by team members, interviewed for the use, possession, and disposal of chemicals, and plastic garbage was collected and weighed. Disposed plastics varied between 24-228g, (mean 75, SD 85g), most of them were plastic bags for food and snacks. Also contained were containers for pesticides, fertilizers, and medicines. Some garbage collectors were operating to collect plastics and metals.

(SG2)Exploratory analyses for potential chemical contaminations in environmental and biological samples

This subgroup has been in charge of conducting the exploratory analyses for chemical contaminants in the collected samples. So far, Stir Bar Sorptive Extraction（SBSE）- thermal desorption（TDS）-GC/MS and quantitative data base were used for establishing rapid screening protocol for human urine samples. In this fiscal year, additional protocol that enables the measurement of conjugated components in the urine samples has been developed. Using the samples collected from three Indonesian communities (Bongas, Cihawuk, Tarma Jaya), SBSE-TDS-GC/MS analyses were made for β – glucuronidase-treated urine samples. In addition,

to enable the analyses of small volume samples, SBSE-absorbed samples were eluted from the stir bar and subject to GC/MS. SBSE was applied at 600 rpm for 60 min; alternatively ultrasonication (15 min) was applied. For eluting media, several media including methanol, acetone, hexane, or methanol: dichloromethane (1:1) were used. Two μl of the final samples were applied to the GC/MS.

As the result, pesticides and phthalate esters（diethyl phthalate, 2,4-dichloroaniline, m-&-p-cresol, 2-tert-butyl-4-methoxyphenol, 3-&-4-tert-butylphenol, 4-phenylphenol, cloroneb, bisphenol A, 4-tert-octylphenol） were detected (LOQ~11.00 μg/ml). In addition, β-glucuronidase-treated samples, several chemicals (acetophenone, 2-naphthol, 2,4-dimethylphenol, 2-sec-butylphenol) that were not detected in the un-treated sample were detected, suggesting the applicability of this method to conjugated samples.

Results of the methanol: dichloromethane (1:1) -SBSE showed generally good recovery for 8 spiked chemicals. Although the content was too low to calculate the exact concentrations of pesticides and phthalates, the existence of these materials was confirmed. Therefore, this protocol could be applicable for semi-quantitative screening, although some protocol improvements are necessary.

(SG3)Evaluation of Biomass/biodiversity and collection of basic data for subsistence transition

This group aimed at collecting the information on the driver and descriptor of subsistence transition. The information was collected in Viet Nam (4 communities), Nepal (5), Bangladesh (6), Papua New Guinea (7), Hainan island of China (5), and Indonesia (5). Each case study was analyzed to generate the X-Y-Z diagrams for each community.

In most communities, several cause-effect pathways were identified, in which one driving event created both beneficial and adverse outcomes; for example, i) market-promoting policy led to improved nutrition and increased chemical burden, or, ii) environmental conservation policy led to recovery of secondary forest and chemical burden.

Using the remote-sensing data and SRTM (Shuttle Radar Topography Mission) digital elevation model, relationship between land-use and geographical characteristics was analyzed. Finally, using wearable GPS and accelerator, methodology to measure individual's activity related with time and place was developed and applied.

5. Discussion

Based on the ground work, we, in collaboration with the researchers in the counterpart institutions, could conduct the surveys in 32 communities in 6 countries (SG1 and SG3). SG2 established the rapid semi-quantitative screening method for exploratory analyses of chemicals in urine samples.

Results of SG1 showed substantial between-community differences in the six countries, confirming the existence of such difference, which should be the basis for within-country analyses of chemical burden-subsistence relationship. That within-country difference appeared to be larger than between-country difference would be favorable in conducting across-country analyses of

individual differences.

Our trial for generating composite scores suggested that effects of a subsistence transition would exert differential effects on males and on females, which will be important not only in generating policy recommendations but also as finding for basic environmental-health sciences.

SG2 conducted an explorative strategy to reveal the exposure status in rural Asian populations, using SBSE and quantitative database. As the results, analyses with SBSE-TDS-GC/MS demonstrated the effectiveness of this method for small volume of samples, and applicability of this method to chemical metabolites by employing enzymatic-treatment of the samples. Also, SBSE-utilizing extraction enables semi-quantitative analyses with small amount of samples.

SG3 collected and supplemented the driver and descriptor information on subsistence transition in 32 communities of 6 countries. It became evident that each community has different "story" of subsistence transition, confirming one of basic assumptions in the entire project, diversity of the subsistence transitions.

The relationship between the policy and subsistence/health appears to have a unique aspect in each community with unique context only applicable to that society. Therefore, in designing/evaluating the driver for subsistence transition (policy and infrastructure) both positive and negative impacts need to be addressed in terms of economy, health, and environment.

6. Significance of the findings

(1) Scientific significance:

1) Inter-community differences in many chemical exposure statuses have been revealed; within-country difference appeared to be larger than between-country difference. A principal component analysis showed the effects of a subsistence transition may be different between sexes, which may have some biological background.

2) Ecological histories (subsistence transition) of 32 communities have been reconstructed and their diversity has been confirmed in a qualitative manner. Quantitative treatment of the information will be developed.

3) Feasibility of conducting exploratory analyses for urinary chemicals with SBSE-quantitative database was demonstrated. Further analyses using these methods are expected to reveal the scenario connecting subsistence transition (marketerization) with chemical burdens.

(2) Significance for global environmental policy

We have constructed a database that covered over 5500 individuals from 6 Asia-pacific nations. The database included the exposure levels to 500 man-made chemicals and heavy metals, as well as basic health indicators such as blood pressure and Hb. It will provide the basis for the policy making regarding the mitigation of environmental and health impacts due to subsistence transformation.

We are also making effort to construct a network of researchers; so far we have been collaborating with over 30 researchers in the counterpart countries. Further effort will be made to

enlarge and strengthen the network through which the output of this project could have impact on the environmental policies of the target countries/areas.

Major Publications

1) Jiang, H.W., Umezaki, M., and Ohtsuka, R. (2006) Inter-household variation in acceptance of cash cropping and its effects on labor and dietary patterns: a study in a Li hamlet in Hainan Island, China. Anthropological Science, 114: 165-173.
2) Nishitani, M. (2007), The Birth of Markets and Urbanization, Bulletin of The National Museum of Japanese History, Vol. 136,267-333 (in Japanese).
3) Nishitani, M. (2007) Diversity in Wet Rice Cultivation Seen from Irrigation System, Bulletin of The National Museum of Japanese History, Vol. 136, 335-378 (in Japanese).
4) Nishitani, M. (2008), Land Use and Diversity in Wet Rice Cultivation as Seen in Terraced Field, Bulletin of The National Museum of Japanese History, Vol. 139, 53-98 (in Japanese).
5) Sekiyama, M., Tanaka M., Gunawan B., Abdoellah O., and Watanabe C. (2008), Pesticide Usage and Its Association with Health Symptoms among Farmers in Rural Villages in West Java, Indonesia. Environmental Sciences 14, 23-34.
6) Hirano, M., Kitamura, K., Kato, I., Yanaihara, C., Iwamoto, K., Sekiyama, M., Watanabe, C., Nakamoto, T., Miyamoto, N., Onishi, Y. and Arizono, K.(2007), Development of enzyme immunoassay for detection of DDT. J. Environ. Sci. Health Par.t A., 43: 44-49.
7) Parajuli R.P., Umezaki M, and Watanabe C. (2008) Behavioral and nutritional factors and geohelminth infection among two ethnic groups in the Terai region, Nepal. American Journal of Human Biology 21: 98-104.