

# Water Policy Briefing

Issue 9

Putting research knowledge into action



## Confronting the realities of wastewater use in agriculture

Recent worldwide reviews of wastewater irrigation have demonstrated the contribution this widespread, and often unregulated, practice makes to the livelihoods of poor farmers in developing countries.

Policymakers and planners can maintain or increase the benefits of wastewater irrigation, while minimizing negative health and environmental impacts, by developing a realistic strategy for managing wastewater use—one based on an understanding of all the options available.

# Confronting the realities of wastewater use in agriculture

In urban and peri-urban zones in developing countries, poor farmers commonly use nutrient-rich sewage and wastewater to irrigate high-value crops. In many places, this untreated wastewater is their only source of irrigation water—so their livelihoods depend on it. But, as well as bringing benefits, the unregulated use of wastewater also poses risks to human health and the environment.

The prevailing “scientific” approach to wastewater irrigation advocates treatment before use and the implementation of strict regulations. But many developing countries can’t afford to build treatment facilities and do not have the resources to enforce regulations. There are other options, as IWMI research in Mexico and Pakistan demonstrates.

Well-crafted policies on wastewater use have the potential to improve the incomes of poor urban and peri-urban farmers and reduce pollution of lakes, streams and aquifers. Continuing to turn a blind eye to wastewater use can result in higher incidences of disease among farmers and consumers and in irreversible degradation of the environment. Policymakers need to develop comprehensive strategies for managing wastewater tailored to local socioeconomic and environmental conditions and for analysis of the short- and long-term risks and benefits of all available options.

## Wastewater use benefits farmers

In areas where freshwater is scarce, wastewater allows low-income farmers to produce crops they would otherwise not be able to grow. Plus, wastewater production is continuous, making it a reliable and demand-based source of water that is available to farmers whenever they need it (unlike canal irrigation).

Being sure of their water supply, even in the dry season, means that farmers can grow high-value crops—water security makes them willing to risk investing in the extra inputs such crops require. They can also grow crops that are more sensitive to water stress (e.g., vegetables) than lower-value staple crops. The nutrients the wastewater contains are an added benefit, saving farmers money (in terms of chemical fertilizers) and increasing crop yields.

Finally, being a source of livelihoods, wastewater may provide farming families with other benefits, such as improved nutrition, access to health care, and education.

IWMI has studied the realities of wastewater use both in the Guanajuato river basin in Mexico and at the town of Haroonabad in Pakistan’s arid southern Punjab. Both areas experience water shortages and have little industry. Researchers have found that wastewater irrigation provides various stakeholder groups with diverse economic and social benefits.

## Wastewater use benefits society as a whole

Obviously, using wastewater means that there is less demand for freshwater for irrigation—an advantage in water-scarce areas. Applying wastewater to land also removes a number of contaminants from that water, making irrigation a low-cost method for the sanitary disposal of municipal wastewater. At the same time, this practice limits the pollution of rivers, canals and other surface-water resources, which would otherwise be used as disposal outlets. This benefits the health of people downstream, who use these water resources for domestic and drinking-water needs.

This issue of *Water Policy Briefing* is based on research presented in: *Urban-Wastewater Reuse for Crop Production in the Water-Short Guanajuato River Basin Mexico* (IWMI Research Report 41) by C. Scott, J. A. Zarazua and G. Levine; *Urban Wastewater: A Valuable Resource for Agriculture: A Case Study from Haroonabad, Pakistan* (IWMI Research Report 63) by W. van der Hoek, M. Ul Hassan, J. Ensink, S. Feenstra, L. Raschid-Sally, S. Munir, R. Aslam, N. Ali, R. Hussain and Y. Matsuno; and *Use of Untreated Wastewater in Peri-Urban Agriculture in Pakistan: Risks and Opportunities* (IWMI Research Report 64) by J. Ensink, W. van der Hoek, Y. Matsuno, S. Munir and R. Aslam. The full text of these reports is available at [www.iwmi.org/pubs](http://www.iwmi.org/pubs).

Wastewater irrigation can also significantly contribute to urban food security and nutrition. Recent studies in several Asian and African cities have revealed that wastewater agriculture has accounted for over 50% of urban vegetable supply.

## Wastewater use can create health and environmental problems

Prolonged contact with wastewater can, however, expose farmers and their families to health risks—such as parasitic worms, and disease-causing viruses and bacteria. There is also a risk to consumers if vegetables are irrigated with wastewater; and, wastewater canals can act as habitats for disease vectors, such as snails and mosquitoes.

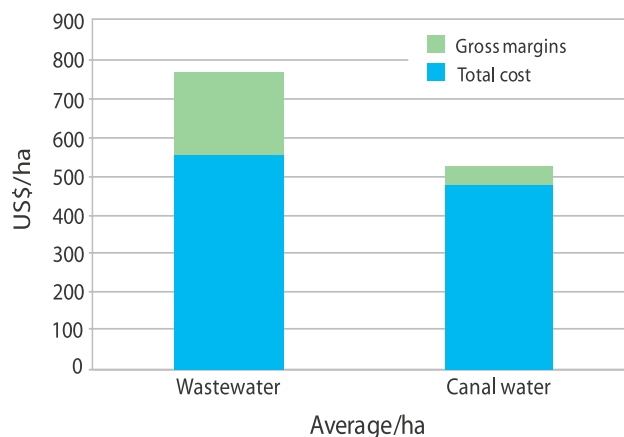
But, such localized health risks may be more manageable than the dispersed public health problems that arise in downstream communities if wastewater is discharged directly into lakes and rivers.

Use of wastewater irrigation can also result in serious environmental problems, contaminating groundwater with nitrates and chemical pollutants, including heavy metals (especially if the wastewater contains industrial wastes). Such pollutants may build up over time in the soil and be taken up by food crops, though evidence suggests that this problem is severe only in industrialized areas. Nutrients, such as

### Box 1. Wastewater policy options: Maximizing benefits, minimizing risks

- Crop selection and irrigation practices—minimizing risks by applying suitable irrigation techniques and selecting crops that are less likely to transmit pathogens to consumers.
- Human exposure control—use of protective measures.
- Preventive medical care programs—use of preventive therapy such as anti-helminthic drugs.
- Post-harvest handling—washing of vegetables, improved storage.
- Conjunctive management of wastewater and canal water.
- Upstream wastewater management and appropriate low-cost treatment.
- Educating farmers and awareness-raising among consumers and authorities.
- Monitoring programs—routine monitoring of key environmental, health and food safety parameters.

Figure 1. Total cost and gross margin (US\$/ha) for a wastewater farmer and regular canal water farmer in Haroonabad, Pakistan



Factors that contribute to higher gross margins for wastewater farmers include savings in fertilizer costs, a higher cropping intensity and the ability to grow higher-value crops.

**Source:** Ensink, J.; Simmons, R.; van der Hoek, W. (forthcoming). "Wastewater use in Pakistan, the cases of Haroonabad and Faisalabad". In *Wastewater Use in Irrigated Agriculture: Confronting the Livelihood and Environmental Realities*, ed., C. Scott, N. I. Faruqi, and L. Raschid. Commonwealth Agricultural Bureau International, Orient-Longman, and International Development Research Centre.

nitrogen, in the higher concentrations often associated with wastewater use, can reduce the productivity of some crops, thus limiting the crop choice for farmers.

## New approaches?

But, while the uncontrolled use of untreated wastewater cannot be encouraged (because of the environmental and health risks) unconditional restriction is not the solution. The resource is too valuable to farmers, who will continue to use it as long as it is accessible, and alternative disposal solutions are not currently available. Wastewater use guidelines must be sensitive to these issues.

Addressing this, the World Health Organization (WHO) recently made a commitment to take into account the realities faced by developing countries when reviewing its guidelines for wastewater use in agriculture. Plus, at a recent global workshop, representatives of 27 international and national institutions developed the Hyderabad Declaration (see [www.iwmi.cgiar.org/home/wastewater.htm](http://www.iwmi.cgiar.org/home/wastewater.htm)). This major breakthrough constitutes a common vision and direction for wastewater management.

In light of the research undertaken in Mexico and Pakistan, a number of feasible policy options have been identified.



## Box 2. The realities of wastewater treatment and use

### Results from a nationwide IWMI survey in Pakistan:

- Percentage of cities (population of over 10,000) with wastewater treatment facilities – 2%
- In cities with treatment facilities, estimated percentage of wastewater that receives treatment – less than 30%
- Amount of wastewater used directly for irrigation – 2,400,000 m<sup>3</sup>/day
- Amount of untreated wastewater disposed of in irrigation canals – 400,000 m<sup>3</sup>/day
- Percentage of wastewater generated daily that is used in agriculture: 36% (direct use – 31%, through contaminated canal water – 5%)
- Percentage of wastewater generated daily that is disposed of in rivers or the Arabian Sea – 64 %

## Banning wastewater irrigation would hit the poorest hardest

A straightforward ban on the use of wastewater for irrigation would mean the loss of thousands of thriving micro-economies based on growing wastewater-irrigated crops. Indeed, researchers estimated that just 140 hectares of such crops in the Guanajuato river basin (Mexico) had a value of US\$256,000 per year. This represents a significant monetary benefit to both the water users themselves and the community as a whole.

Moreover, the Pakistan studies found that many of the farmers who utilize wastewater irrigation are landless—the poorest of the poor. Only the high returns they obtain from irrigated crops enable them to rent land and make a living from agriculture. IWMI research estimated that farmers using untreated wastewater earn US \$300 - 600 more annually than non-wastewater farmers. Policymakers considering a ban on wastewater irrigation would need to make provisions for the large numbers of people who might be adversely affected.

Finally, there are two additional problems associated with the banning of wastewater irrigation. First, because farmers value it highly, a ban on wastewater use may simply not be enforceable—especially if resources are limited.

Second, a ban on the practice in many cases may lead to an increase in surface-water pollution, negatively impacting the health of downstream water users. This can only be avoided if funds are available to build treatment plants and operate them efficiently. But such treatment is prohibitively expensive in many developing countries.

## Treatment is not always the best option

Large capital investments are needed to construct treatment plants. For example, a plant proposed for use in Guanajuato City, in the Mexican study area, was estimated to cost US\$2.6 million to build, and a further US\$200,000 per year to run.

Besides the initial building and running costs, additional costs are also associated with the land needed for treatment plants.

Depending on the treatment technology used, these can be considerable. For example, aeration lagoons, which have the advantage of needing low maintenance, take up many hectares of land even for medium-sized towns and cities.

Scientists have found, however, that using wastewater for irrigation results in the removal of contaminants from that water, so improving its quality. Though contaminant removal is not at the 90% level achievable in a treatment plant such as the one proposed in Mexico, the reductions were considerable. Clearly, in this case, the continued use of wastewater in irrigation is far more economical than the building of a treatment plant.

**Table 1. Total Nitrogen and Phosphorus delivered to fields through untreated and treated wastewater, Mexico**

Canal	Untreated		Treated	
	N (kg)	P (kg)	N (kg)	P (kg)
San José de Cervera	45,483	7,553	3,556	711
Santa Catarina	63,865	10,308	11,397	1,698
	N (kg/ha)	P (kg/ha)	N (kg/ha)	P (kg/ha)
San José de Cervera	455	76	36	7
Santa Catarina	1,597	258	285	42
Alfalfa requirements	88	115	88	115

Researchers estimated that treating wastewater before use would reduce farmers' annual net-incomes by US\$135 per hectare because of added fertilizer costs.

*Source: IWMI Research Report 41*

Even if treatment is affordable, there may be other, social, costs. Treated water may be allocated to other uses. In Mexico, the municipal authority planned to sell the treated water to a golf course. In such cases, the impacts—loss of livelihoods, etc.—will be similar to those caused by a ban.

Partial treatment would result in farmers continuing to have access to wastewater—however, they would lose a valuable source of nutrients. Using simulation models, researchers studying wastewater irrigation in Mexico estimated that treatment would result in a loss of US\$18,900, in terms of farmers having to buy fertilizers to replace the nutrients lost through treatment (see table 1). Thus farmers would be directly affected, suffering an estimated reduction in their net incomes of US\$135 per hectare of wastewater-irrigated land, per year.

In the Pakistan study, researchers found that municipal councils actually had little incentive to invest in treatment facilities. Councils there recognize the value wastewater has to farmers, and so sell it to them. The revenue gained is then used to finance the operation and maintenance of other utilities—both local governments and farmers consider this to be a win-win situation.

## Constructively managing wastewater irrigation

How can we maximize the benefits associated with wastewater irrigation, while reducing the risks? Researchers have identified a number of measures critical to achieving this goal.

### Environmental- and health-monitoring programs

If the use of untreated wastewater is to continue, monitoring programs are essential to ensure that the short-term benefits of wastewater irrigation are not offset by high health and environmental costs.

In Haroonabad, researchers measured the concentrations of heavy metals in soils. They found that the levels detected did not exceed internationally recommended values—even after 35 years of wastewater irrigation. In the Mexican study too, the buildup of heavy metals found in the soil fell within EU and US norms. But, the composition of wastewater varies tremendously from city to city, depending on the number and type of industries present, so the importance of monitoring will also vary. However, in

**Table 2. Prevalence of intestinal parasitic infections in wastewater and canal-water farmers, Pakistan**

Disease	Wastewater farmers*	Canal farmers**
<i>Giardia lamblia</i>	35.6%	34.0%
<i>Entamoeba coli</i>	37.8%	44.7%
<i>Entamoeba histolytica</i>	14.8%	9.0%
<i>Ascaris lumbricoides</i>	5.2%	0%
<i>Trichuris trichiura</i>	0.7%	0%
Hookworm	39.3%	27.7%
<i>Taenia saginata</i>	0.7%	0%
<i>Hymenolepis nana</i>	8.9%	13.8%

\*Based on a sample of 135 farmers \*\*Based on a sample of 188 farmers  
**Source:** *IWMI Research Report 63*

the case of small towns and cities without much industry, environmental risks of soil contamination and plant uptake of heavy metals seem to be negligible.

Nitrate levels in the irrigation water in the Mexican study were higher than those recommended for agricultural use. But, this had not affected nitrate levels in groundwater—water in the wells studied still met the USA's drinking-water-quality standards for nitrate.

In Pakistan, however, researchers found that the quality of the groundwater had deteriorated in wastewater-irrigated areas, as compared with canal-water-irrigated areas. Levels of coliforms, salt and nitrate contamination were higher in groundwater in the wastewater-irrigated areas. In this case, deterioration had no significant impact on health, because the naturally brackish groundwater was not actually used for drinking or irrigation. A general conclusion, therefore, is that in places where groundwater is not used for consumption, contamination of groundwater (as a result of wastewater use) is not actually an issue for human health.

Untreated wastewater can also contain viruses, bacteria, protozoan parasites, and helminth (worm) eggs, all of which pose potential health risks. The importance of health-related monitoring has been illustrated by researchers who compared the health of wastewater farmers with that of canal-water farmers in Haroonabad (see table 2). The one-year study found that incidences of diarrhea and infection with helminths (hookworm and roundworm) were significantly greater in wastewater farmers. Indeed, the prevalence of diarrhea in farmers using wastewater (12% of farmers) was double that of canal-water farmers (6%). And, 80 percent of male wastewater-farm workers were infected with hookworm—an extremely high figure for Pakistan.

To establish whether specific epidemiological linkages exist between wastewater use and disease in particular areas, field studies such as this are often required. Reported public health data in developing countries cannot always be relied upon to give a clear picture.

Food safety monitoring is common in most countries that export agricultural produce; however, it is rarely implemented for domestically consumed crops. Routine monitoring of contaminant levels in crops, particularly vegetable contamination by helminths, bacteria and protozoa, is crucial to reduce human health risks. Depending on the level of industry in the area, regular monitoring of heavy metals and other industrial pollutants may also be required. Where wastewater is used for forage production to support peri-urban dairy farming, milk quality should also be routinely checked for contamination.

### Health protection measures for farmers

Two main methods have been recommended to reduce the problem of helminth infections in wastewater farmers—both are simple and relatively inexpensive.

The first involves farmers wearing shoes and gloves while working in wastewater-irrigated fields. This would prevent hookworm larvae present in the soil penetrating the skin of farmers. The drawback of this measure is farmers' reluctance to wear such protective gear in hot climates.

The second, and perhaps more effective, method involves treating farmers and their families with anti-helminthic medication. The drugs commonly used against soil-transmitted helminths are safe, cheap, effective and widely available in most developing countries, so regular de-worming campaigns are likely to have an important positive impact on the health of people exposed to untreated wastewater.

### Health education

Health education, both for farmers and the public at large, can help minimize the health risks associated with wastewater irrigation. Farmers should be made aware of all the potential risks they face. They would also benefit from a knowledge of the basic hygiene-related precautions they could take to avoid infection and prevent the spread of gastro-intestinal diseases to their families. Because the communities of wastewater farmers studied in Pakistan were small and localized



A farmer wades through a homemade diversion canal, which carries wastewater to his fields, Pakistan

(around the wastewater supply point), researchers concluded that the introduction of new health-education and health-protection measures would be successful and effective. A program that educates consumers about the need to thoroughly wash fruits and vegetables before use would also be beneficial.

### Restrictions on the types of crops grown

In some countries, restrictions are placed upon the types of crops that can be grown under wastewater irrigation. For example, in Mexico, regulations state that no vegetables or fruit can be irrigated with untreated wastewater. There, wastewater can be used to irrigate only low-value grains (maize, sorghum, and wheat) and fodder (alfalfa).

Though crop restrictions such as these can prevent human-health problems, they clearly reduce the economic benefits of using wastewater. This is because high-value crops such as vegetables (for which there is a large market in peri-urban areas) are the most susceptible to contamination. What is more, it is possible that crop restrictions might not be effectively enforced in a developing country setting.

Encouraging the production of non-food crops, such as ornamentals, flowers and agro-forestry, may be a more-effective option than overt restriction. This, of course, requires access to the necessary inputs, extension and market linkages.

### Alternative cultivation and irrigation systems

The use of alternative cultivation systems may also be worth further investigation. At the Pakistan study site, researchers found large numbers of helminth eggs in irrigation water entering fields, but found no eggs on

the vegetables harvested from these fields. They attributed this to the “bed-and-furrow” cultivation system the farmers used, which prevented the vegetables from coming into direct contact with the wastewater. This cultivation method seems to limit the health risks posed to consumers by wastewater-irrigated vegetables grown in that area.

### Conjunctive use of wastewater and canal water

In the Pakistan case study, researchers found that, because the wastewater used has a low/negligible cost, farmers tended to overwater. This is particularly true during the rainy season, when they have too much water. Such overwatering contributes—needlessly—to the environmental and human-health problems associated with wastewater use. It also means that the amounts of nutrients applied to the crops, such as nitrogen, phosphorus, and potassium, far exceed the crops’ agronomic needs. Researchers calculated that, in some cases, nutrients had been applied at more than nine times the recommended rate.

The huge excesses of water and nutrients being used suggest that wastewater could be applied more rationally by mixing it with canal water. Provided that other factors are not limiting, this would allow the irrigated area to be expanded. This possibility has been assessed using modeling simulations based on measurements made in Haroonabad. Each of the four scenarios modeled included different combinations of potential options,

such as improving irrigation efficiency, and using different numbers of wastewater and canal-water applications per cropping season (see table 3).

The simulations made clear that conjunctive use of fresh irrigation water and wastewater, in a ratio of three to one, was the most beneficial of the four scenarios. In this scenario, the current wastewater-irrigated area (85 hectares) could be greatly increased in size—by 335 hectares. So, based on the average size of farms in the area, an additional 300 farmers could benefit from wastewater.

The economic component of the Haroonabad study also showed that the average annual farm income of wastewater farmers was considerably higher than that of regular canal-water farmers. Based on the conjunctive use of wastewater, and the concurrent expansion of the wastewater-irrigated area, researchers calculated that the resulting additional farm incomes would be around PRs 3 million (US\$50,000) per year. Such financial gains, made through the conjunctive use of wastewater and canal water, would make investments in new infrastructure (and treatment programs) viable.

But, the building of new infrastructure on farmers’ land (e.g., additional channels to transport wastewater) requires the permission and active cooperation of these farmers. Therefore, when municipalities plan and implement wastewater schemes, they need to involve the potential wastewater users in the entire process, from the

design stage onwards.

In practice, conjunctive use also requires those who currently have exclusive access to wastewater to be willing to share it with other farmers.

In theory though, the conjunctive use of wastewater and canal or groundwater has great potential in terms of reducing negative environmental and public-health impacts, and could allow a larger group of farmers to benefit.

**Table 3. Potential for expanding irrigated area under different conjunctive water-management scenarios, Pakistan**

	Water fraction	Average nutrient fraction	Irrigated area (ha)	Average nutrient application per cropping season through wastewater (kg/ha)		
				N	P	K
Current practice	47	570	85	1385	765	260
Scenario 1	70	570	105	1385	765	260
Scenario 2	47	285	170	690	380	130
Scenario 3	70	285	210	690	380	130
Scenario 4	70	140	420	345	190	65
Scenario 1 = Improved irrigation efficiency Scenario 2 = One water application followed by one wastewater application. Scenario 3 = Scenario 1 + Scenario 2. Scenario 4 = Scenario 1 + three normal water applications followed by one wastewater application						

If farmers and irrigation agencies can cooperate to improve irrigation efficiency and use wastewater as a supplement to canal (or groundwater) irrigation, more farmers could benefit from the resource. Scenario 4—improving efficiency and using canal water and wastewater at a ratio of three to one—would enable 300 more Haroonabad farmers to benefit.

**Source:** IWMI Research Report 64



## Water Policy Briefing Series

The *Water Policy Briefing Series* translates peer-reviewed research findings into useful information for policymakers and planners. It is published several times yearly, with the goal of bringing new and practical approaches to water management and planning into the policy recommendation process.

The Series is put out by the International Water Management Institute (IWMI) in collaboration with national and international research organizations.

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Comments and questions are welcome. Please send correspondence to:

Sarah Carriger, Water Policy Briefing, IWMI, P.O. Box 2075, Colombo, Sri Lanka  
Telephone: 94-1 2787404 Fax: 94-1 2786854 E-mail: [waterpolicybriefing@cgiar.org](mailto:waterpolicybriefing@cgiar.org)

## About IWMI

IWMI is a nonprofit research organization focused on improving land and water management in developing countries for food, livelihoods and nature.

IWMI's research centers around five core themes:

- Integrated Water Management for Agriculture
- Sustainable Groundwater Management
- Smallholder Water and Land Management Systems
- Water Institutions and Policies
- Water, Health and Environment

The Institute fields a team of some 50 senior researchers with significant international experience, supported by national research staff and a corps of some 20 Postdoctoral scientists, mostly from developing countries. IWMI is headquartered in Sri Lanka with regional offices in India, Pakistan, South Africa and Thailand.

All IWMI research is done with local partners (universities, government agencies, NGOs, research centers, etc.). The Institute's outputs are public goods that are freely available for use by all actors in water management and development. The IWMI Research Reports, data and other publications can be downloaded from the IWMI web site. A series of tools for improved water management is also available.

For further information see [www.iwmi.org](http://www.iwmi.org) or write to [iwmi@cgiar.org](mailto:iwmi@cgiar.org)

## IWMI's Research Program on Wastewater Use for Agriculture

This research is working to improve the livelihoods of urban and peri-urban farmers by providing safe, productive and sustainable options for the use of wastewater in agriculture. The program focuses on low-income countries with rapidly growing populations where conventional solutions are not realistic. IWMI has completed studies in Mexico and Pakistan and is currently working in Ghana, India, Nepal and Vietnam.

The results of the program will include:

- A clearer picture of the global extent of wastewater irrigation and the associated risks and benefits
- Pragmatic approaches to wastewater management and use for policy makers, local authorities and wastewater farmers—including recommendations for increasing the benefits of wastewater irrigation while reducing the risks, effective legal and institutional frameworks, and appropriate agricultural and irrigation practices
- Tools to support decision making and monitoring.

**Partners:** **International:** CGIAR Strategic Initiative on Urban and Peri-Urban Agriculture, Philippines • Danish Hydraulic Institute, Denmark; Department of Water and Sanitation in Developing Countries (SANDEC), Switzerland • HR Wallingford, UK • Institute of Public Health of the University of Copenhagen, Denmark • IRC International Water and Sanitation Center, Netherlands • Resource Center for Urban Agriculture and Forestry (RUAF), Netherlands • Royal Veterinary and Agricultural University (KVL), Denmark • Streams of Knowledge, Philippines • Technical University of Hamburg-Harburg, Germany • University of Wageningen, Netherlands **Ghana:** Kwame Nkrumah University of Science and Technology • University for Development Studies **Pakistan:** Faisalabad Agricultural University • Institute of Public Health • Water and Sanitation Agency, Faisalabad **Vietnam:** Center for Irrigation and Water Supply Research • National Institute of Hygiene and Epidemiology • Vietnam Institute for Water Resources Research

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