Interdisciplinary Water and Sanitation Project in Burkina Faso

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Abstract

Interdisciplinary project on water and sanitation was performed in Burkina Faso from 2010 to 2015. The title of the project was "Development of sustainable water and sanitation systems in the African Sahel region", and the project was supported by SATREPS (JST and JICA) and collaborated with International Institute of Water and Sanitation (2iE). The main purpose of the project was to develop and demonstrate the new system of water and sanitation based on the concept of "do not mix" and "do not collect" water and wastewater. In the project, we have proposed the following concept that the water and sanitation system is not a technical system, but it is characterized comprehensive system which includes functions for institutional design, finances and human resources development. The project proposed several element technologies for sanitation which includes composting toilet; gray water reclamation unit; urine recovery unit; and agricultural technologies for effective uses of compost and urine and salt management of soil. The project also proposed the business model for installation of the system. New water and sanitation system tried in Burkina Faso will be an adequate system not only for the developing countries, and the proposed system might be considered to indicate the future direction of water and sanitation system.

Keywords:Sanitation; value chain; business model; urine; feces; gray water

Introduction

The United Nations reported that the world population in 2050 will reach to 9.7 billion. Food production to support this population has already become a global discussion. But the discussion on how to treat solid and liquid waste from human from this population is not active, in spite of such fact that 36% of people do not have a proper sanitation in 2012 (World Health Organization and UNICEF 2014).

It is well recognized that "Sanitation" is the hygienic means of promoting health as well as treatment and proposal of human waste which includes human excreta, solid waste, greywater, and sanitation is one of the important factor to control material flow and resource management. This study categorizes sanitation systems into following three generations; the Primitive, the Modern, and the Postmodern Sanitation (Ushijima et al. 2014). The system which relies on only natural purification and natural material cycle system is categorized into the Primitive Sanitation, such as open defecation. The next generation, the Modern Sanitation, is defined as the sanitation purposing safe separation and disposal of human waste from human living environment. Urbanization and modernization made people difficult to continue the Primitive Sanitation. MDGs is directed to a transition from the Primitive to the Modern sanitation. However, there is a case where it is difficult to change sanitation from Primitive to Modern in developing countries, because the Modern Sanitation requires overall ability of policy, financial, legal, institutional design and technology of national and local governments as the implementing body. On the other hand, in developed countries, including Japan, the following question has been beginning to be discussed: Can we support the current sanitation infrastructure (the Modern Sanitation) in the future low economic growth and depopulating society?

The authors have organized the interdisciplinary research team and conducted a joint research project in Burkina Faso (see Figure 1), West Africa which title was "Development of sustainable water and sanitation systems in the African Sahel region." This project was supported by SATREPS and collaborated with Internal Institute of Water and Environment (2iE). The project was the international collaboration project with 2iE and its aim was to develop and demonstrate the new system development of water and sanitation based on the concept of "do not mix" and "do not collect" water and wastewater. The Burkina Faso is a country located in Sahel region where the influence of global climate change is visible and the poverty index is very high. And the project also aimed to develop the joint research center on water and sanitation in West Africa with human resources through the joint research. In this contribution, a part of the research results and the concept of this project are introduced.

Figure 1. Burkina Faso.

1. Interdisciplinary approach is essential in water and sanitation study

In Japan, the population that use the so-called centralized sanitation is about 79.7% in the 2013 fiscal year (Ministry of Land, Infrastructure and Transport 2015). The centralized sanitation is a system with sewer pipe network and treatment plant for collecting and treating wastewater (human waste is also included). The remaining 21.7% of the people are using so-called decentralized sanitation (Jokaso about 8.9% and vault toilet about 11.4%). In order to explain that sanitation is not just engineering system, the Jokaso and vault toilet are picked up here as an example. And the interdisciplinary of sanitation is outlined by using this example and the reason why the decentralized sanitation in Japan is working well is discussed.

Jokaso is a waste water treatment apparatus installed in each home. This apparatus does not function well only be installed, but it requires a mechanism to recover the sludge generated by processing the waste water. In other words, collection of sludge by vacuum car and treatment facilities for processing the collected sludge are required. Further, it is also necessary to maintain the quality of the effluent from Jokaso so as to satisfy the effluent quality criterion. In addition, in the vault toilet system, the collection and transport system and treatment facilities for collected human waste are required. These requirements are summarized as such related stakeholders related to decentralized sanitation system as users of toiler and/or Jokaso; group for maintaining Jokaso; group for collection and transport of sludge and human excreta; group for operating treatment facility. In many cases, the collection industry and septic tank maintenance industry is a private enterprise, management and operation management of human waste treatment facilities are making organized around the local government. In addition, in the case of Jokaso there is a mechanism that municipalities install Jokaso. Local government becomes the operating body, set up Jokaso on personal grounds and operates it.

This mechanism is also characterized from the flow of money. There is a policy to promote the installation of Jokaso by financial system, this is called as "municipalities installation type Jokaso". In this financial system, the user of Jokaso is asked to pay only ten percent of the cost of Jokaso, and the rest of the initial cost is covered by national and local government. The maintenance of Jokaso is also supported by local government. Local government make a contract with maintenance company and user of Jokaso will pay the cost of maintenance to local government as a "Tariff". Operation of treatment facilities of sludge and human waste are managed also by local government. In some cases, more than one local government form te part-affairs associations and these association have a responsibility of operation and maintenance of treatment facility. In addition, technical standards for Jokaso have been set, and qualification system of technicians involved in maintenance has also been developed.

In this way, sanitation is not just a technical system, but it is characterized as a comprehensive system that includes functions for institutional design, policy, finances and human resources development. Therefore, there is a necessity to study for sanitation is interdisciplinary.

In addition, in Japan through the 1970s from the 1950s, national government set the policy that the system with the vault toilet + collection + treatment facility should be installed first and government supported this policy by financial support. This policy was easily accepted by people because people had a tradition to recognize human excreta as an agricultural resource (fertilizer).

Currently in Japan, sanitation including the sewerage system and decentralized system has been widely recognized as a "public service". In other words, sanitation in Japan is carried out based on the following conditions: (1) local government is main player of the system and has a responsibility of sanitation; (2) local governments has enough creditworthiness for the initial investment and has a governance capacity. In addition, user does not recognize the benefits from sanitation as "prevention of disease, reduction of health care costs, environmental protection", although these benefits are evaluated in monetary sense. But even in such situations, user pays the cost of sanitation without any doubt. Therefore, the attitude of people to human excreta should be considered in the discussion on sanitation system.

2. New approach proposed by SATREPS project: Agro-Sanitation and its concept

2.1. Current situation of Burkina Faso

First, current state of sanitation in Burkina Faso is summarized briefly. Poverty is as important as other Sub-Saharan countries in Burkina Faso. The population who is less than the poverty level is up 43.9 percent in 2009. (National Institute of Statistics and Demography Burkina Faso 2010). Although the main industry of Burkina Faso is agriculture, its productivity is low, and it has received the damage of drought caused by global warming. In particular, a decrease in vegetable production, decrease of forest, and the erosion of soil are significant. According to the statistics of 2010, the 74% of the soil has received the adverse effect, and it has dropped a big shadow on food production (Mortimore 2010:134-143; Ministry of the economy and finances Burkina Faso 2011).

In addition, due to the lack of sanitation, pollution of water resources is also a major problem. According to the 2010 data (Ministry of agriculture and the hydraulics Burkina Faso, 2010), the coverage rate remains at 3.1 percent, against 14 percent in urban areas, and only 1% in rural areas. Lack of sanitation facilities is also causing the problem of public health, and water-based disease such as diarrhea accounted for 17% of under 5-year-old mortality rate (World Health Organization and UNICEF 2005).

2.2. Approach used in SATREPS project

Therefore, in this study, for the purpose of escape from the poverty cycle in Burkina Faso of the rural areas, it was conceived cooperation between sanitation and agriculture, such as shown in Figure 2 (Agro-Sanitation). In other words, (1) the introduction of sanitation system improve the health status of people; (2) the sanitation system provide agricultural resources (fertilizers and irrigation water and contributes to increasing the agricultural production and promoting the increase of revenue; (3) also, food production also contributes to the improvement of the nutritional status of people.

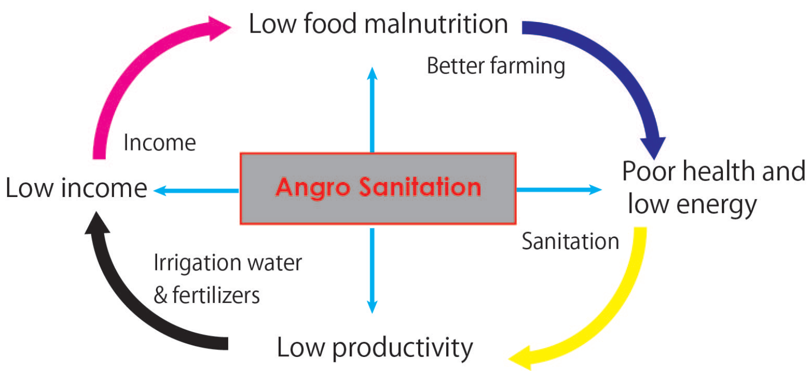

Figure 2. Agro-Sanitation and the cycle of poverty.

Then, when the introduction of sanitation in rural areas of West Africa Burkina Faso, it is determined that it is difficult to introduce the same kind of mechanism as Japan.

One of the reasons is that there is not enough system to support sanitation system in Burkina Faso. In other words, the financial capacity of local governments and human resources are not sufficient, and it may be difficult to foster the groups which support sanitation system.

The second reason is related to the issue on the values of people to the sanitation system. In Japan, the sanitation system is well recognized as an important system for protecting public health and conservation of environment, and user is willing to pay tariff and sharing the cost. In fact, the mechanism of sanitation is reducing medical costs of the society. On the other hand, in the rural areas of Burkina Faso, as described above, it has been delayed installation of sanitation. This may reflect the values of people who set lower priority to sanitation than other things. Therefore, it is decided that the installation model used in Japan is not applicable to rural area in Burkina Faso.

Therefore, in this project the following such a strategy (introduction model that takes into account the population of the value chain (Funamizu 2013) were investigated. That is, it was examined whether it is possible to incorporate sanitation systems in residents value chain.

First, the material (Nitrogen, Phosphorous, water) flow of farmers' life is analyzed, and the results showed that (Ushijima 2013): 1) the amount of water used in the living system is comparable to the amount of water required for small vegetable garden; 2) nitrogen and phosphorus that has been discarded as human waste is comparable to phosphorus and nitrogen amount required for the small garden; 3) arable area is constrained by the amount water available. Then, the analysis of value chain of people showed that composting of feces, use of urine as a liquid fertilizer and re-use of treated gray water as irrigation water was to increase the cash income of people and this could be an incentive for the introduction of sanitation.

In other words, the possibility of integrally designed sanitation and agriculture has been shown. And, we determined the following items as basic idea of this Agro-Sanitation:

- Recognize gray water and black water as a personal property
- Treat black and gray water to improve their value
- Use reclaimed black and gray water as an agricultural resources
- Recognize the Sanitation System as an "agro-sanitation asset" which provide income to users
- Create micro-finance system for supporting this model
- Develop the hard ware to fulfill the possible loan supported by the income from human excreta.

Figure 3 is showing the structure of the Agro-Sanitation. In the system, feces, urine and gray water are separated at the source ("Don't mix") and they are reclaimed at source respectively ("Don't collect") and used as agricultural resources. Element technologies supporting the present system are (1) recycling of feces: compost toilet, (2)recycling of urine: retention of urine and disinfection unit; (3) Reclamation of the gray water: slanted soil system; (4) agricultural technology for efficient use of recovered resources. In other words, feces is composted by compost toilet and used as a soil conditioner. Urine is stored and used directly as a liquid fertilizer after disinfection by solar heat. Gray water from bathing and washing closes and dishes are reclaimed by the slanted soil system and used as irrigation water. It should be noted that, since the electrical supply is not available in the rural areas of Burkina Faso, the use of electricity is not assumed. And since there is no water supply facilities, the amount of water available per capita per day was about 20L (field survey by the result).

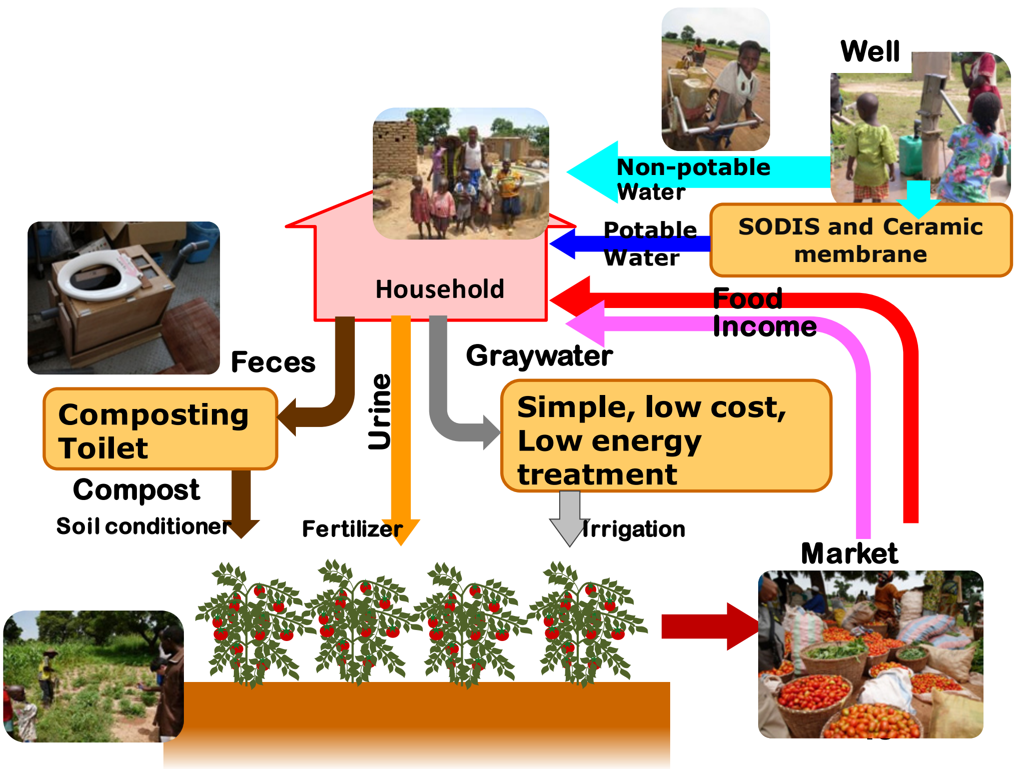

Figure 3. Schematic description of Agro-Sanitation. (Adopt from Funamizu(2015). Photos by Ushijima)

2.3 Research structure of SATREPS project

Research strategy for development and demonstration of this Agro-Sanitation were prepared as shown in Figure 4. The strategy included (1) Proposal of the model for installation; (2) Development of engineering technology; (3) agriculture technology; and (4) pilot study at four villages.

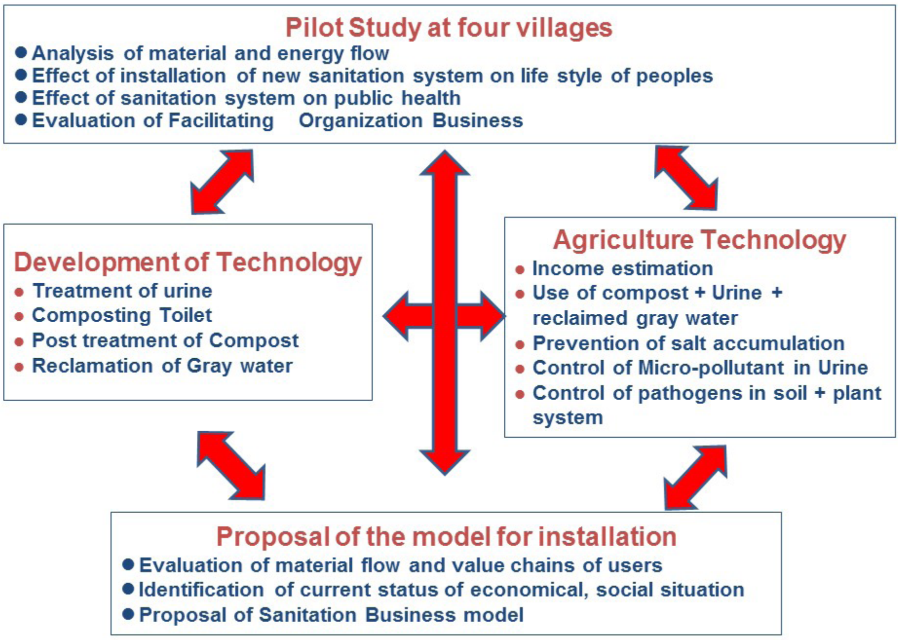

Figure 4. Structure of project.

The demonstration sites were Kamboinse village (Mossi) near Ougadougou, capital city of Burkina Faso; Barkonba village (Fulani) near Ziniare; and Kologondejess village (Mossi) as well as village which is suburb of Bobo-Dioukasso. The toilet room was constructed in each pilot family and composting type toilet was installed in it. And the urinary was installed in the water bathed place. This construction adapted the such life style of people that they urinate at the water bathed place and defecate at farmland. In order to recover the drainage after bathed water, the floor with waterproof mortar was installed at bathing place and treatment unit for gray water was set next to the bathing place

In the study of the model for installation of sanitation units, analysis of the economic, social and educational situation of farmer were performed as well as the analysis of material flow and value chain, and then a business model for installation was proposed. The development of engineering technology was related to resources recovery technology from feces, urine and gray water. The composting technology of feces have been developed by authors (Lopez Zavala et al. 2004; Hotta and Funamizu 2007: 3412-3414; Ito et al. 2006; Hotta and Funamizu 2009) and the design principles have been also proposed (Lopez Zavala 2006). In the project, based on the above mentioned technical experiences, the structure of toilet and toilet room were developed by obtaining several feedbacks from users. In addition, the fate of parasite eggs, protozoa and pathogenic bacteria and virus were monitored and the health risk assessment was performed. Urine was stored in the plastic tank through a urinal which was installed in the bathing place. Stored urine was then transferred to a plastic bottle and set on the roof of toilet room. By this operation, urine was disinfected by solar heat.

Gray water was reclaimed by slanted soil treatment unit. Gray water just flows down in soil layer of this slanted soil treatment by using gravity force. Since this unit does not require any energy supply like electricity nor special character soil, the unit is sdequte for de-centralized system (Ushijima et al. 2013a).

2.4 Agriculture technology

The purpose of the study on agricultural technology development is to consider the following matters: (1) how to use recovered compost, urine and irrigation water in agriculture; (2) how sanitation can contribute to increase income through supplying agriculture resources. Also, in general, in the re-use of human waste and wastewater micro-pollutants such as pharmaceuticals should avoid to enter the circulation of the material recycling loop. Therefore, we added the following topic in the research: (3) study of the fate of malaria pharmaceuticals in soil drugs associated with use of compost and urine.

(1) How to use the recovered compost and urine

In the semi-arid regions such as Burkina Faso, salinity management associated with the use of compost, urine is important as agricultural technology. That is, in the semi-arid regions, because the water evaporation amount is larger than the rainfall, salts in irrigation water, urine and compost may be gradually accumulated in the soil. This accumulated salt may cause the adverse effect on crop. For this reason, the study of the relationship between the rate of compost, urine application and salt accumulation in soil was important.

According to the studies by the greenhouse (Sene et al, 2013), 1) in the case of continued about excess urine fertilization three times also, inhibitory effect on crop growth was not observed; 2) if urine is applied based on proper Nitrogen amount based on the fertilizing criteria, about 50% of applied salts was absorbed by the plant. These results as well as vegetable cultivation results in the demonstration experiment site gave the following urine application method (Funamizu 2015):

- Since urine has high Nitrogen supply capacity, but low capacity of phosphorous, it is effective to use urine with compost which has high phosphorous supply capacity;
- It is effective to set the amount of urine in accordance with the nitrogen requirements of the crop;
- It is better to fertilize urine divided into several times.

Also, in order to obtain the adequate water management method that takes into account the salt accumulation in the soil, two methods were compared: the salt removal by rinse by rain fall (rising method) and high salt absorption effect crops from the soil (cleaning crop method). As a result, salt cleaning effect due to rainfall was higher than the cleaning crop method, and also adequate amount of urine for avoiding salt accumulation in soil. Further, as a method for enhancing the salt cleaning effect due to rainfall, calcium salt addition method was also examined and the result showed that the calcium salt addition method could mitigate the adverse effect caused by excess amount of urine application.

Status of the field is shown in Figure 5 which was taken in January 2013.This time was the dry season and it was not raining since October 2012. Therefore, usually no vegetable production was possible in this season, but in the pilot family, they were able to grow okra as shown in the photograph. Such a combination of agriculture and sanitation system was an important part of this project.

(2) Fate of malaria medicines in the soil (Funamizu 2015)

Anti-malarial drugs are used in Burkina Faso. Some of the drugs are discharged in the urine, and this means that the anti-malarial drugs may enter into farmland. Therefore, the fate of malaria medicines in soil-plant system was examined. The experimental results showed that chloroquine, quinine, pyrimethamine, sulfur ferredoxin was higher degradable in the soil, doxycycline, artesunate, mefloquine, lumefantrine was poor degradable in the soil. Among pharmaceuticals showing low degradablity in the soil, doxycycline, artesunate and mefloquine

Figure 5. Farm land having our sanitation system where cultivation was possible even in dry season.
(photos by Hijikata)

transition to plants was detected, but lumefantrine was not detected. The transition of pharmaceuticals having low degradability from soil to plant is reported, but the fate of pharmaceutical having high degradability such as lumefantrine is not well-examined. One of the possible reasons why lumefantrine did not move to plant may be hydrophobic nature of lumefantrine and adsorption or adsorption to the roots and/or the soil surface prevent the movement of it. It is necessary to further verification. Moreover, the similar degradable test with disinfected soil showed the significant decrease of degradation of pharmaceuticals. But the addition of compost to disinfected soil promoted the degradation. These results implied biological degradation of anti-malarial.

(3) Income estimation of installation of sanitation facilities (Funamizu 2015)

In the Agro-Sanitation where sanitation and agriculture are integrated, the value of the resources (fertilizers and irrigation water), which is collected by sanitation, can be evaluated as additional income of sanitation facility users. Cultivation possible area was estimated by using the following results: Interviews on daily use of water in rural area (Ziniare suburbs); FAO estimation method for required irrigation water; recovery amount of Nitrogen and Phosphorous from feces and urine. In addition, the model for comprehensive crop rotation model was also proposed based on the survey results on vegetable distribution system in the region; farming schedule; and climate condition. Then the income of farmers (user) was estimated from agricultural products. The results gave the following findings:

- In the dry season, gray water produced from one person will give 2.3-4.4 m^2 of cultivation possible area in Zineare suburbs, and 2.9-6.9 m^2 in Bobo suburbs. This means that, assuming a family with six members, one family can cultivate 14-26 m^2 of farmland in Zinare and 17-41 m^2 in Bobo by gray water from bathing place in the dry season.
- Considering the yield obtained pilot farmland and the data on vegetable trading price in the market, the proposed crop rotation model with sanitation facilities will produce about 23 € /capita in Ziniare and 33 € /capita in Bobo. Assuming 6 persons per family, the value of sanitation facilities is estimated as 140 € in Ziniare suburbs and about 200 € in Bobo suburbs. The added value to the entire value chain is estimated to be about 250 € per family in Ziniare and to be about 300 € in Bobo suburbs.

Summary

The sanitation system proposed at the SATREPS project was introduced in this article. SATREPS project carried out in West Africa Burkina Faso was collaborative research project. The proposal of a new sanitation system that includes the business model for installation, which is a joint research achievements, will give the opportunity of a paradigm shift both for regional planners of social infrastructure facility and for the international donor. In addition, the proposal indicates the direction of the future of the sanitation system.

New sanitation system that was tried in Burkina Faso is adequate not only for the developing world without infrastructures such as electricity and water, but also for developed world. In other words, the idea that has been proposed by author provides the direction of the future development of the sanitation system which includes the construction of “resource-recycling society” and “low-carbon society”. Burkina Faso is one of the countries that can be carried out the introduction of the world's state-of-the-art system because many of the infrastructure are in the development or planning stage. This trial is a new initiative that was ahead of the rest of the world.

The reasons why the proposed system is considered to indicate the future direction are summarized from a variety of point of view as follows (Funamizu 2012, 2013):

a) The world economy

It has already been recognized that to install a sewer pipe all over the world is far beyond the economic level of the whole world and that sewerage system is not a solution for the corresponding of the sanitation problem. Also, in Japan, where aged and depopulated society is coming, it is recognized that Japanese economy can’t meet the demand of rehabilitation of sewerage infrastructure especially for small and medium-sized municipalities. The mechanism of the new sanitation is needed. In particular, in Japan about 70% of the initial construction costs of sewerage system are used for sewer pipes. Moreover, it is unclear that ensuring maintenance costs of sewerage system (maintenance costs especially pipe) is capable future. That is, the system which does not require a pipe is required.

b) The sustainable water cycle

The current water use system (the water intake upstream of the basin, after the water distribution, water use and collection of wastewater, discharge of the treated water to the downstream) is considered to distort the water cycle structure of the region. In addition, in the low shallow groundwater level areas, leaks from the sewer occur, and sewer pipe has become a soil contamination source. On the contrary, in the underground water level is high region, there is a case where groundwater is penetrating into sewer pipes and the total amount of wastewater to be treated is increasing. The system without pipe, “Not collected” system is required.

c) Water resources management

In urban areas, only a small part of high quality of tap water is used for potable purpose, and most of it is used in toilet cleaning and watering. Namely, substantial amount of drinkable water are used for just transporting pollutants to wastewater treatment plant. The region, where drinkable tap water can be used such just to transport the polluted materials such as feces, is very limited. The sanitation system without using water, “Don’t collect system”, is needed.

d) Management and re-use of nutrients

Among the nutrients (phosphorus and nitrogen), which are a fertilizer component, phosphorus is a limited resource and the recovery of phosphorus has been demanded. In addition, in the contrary, phosphorus and nitrogen in the waste water are causing eutrophication in lakes. The recovery of fertilizer element and re-use them at agriculture is urgent issue. However, because wastewater also simultaneously contains harmful components as well as useful components, it is not easy to reuse them effectively.

Among wastewater from several appliances, wastewater from toilet (black water) contains about 44% in organic matter, about 97% in the ammonia nitrogen, accounts for about 80% phosphorus. This means that separation of black water makes nutrient recovery easier. Namely, Separation and treatment of black and gray water at source, "Don't mix" and "Don't collect" system is desired.

e) Treatment technology

In order to construct the new sanitation system, it is necessary to consider what should be treated and how the waste water treated from its occurrence form. The following principle of water treatment is well-known, "The wastewater with simple constituent gives simple treatment process. It is easier to treat wastewater from a single source than from waste

water consisting of a variety of sources." This principle gives the opportunity for re-considering and re-constructing new treatment system both for developing and developed world.

f) Culture related to water

Water use pattern and the way how people relate to water have been developed as a unique culture in each region. And, the norm to human waste is also closely related to the religion and culture. Current status of the sewer system is uniform in structure and concept and there are no big differences among countries. This is not said to be sustainable, there is a need for a variety of systems. The concept that "Do not mix", "Don't collected" offers the possibility of a variety of system.

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