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Actions for Preserving the Quality of Drainage Water and its Reuse Based on Community Resident Initiatives in Rural Areas of Egypt

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Abstract

Due to growing water demand in Egypt, the reuse of drainage water for irrigation purposes has become an important policy issue, while the pollution of drainage water interferes with such reuse. To prevent water pollution in rural areas, the processing of household garbage and domestic wastewater is important. However, rural areas are not considered under government policies. To preserve the quality of water in drainage canals, we initiated activities conducted by local residents to prevent the dumping of garbage and to construct wastewater treatment facilities. As a result of these activities, a garbage collection system and wastewater treatment facilities were developed under an operation and management system run by the residents. Thus, utilizing the power of community residents is one solution to water quality problems in rural areas.

Discipline: Irrigation, drainage and reclamation
Additional key words: consensus building, rural sewage, technical cooperation, water pollution, workshop

Introduction

The Egyptian government (hereinafter "the government") continues to promote the expansion of farmland into desert areas to increase food production and job opportunities. Egypt's Ministry of Water Resources and Irrigation (MWRI 2005) reports that the country's farmland is expected to grow from 3.3 million ha as of 1997 to 4.5 million ha by 2017. The amount of water available from the Nile River is restricted to 55.5 billion m^3 per year by the 1959 bilateral agreement with the Republic of Sudan. Therefore, water resources must be developed by improving the efficiency of existing agricultural water use that consumes more than 80% of the available water resources.

In 2005, the government enacted a "National Water Resource Plan 2017 (NWRP)" to focus on the development of new water resources through the introduction of modern irrigation technology, including the reform of irrigation facilities and improvement of operation/maintenance activities by establishing and developing water users' associations, and the reuse of drainage water for irrigation. Under the NWRP, the reuse of drainage water must increase from 3.5 billion m^3 per year in 1997 to 8.9 billion m^3 per year by 2017 (MWRI 2005).

In Egypt, irrigation and drainage canals are completely separate, and drainage water is discharged into the sea without being reused as irrigation water. Where there is an insufficient amount of irrigation water, drainage water is mixed in and used for irrigation purposes. The government reports the standards for reusing drainage water in Article 65 of Law 48 (1982). These standards include Biochemical Oxygen Demand (BOD) of 10 or less, Chemical Oxygen Demand (COD) of 15 or less and Dissolved Oxygen (DO) of 5 or more. The Japan International Cooperation Agency (JICA 2011) reported the results of an investigation conducted by the government on BOD and DO in drainage water in the Nile Delta—an area experiencing one of the most serious water shortages. This study was carried out between 2006 and 2007, and the reference values were not met for all 22 sites investigated.

The government normally gives permission for

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drainage water reuse if it is mixed with irrigation water at a constant rate, as a practical solution in areas where irrigation water is insufficient (JICA 2011). In this situation, the standards of Article 65 are ignored.

However, water pollution caused by the mixing of drainage water has become serious and hinders its reuse for irrigation. According to JICA (2011), some pumping was discontinued because the drainage water became too contaminated, even though pumps were installed for reusing drainage water.

In rural areas of Egypt, garbage problems are also serious issues. Household garbage is dumped into canals not only near residential areas but also in other areas. The garbage left in the waterway causes contamination and clogs the flow of water. Raw sewage (or human waste) is commonly carried away by vacuum trucks. The monthly cost for this process is 20-50 Egyptian pounds (LE) (1 LE = approx. 15 yen in 2015) per household. This cost is substantial for rural residents with low monthly incomes less than 1,000 LE. Therefore, raw sewage is sometimes directly released into drainage canals, and most other domestic wastewater is directly discharged into the drainage canal (Shindo and Yamamoto 2015). The Ministry of Housing has developed a plan for sewage treatment facilities in cities or areas with populations greater than 8,000. However, sewage treatment planning in rural areas has not been developed. This can be considered a problem in the policies. The lack of irrigation water is becoming more serious each year, so purification measures for drainage water are now an urgent issue.

Purpose and methods of the study

1. Purpose of the study

While the reuse of drainage water is one strategy of the water resources policy in NWRP, concrete measures yet to be determined. Past research (e.g. JICA 2010, 2011) and our observations show that the major sources of pollution are household garbage and the inflow of domestic sewage (Figs. 1 and 2). Since garbage disposal and sewage treatment in rural areas are not targets of the policy, the methods or activities that the resident themselves can undertake should be considered. Therefore, this study is intended to maintain the water environment through the support of local residents in rural areas of Egypt, and to clarify the possibilities and applicable conditions for the reuse of drainage water.

2. Sources of pollution

JICA (2011) conducted a survey on the sources of wastewater in 2010 in the Nile Delta region. Fig. 3 shows the survey results. All governorates, except Damietta, an urbanized governorate, in this figure cover the majority of rural areas in the Delta. According to the survey, drainage from rural households has become the largest source of pollution, accounting for nearly 30% of the BOD loading of rivers and streams.

As described above, such rural drainage contamination is not only due to the policies but is also affected by the attitudes and consciousness of the residents.

Fig. 1. Residents dumping garbage into a drainage canal (Nile Delta)

Fig. 2. Drainage water polluted by an inflow of domestic sewage (Sinnoris pilot site)

3. Rural sewage treatment systems in Japan

Rural household wastewater has become a major cause of pollution, so we can take advantage of the experience gained from rural sewage treatment systems in Japan.

In Japan, water pollution in rural areas became serious in the 1970s and 1980s, so Japan's Ministry of Agriculture, Forestry, and Fisheries (MAFF) began improvements of rural water quality through the Rural Sewage Project (RSP) initiated in 1983. The RSP targeted rural villages with a population of about 1,000 people and installed small-scale sewage facilities to circulate or reuse treated wastewater (Japan Association of Rural Solutions for Environmental Conservation and Resource Recycling (JARUS), 1989)). According to MAFF officials, about 5,100 villages with a total population of approximately 3.35 million have installed small-scale sewage facilities with the assistance of the RSP as of the end of fiscal year 2014. In 2013, the amount of treated water totaled almost 340 million m^3 and the amount of water reused downstream was estimated at 270 million m^3 (79% of the total treated wastewater).

Notably in rural areas of Japan, many local residents have joined in the maintenance of regional facilities through such activities as cleaning roads and removing silt from waterways. Although the actual construction work is carried out with financial support by both national and local governments, the RSP has also begun initiatives to encourage local residents to share in the operation and maintenance of facilities, including the cost of repairs. Good practices for maintaining the rural environment with the participation of local residents may also be applied in the rural areas of developing countries that face water pollution problems.

4. Methods for study

In reference to activities in Japan, similar methods were attempted through local residential initiatives in rural areas of Egypt, while considering the possibility of reusing drainage water.

Our action plan was based on consensus building by the residents. Originally, we planned to carry out activities in the "Old Land" (farmland used a long time for agriculture) in the Delta region where water shortages are the most serious, but water conflicts frequently occurred, making it impossible to perform sufficient activities necessary for the study. Therefore, we decided to conduct the study in the following agricultural areas outside the Delta: 1) Rash El Gharbi pilot site (El Behera Governorate); the "New Land" (newly reclaimed farmland in the desert) in the West Delta; 2) Sinnoris pilot site (Fayoum Governorate); and 3) Beni Ebeit pilot site (Minia Governorate), both being Old Land and located upstream of the Delta region, where similar problems such as water shortages and water pollution have occurred in agricultural areas. Fig. 4 shows the locations of the three pilot sites.

The dumping of garbage and inflow of sewage occurs not only in drainage canals but also in irrigation canals. The best way to improve water quality is to remove the source of pollution because purifying polluted water is very costly. In order to cut costs, it is vital to educate local residents on the impacts of throwing garbage into and separating sewage from the canals. The towns and villages are outside the sewer policy targets of the government, and these residents need to solve the domestic drainage problems by themselves.

To encourage local residents to proactively participate in activities to improve water resources, as well as raise awareness, the motivation for participation needs to be increased. In a prior study, the motivation to

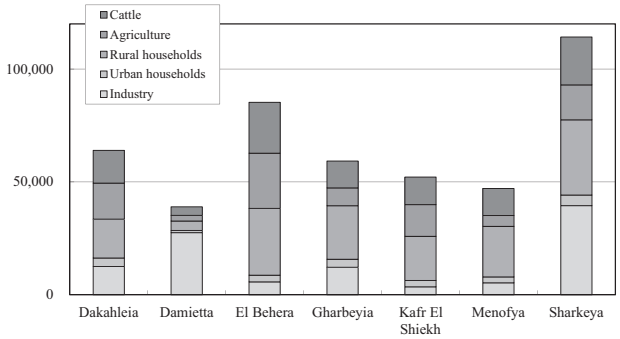

Fig. 3. Sources of BOD loading in governorates of the Nile Delta

Fig. 4. Locations of the pilot sites

participate was achieved by holding workshops for the stakeholders, which also strengthened the water users' organizations in Egypt (Shindo and Yamamoto 2012). At workshops, participants shared their problems, discussed possible solutions, and created a plan for activities. Since these workshops encourage local residents to share their problems and come up with solutions, it created initiatives among local residents. In this paper, the stakeholders are direct water users, and the irrigation/drainage facilities administrators include farmers, members of water user associations, and relevant government engineers.

A series of activities were carried out as part of the "Water Management Improvement Project Phase 2 (WMIP2)" of JICA.

Results

1. Procedures for activities

To improve the quality of drainage water, a workshop was held as called for by the project staff, and a total of 30-40 participants attended, including stakeholders and local residents. The following activities were carried out: 1) participants analyzed the causes of household garbage being discarded into waterways; 2) possible solutions were discussed; 3) representatives of the stakeholders and residents created an action plan based on the results of discussions; and 4) the plan was put into action after obtaining the consent of the residents. The Project Cycle Management (PCM) methods developed by the Foundation for Advanced Studies on International Development (2004) were used to conduct root cause analysis and create action plans. The details of these activities are described below.

2. Garbage collection and disposal systems built in collaboration with local residents

At the Rash El Gharbi pilot site, deteriorated water quality was deemed a serious problem as related to water shortages when irrigation and water problems were analyzed by the participants.

The workshop participants understood one reason for deteriorated water quality was that the regional garbage collection and disposal system was out of commission due to a lack of funding from local governments. Residents of Shagaa village in the Rash El Gharbi pilot site were dumping garbage, which included vegetable scraps and plastic trash, into the irrigation and drainage canals on a daily basis.

The reasons for dumping garbage into the waterways included: 1) no place to dispose of the garbage, and nonexistent processing methods (including the collection and disposal of garbage) due to a lack of financial resources from local governments who inherently should be responsible; and 2) residents dumping garbage in the waterways and expecting the national government to collect and remove the waste because the government owns the canals as public property and regularly maintains the canals. However, the "regular" maintenance of the waterways is only performed once or twice a year, which leaves waste in the waterways for long periods, thereby causing water pollution to become a serious problem.

Given these circumstances, we provided training for the residents, as a part of the project activities, to increase their understanding of environmental issues and urge the resident representatives to build a garbage processing system. By carrying out these activities at the initiative of the residents, sustainability can be increased.

In considering a sustainable system for the disposal of garbage by the residents, the workshop participants discussed and determined the following:

1)Reconstruction of a sustainable household garbage processing system

Although the residents know that discarding garbage in waterways is illegal, there was no other choice. Therefore, Non-Governmental Organizations (NGOs) working in the region should collect and transport the garbage. The expenses necessary would then be collected at a rate of 2 LE per month from each household. In addition, the NGOs would distribute garbage bags to each household and then each household should place garbage in the garbage bag and discard it at the collection point on a fixed day of every week.

2)Building an action plan that does not permit garbage to be disposed into waterways

The Branch Canal Water Users Association (BCWUA) set up trash boxes along roads running along the canals and collected garbage on a regular basis. Trees were also planted along the roads to maintain an aesthetic appearance.

3)Continuous dissemination of enlightenment activities related to water and the environment

A "Water Club" consisting of boys and girls from schools in the region was organized to carry out enlightenment activities related to the environment and water conservation.

Based on these three activities, the representatives of residents and the project staff decided to hold an enlightenment rally to remove garbage from the waterways and communicate the importance of conserving water quality. A series of activities known as the "Environment Campaign" was carried out on May 29, 2011. Following the enlightenment rally, most of the villagers participated in the garbage removal activity. Not

only was the garbage removed from the waterway areas as originally planned, but the cleaning extended to the village. After the campaign, the waterway and village continued to be maintained until subsequent visits in March 2012. After this time, local officials confirm that the village is still being properly maintained.

These sustainable activities were achieved by encouraging the initiative of residents through workshops and environment campaigns. Similar programs were conducted at the Beni Ebeit (Minia Governorate) and Sinnoris (Fayoum Governorate) pilot sites.

3. Installation of rural sewage treatment facilities

As previously mentioned, wastewater from rural households has become the most significant source of contamination for drainage water. Therefore, we tried to introduce small-scale sewage facilities to minimize the pollution as was done by the RSP in Japan. Construction sites were selected for the following: 1) villages with a population of less than 1,000 residents; 2) located at the WMIP2 pilot site and approved by the JICA project stakeholders; and 3) using funds collected from the beneficiaries to maintain the sewage facilities.

Shaeitan in the Sinnoris pilot site is a small village consisting of 120 houses and 750 inhabitants, located at the end of the branch canal. This village always faces shortages in irrigation water and uses drainage water mixed with irrigation water, even though the water quality is very low due to the dumping of garbage, the influx of raw sewage, and mixing with domestic wastewater.

As part of the project activities, the stakeholders and residents received training on environmental issues, and then analyzed the problems and discussed possible solutions at workshops using PCM methods. They reached the conclusion that in order to solve the water quality problems, not only must a garbage collection system be organized but also a domestic wastewater treatment facility must be established in the village.

Based on the recommendations of the project staff, the village representatives decided to construct small-scale sewage facilities using the Grant Assistance for Grassroots Human Security Projects provided by the Japanese government. In accordance with the Grant Assistance conditions, NGOs in the region should construct the sewage treatment facilities and government engineers should assist with technical support.

As part of our studies on the installation of sewage treatment facilities, we visited and analyzed one small sewage facility installed by the government with the assistance from a donor agency in Fayum Governorate. This facility included an aeration system and a disinfection system using chlorine before water discharge into the drainage canal. Measurements of the processed water quality showed that COD exceeded 100, and thus the sewage was not properly purified and processed. Problems in the operation and management of the facilities included: 1) insufficient aeration; 2) lack of sterilization with chemicals; and 3) improper scale of the facility for the existing population (JICA 2010). Aeration and disinfection systems did not function. Moreover, once the treated water is released into the drainage canal, the facility administrators are not responsible for securing the water quality, so they have little incentive to conduct sewage treatment.

An important point for the construction of rural sewage facilities is that local residents can manage the facilities on their own as is done in Japan. The rural sewage facilities built and operated by the NGO "Together Association" in the neighboring Beni Suef Governorate were successfully established. The benefits of these facilities included: 1) inexpensive operation and management costs because the facilities do not use chemical treatments; and 2) treated water that met the effluent standards. However, a drawback was 3) a rather long facility scale as a natural stone gravel floor and aquatic plants were used to purify the sewage. The Together Association's facilities purified more than 90% of the sewage BOD and COD so that the treated water met the effluent standards. The facilities also had a sufficient capacity. Fig. 5 shows a schematic outline of the facility adapted to Shaeitan village.

Based on the above, we determined the construction and maintenance of facilities as follows: 1) sewage treatment facilities and sewage mainline pipes can be constructed by the Together Association through financial cooperation; 2) operation and maintenance work can be done by the Mubarak Association, though the Together Association currently supports maintenance work; and 3) the housing and trunk sewer can be connected by the residents themselves. According to the Embassy of Japan in Egypt, the cost of grant aid required for constructing

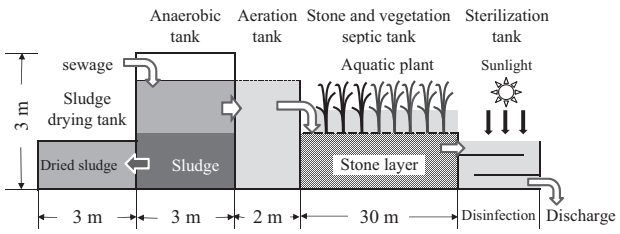

Fig. 5. Outline of a small sewage facility system

the sewage treatment facilities and the main pipeline is 107,580 US dollars (¥ 9,574,620 in Feb. 2012). The Together Association is an active NGO that targets the development of rural areas in Egypt with assistance from aid agencies. The Mubarak Association is an NGO engaged in activities rooted in local communities, such as operating a nursery in the Sinnoris region.

The main costs for maintaining a sewage facility are electricity and labor. The cost for each household was estimated to be 5 LE per month, but sewer connections for all residents take time, so 10 LE per month was decided to be collected, but this is still much lower than for the vacuum method, which costs an average of 30 LE per month. The sewage facility is economically advantageous for the residents. The land for the facility was donated by farmers who suffer from water shortages under the condition that they can use the water for irrigation after treatment.

A revolution in Egypt occurred in January 2011, so the adoption of Grassroots Grant Aid was postponed until February 2012. Although the construction period was extended due to difficulties with the procurement of materials amid the confusion in Egypt, the facility was completed in September 2014 with the cooperation of the residents. Fig. 6 shows the completed sewage treatment facility in Shaeitan village.

Two years after the sewage treatment facility was installed, we could not test the quality of the treated water because of worsening security concerns. However, the resident representative reported that the facilities are still working and being maintained by the NGO.

Fig. 6. Completed sewage treatment facility
(View from the anaerobic tank to the stone and vegetation septic tank)
Note: Photo by Embassy of Japan in Egypt

Discussion

1. Effectiveness of the workshop

We introduced two cases where residents and stakeholders built a consensus in a region through discussions at workshops, in order to resolve water quality problems.

Before we began the project activities, the government and local residents were engaged in conflict. In other words, the government accused the residents of throwing garbage and sewage into the waterways, while farmers and residents complained to the government about water shortages and water pollution. Under these circumstances, training and workshops for the project were provided, through which both parties shared an awareness of the issues, discussed possible solutions, and reached a decision to carry out the activities. Fig. 7 shows the processes of the activities in this study. According to the participants, this was the first time that stakeholders came together to discuss the problems, and can be evaluated as an opportunity for solving problems.

Initially, a JICA project was scheduled to disseminate knowledge in the training, but activities related to environmental campaigns or wastewater treatment were not planned due to the lack of a budget for running campaigns or constructing rural sewage facilities. Residents also hoped to solve the problems posed by waste disposal and water pollution. With shared recognition by workshop participants, specific activities

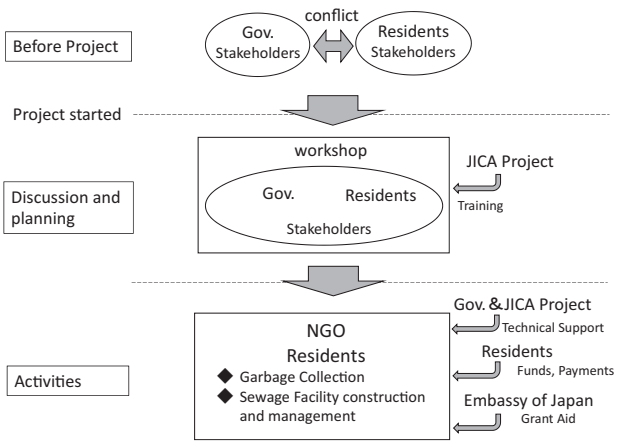

Fig. 7. Process of the activities in this study

were initiated.

We also undertook a series of activities at another site in the Delta region, but activities were not achieved. During a workshop and discussion of solutions, participants were unable to agree at the expense of the activities. Conflicts always occur between upstream and downstream farmers in branch canals during water shortages, so community leaders abandon arbitration. Discussing solutions in a workshop appears to be difficult when there is a serious conflict in the region.

2. Effectiveness of decision-making with a bottom-up process

Generally speaking, when advanced technology is introduced through technical cooperation programs in developing countries, dispatched experts train the major counterparts, and then the counterparts disseminate information to the targets in the community. This process of training is a top-down method. However, in this study, a bottom-up process with focus on residential initiatives was adopted. By educating the residents and stakeholders regarding the problems, a more sustainable process is achieved because the residents can continually provide solutions for future problems. Success was evident even after the revolutions of 2012 and 2013, and although the Japanese experts left due to the project being terminated, a series of sewage facilities have continued being constructed. This shows that the level of consciousness was increased among residents and stakeholders in the region.

On the other hand, if we try to apply the bottom-up approach in developing countries, we need to recognize that it takes time. In the case of the Rash El Gharbi pilot site, it took approximately two and one half years from starting the activities to carrying out an environmental campaign through various types of workshops and training sessions. Workshop methods must be approached with a sufficient time margin.

3. Proposal for small-scale dispersed sewage treatment systems in rural areas

If the efforts of rural sewage facility installation can be widely deployed in areas that lack irrigation water, we would like to propose the introduction of small-scale dispersed sewage treatment systems in rural areas of Egypt. By returning not only drainage water but also the treated water from sewage treatment facilities, the amount of water for irrigation purposes can be increased. Fig. 8 shows a placement image of these facilities. However, the length and placement of pipelines from houses to the sewage facility and from the sewage facility to irrigation canals may vary greatly with the terrain, houses and waterway arrangements, so the plan must be carefully considered for each area.

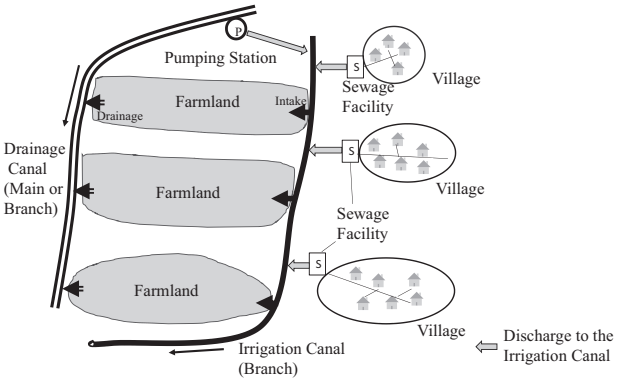

Fig. 8. Image of the reuse of drainage and sewage treated water in rural areas

Conclusion

Reusing drainage water is an important means of developing water resources if not previously utilized. This study created a method of removing two major factors of pollution by sharing common ideas and appealing to the incentives of local residents through workshops involving those residents and stakeholders. More specifically: 1) garbage disposal into irrigation and drainage canals can be prevented through consensus building among local residents by establishing a garbage collection system; and 2) the inflow of sewage can be prevented by targeting small rural villages that are not the subject of government policy, and constructing sewage treatment facilities managed with a fee collection system based on local resident initiatives.

A method of appealing to the incentive of residents is also necessary in order to bring attention to the following: 1) application is difficult amid severe internal conflicts; and 2) a certain period of time is required to increase the awareness of residents.

Not only in Egypt but in other developing countries as well, water quality improvements and the reuse of drainage water in rural areas have not been covered by Japanese international cooperation; therefore, the activities related to water quality revealed in this study should be adopted in other developing countries.

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