Water, Health & Environment

Raising awareness and encouraging the incorporation of health safeguards in water management planning in rural and urban areas.

Documenting the relationships between water, health and environment and develop tools for planning and management.

Developing practical tools to quantify and manage irrigation water and drainage flows to sustain ecosystems while obtaining optimal irrigated agriculture production.

Research Themes:

Integrated Water Management for Agriculture • Sustainable Smallholder Land & Water Management Systems
Sustainable Groundwater Management • Water Resources Institutions & Policies • Water, Health & Environment

Risks and Benefits of Wastewater Irrigation

Finding a balance between small farmers' needs, and impacts on health and environment

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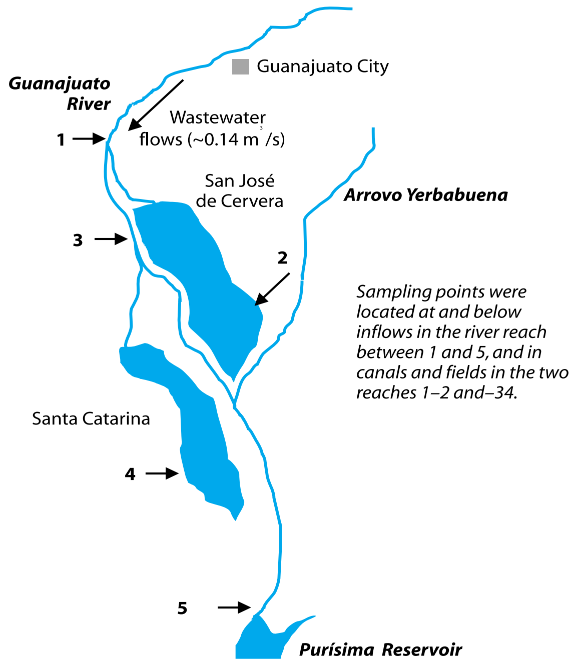
Summary

There are significant trade-offs associated with irrigation using untreated urban wastewater. From a river-basin perspective, wastewater irrigation is an important form of water and nutrient reuse; however, there are important water quality, environmental, and public-health considerations. The risks associated with this practice are increasingly recognized, both in terms of implications for public health, and impacts on the environment. Less well-recognized are the potential benefits from this discharge.

In the water-short Guanajuato river basin in west-central Mexico, urban wastewater is a primary source of irrigation water and nutrients for small farmers. The 140 hectares of land irrigated with raw wastewater downstream of the city of Guanajuato serve as a *de facto* water treatment facility. The City is currently considering construction of a wastewater treatment plant. IWMI research assessed the benefits of the wastewater to farmers and the health and environmental risks associated with the practice. This initial study suggests that continued application of the wastewater to the land would be a much more economical form of wastewater treatment. This conclusion is drawn with the caveat that the potential for serious negative impacts for health and the environment should be evaluated in an ongoing monitoring program.

The City of Guanajuato's basic water supply includes both surface water, impounded in two principal reservoirs located in the upper part of the watershed, and groundwater pumped from one main aquifer in the central part of the watershed. It releases wastewater to the downstream part of the watershed, ultimately reaching the Purísima reservoir, which serves as the water source for part of Irrigation District 011 (where IWMI has been working since 1994). Given the water-short conditions in the basin (annual precipitation of 500 mm, potential evapotranspiration exceeding 1,500 mm,

Schematic map of the study site.



and significant urban and agricultural demand for water), storage levels in the reservoir are chronically low.

Benefits of wastewater irrigation

Since the groundwater costs approximately six times as much as the gravity surface water, the City has a strong interest in maintaining the water-producing characteristics of the watershed as well as in the potential for use of the wastewater to reduce demands on the city water supply.

Similarly, the current users of the wastewater have interests in the future availability of wastewater. These users are small-scale irrigators, organized in *unidades,*[1] whose water sources include the wastewater, flows from natural rainfall, and groundwater. The wastewater represents a significant part of their water supply, especially during the dry season. The typical crops grown are forage (alfalfa) and grains (sorghum and wheat).

The City is currently planning to construct a wastewater treatment plant and to sell the water to a proposed golf course. The IWMI study assessed the monetary impact on the small farmers, based on the estimated levels of water and nutrients derived from the untreated wastewater.

[1]*Unidades* are organizations of irrigators that are user-managed, often with some governmental oversight.

Nutrient value to farmers

The research evaluated the Interactive River Aquifer Simulation (IRAS) model, developed by Cornell University, as a tool for modeling the flow of water and nutrients to farmers' fields. Two sets of waste-load inputs corresponding to untreated and treated wastewater discharged by the City were simulated using the IRAS model. This reflects the City's plan to treat and sell its wastewater to commercial interests. Under the assumption that treated wastewater will be released down the natural river channel to be used by irrigators of the customary San José de Cervera Canal (SJC) and Santa Catarina Canal (SC) until such time that the commercial buyer actually acquires the water, we have simulated the difference in nutrient delivery to crops between the untreated and treated wastewater.

Total N and P deliveries to irrigated fields using untreated and treated wastewater.

	Untreated		Treated		% Change	
Canal	N (kg)	P (kg)	N (kg)	P (kg)		
San José de Cervera (SJC)	45,483	7,553	3,556	711		
Santa Catarina (SC)	63,865	10,308	11,397	1,698		
	N (kg/ha)	P (kg/ha)	N (kg/ha)	P (kg/ha)	N (%)	P (%)
San José de Cervera	455	76	36	7	-92.2	-90.6
Santa Catarina	1,597	258	285	42	-82.2	-83.5
Alfalfa requirements	88	115	88	115		

The proposed treatment plant is designed to remove approximately 90 percent of both the Nitrogen (N) and Phosphorus (P) in the waste stream. Based on the modeling results, this represents a nutrient value of US$95,900. Using the recommended level of N and P for the crops planted, the foregone nutrient benefit has a value of US$18,900 per year. While the value of these nutrients to society is included in the gross value cited above, the loss of these inputs to the farmers is such that their net incomes would be reduced by the cost to replace the nutrients lost.

Unit costs of Nitrogen and Phosphorus fertilizers.

Source of N	% N	Cost (N$/50 kg)	Cost (US$/kg N)
Urea	46.0	87.50	0.40
Ammonium Nitrate	33.5	82.50	0.52
Ammonium Sulfate	20.5	36.50	0.37
Average			0.43

Source of P	% P	Cost (N$/50 kg)	Cost (US$/kg P)
Super Triple	46.0	112.50	0.51
Simple Sulfate	18.0	47.50	0.56
DAP	46.0	137.50	0.63
MAP	52.0	140.00	0.57
Average			0.57

Application cost (combined N+P) (US$/ha)			31.58

Note: *N$=Mexican pesos.*

Water value to farmers

The water used for irrigation represents a recycling of urban wastewater in a basin context. Data from IWMI studies indicate that irrigation water has a gross value of output per hectare of irrigated land[2] of approximately US$1,800, and of a cubic meter of water of US$0.16. For the 140 hectares of land irrigated by the wastewater of the City of Guanajuato, this implies a water value of US$252,000 per year. The water value of wastewater used for irrigation represents a significant monetary benefit to both the society and the water users.

Reduced cost of wastewater treatment

The estimated investment cost for the wastewater treatment plant is US$2.6 million with an annual operating cost of US$200,000. While the field study and analyses were limited, they strongly suggest that continued application of the wastewater to the land

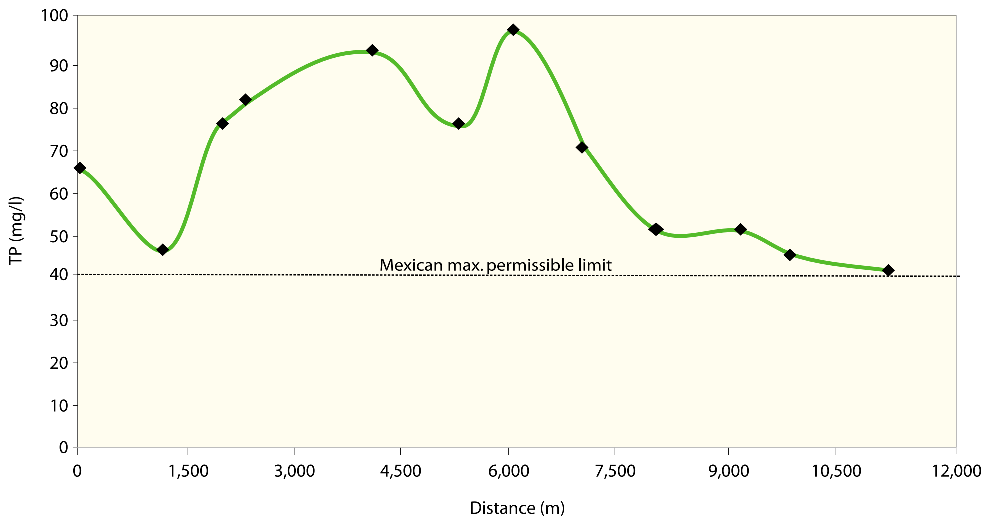
[2]This was based upon a crop mix of wheat and maize, with a relatively small percentage of vegetables. The cropping pattern in the wastewater-irrigated area includes wheat, barley and alfalfa, the last being a relatively high-value crop.

would be a much more economical form of wastewater treatment. This conclusion is drawn with the caveat that the potential for serious negative impacts for health and the environment should be evaluated in an ongoing monitoring program.

Risks associated with wastewater irrigation

In spite of the short-term benefits received from wastewater irrigation, there are considerable medium- and long-term costs associated with this practice. In the study area, N was found in excess of the 40 mg/l Mexican norm for receiving waters. There is also an indication that elevated N levels in irrigation water may contaminate wells with nitrate. However, the limited well-water-quality sampling performed as part of this study did not find levels above the 10 mg/l (as N) US drinking water standard.

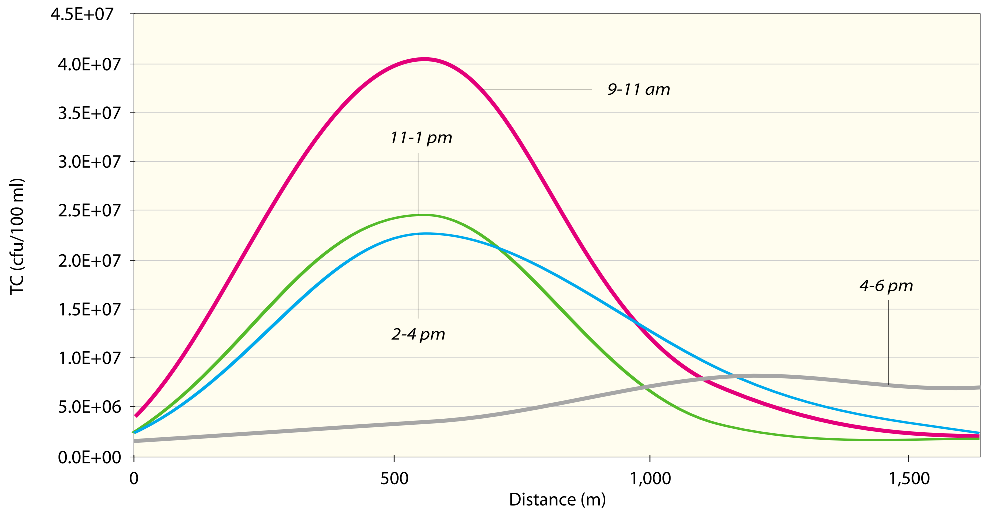
Total Nitrogen with distance down the main river channel.



Adverse health impacts

The potential for adverse health impacts of irrigation with wastewater has been reported in a number of articles, but there was no obvious indication of adverse health impacts in the area of study. The successive reuse of the wastewater in this particular basin suggests that these adverse effects may be smaller than in situations without reuse.

Total coliforms with distance down the main river channel.

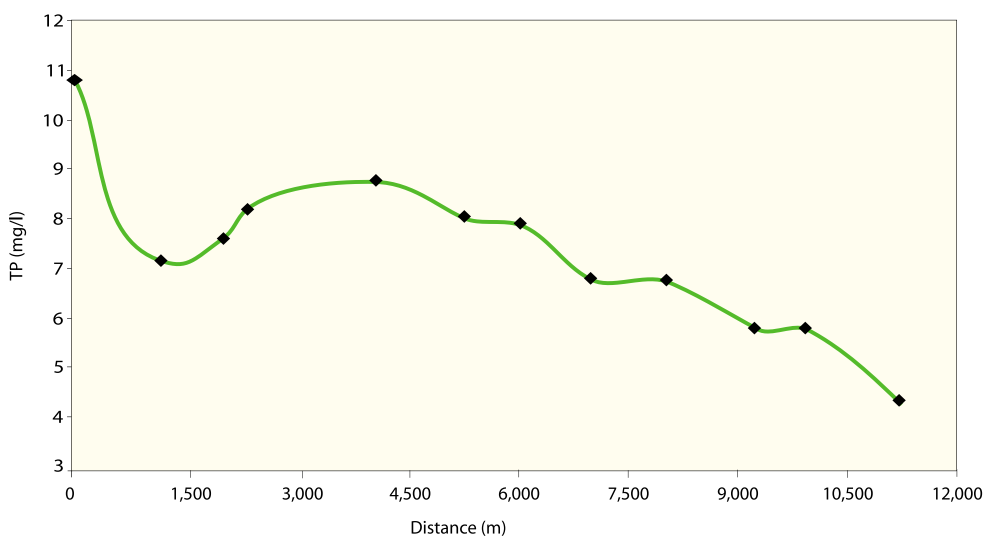


The passage through field vegetation and/or the filtration that accompanies irrigation and subsequent runoff and drainage would be expected to reduce the level of parasites and other microorganisms, in addition to the observed changes in chemical concentrations.

Adverse environmental impacts

The major environmental impact that could be anticipated is increased eutrophication in the Purísima reservoir, due to the P inputs from the wastewater. While the

Total Phosphorous with distance down the main river channel.



concentration of P in the water is relatively high, the flow from the wastewater path represents a small percentage of the total annual flow into the reservoir. Despite the dilution of TP, the reservoir's trophic status has produced some algae problems. Similarly, the salinity contribution from the wastewater source, while at a higher level due to the reuse upstream, is not likely to represent a significant problem.

The extended use of wastewater for irrigation also carries with it the potential for accumulation of heavy metals. The available information did not permit the determination of rates of accumulation because of potentially large changes in wastewater composition resulting from historic changes in mining in the region, as well as changes in the urban population.

Notwithstanding this, the levels found in our limited field study suggest that heavy metals do not represent a significant problem. The composition of the waste stream is likely to vary tremendously from city to city depending on the type and number of industries. We have noted that the City of Guanajuato may not be representative with respect to heavy metals.

Finally, although we have identified and described a number of short-term benefits associated with wastewater irrigation, the longer-term trade-offs associated with the practice must be considered carefully, chiefly for reasons of irreversibility. Nevertheless, the difficulty of financing adequate wastewater treatment in developing countries makes land application an attractive alternative.

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People cannot live by food alone

They need to be healthy in body and mind and live in harmony with their surroundings.

More than two million children die each year of diseases arising from biologically contaminated water, and countless more millions have their physical and mental development retarded as their energy is sapped by repeated battles with these diseases. Thousands more suffer illness and a slow death by drinking water contaminated by chemicals like arsenic and fluoride bubbling up from deep groundwater, or by cadmium and mercury seeping out with the waste from nearby industries. Why do they drink this contaminated water? Because they have no alternative.

Water also gives life to deadly mosquitoes that transmit malaria–the disease that afflicts 300-500 million people and kills more than a million each year. And to the snail hosts that harbor the parasite that causes schistosomiasis, a disease afflicting 200 million people each year. Most of this suffering and death occurs in developing countries, which can least afford such burdens.

We at IWMI proudly proclaim that our mission is to help eliminate poverty in the developing world by managing water used in agriculture more effectively. We do this by looking at ways to produce 'more crop per drop'. But predictable crop yields and sustainable agricultural practices are only part of the picture. People cannot live by food alone. They need to be healthy in body and mind and live in harmony with their surroundings. Focusing on crops alone, and ignoring the health and well-being of these farmers will bring no joy and not alleviate poverty.

Starving nature of its water needs in order to produce food, too, will fail because a degraded environment is bound to strike back eventually. We have recognized this reality and so IWMI's mission, too, has evolved, to become: *'Improving water and land resources management for food, livelihoods and nature'*.

A nice motto.....but also a daunting challenge. How can these often conflicting needs be balanced? How to safeguard peoples' health, protect the environment and still produce enough food with our limited freshwater resources? This is the purpose of our research, to look for these answers.

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