From Fear of Cholera to Full Wastewater Treatment in Two Decades in Santiago, Chile

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Indirect wastewater irrigation in the Santiago Metropolitan Region (SMR): Situation in 1991

- Population of SMR 4.7 million
- GNP per capita $1,930
- Water and sewerage coverage:
  - Water supply 95%
  - Sewerage 87%
  - Treatment < 1%
  - 13.3 m³/s of raw sewage discharged into the Mapocho River, the Maipo River, and the Zanjón de la Aguada drainage canal (virtually an open sewer)
- 130,000 ha of high-producing agricultural land in SMR irrigated with highly polluted water
  - Including 7,000 ha of vegetable crops for raw consumption in the Santiago market
  - Also producing 40% of Chile’s fruit exports
- Agricultural exports valued at $1.1 billion annually
  - growing at 10% annually

Source: Bartone, 1994
Areas Irrigated with Polluted Water in the SMR (1991)

<table>
<thead>
<tr>
<th>Agricultural Zone</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>El Carmen</td>
<td>10,000</td>
</tr>
<tr>
<td>La Punta</td>
<td>6,000</td>
</tr>
<tr>
<td>Pudahuel</td>
<td>300</td>
</tr>
<tr>
<td>La Pava</td>
<td>200</td>
</tr>
<tr>
<td>Ortuzano</td>
<td>2,500</td>
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<tr>
<td>Rinconada</td>
<td>1,500</td>
</tr>
<tr>
<td>Las Mercedes</td>
<td>12,000</td>
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<tr>
<td>Mallarauco</td>
<td>28,000</td>
</tr>
<tr>
<td>Del Maipo</td>
<td>70,000</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>130,500</strong></td>
</tr>
</tbody>
</table>

Source: Bartone, 1994
Health Dilemma in SMR

- Persistent endemic typhoid fever in SMR
  - Unexpected in a country like Chile with moderate income and high levels of education, nutrition and health care
  - Much higher rate of typhoid in SMR than in rest of Chile
  - Linked to extensive indirect wastewater irrigation in the SMR
    - “Long-cycle” of transmission – the SMR loop: Infected person → sewage → water pollution → raw vegetables → people
  - Hyper-endemic typhoid rates between 1976 and 1983
    - up to 215 cases per 100,000 population
  - First major intervention by Ministry of Health in 1984:
    - Prohibited cultivation of vegetable crops consumed raw:
    - Initiated public education campaign on risks of sewage irrigation
    - Resulted in 59% drop in typhoid by 1986, to average levels of endemicity

Source: Bartone, 1994; Ferreccio, 1995
Typhoid Morbidity Rate in Chile, 1950-1991 (cases/100,000 population)

Source: Chile Ministry of Health, 2010

First emergency measures in 1984
A major cholera outbreak started in January 1991 in Peru and quickly spread to other parts of Latin America

- Peru experienced 322,562 cases and 2,909 deaths in 1991
- Wastewater irrigation of crops a major factor is rapid spread of cholera

In Chile, 41 cases and 2 deaths occurred in April-May 1991

- 70% of cases attributed to consumption of Santiago vegetables
- Fear of major outbreak since:
  - Cholera like typhoid is spread by “long-cycle”
  - Peru had similar rates of typhoid as observed in SMR
- Fear of potential health, social and economic impacts
  - 1970 Jerusalem cholera outbreak nearly destroyed Israel’s agricultural exports to Europe (including flowers)
  - Estimated losses to Peru of $177 million in direct and indirect health costs plus export and tourism losses in 1991
  - In 1989, Chile experienced a US embargo on all its fruit exports due to 2 grapes found with traces of cyanide – so GoC politically sensitized to the risk

Source: Bartone, 1994; Suárez & Bradford, 1993
Emergency Response to Cholera Hazard

- GoC took decisive action in 1991 aimed at eliminating the hazard of irrigation with untreated wastewater
  - Created National Commission to Avoid Cholera
    - Including Ministries of Agriculture, Health and Public Affairs
  - Put in place Emergency Control Program of public health interventions and sanitary education including:
    - Measures to improve irrigation water quality (construction of interceptors, chlorination of irrigation water, loans to farmers to drill wells)
    - Measures to change farmers’ irrigation practices (banned sale of wastewater-irrigated produce, removed this produce from markets, banned transport of this produce outside SMR – accompanied by intensive sanitary inspections and destruction of any banned crops found growing)
      - Lettuce, chicory, coriander, parsley, radishes, carrots, celery, cauliflower, beets, spinach, watercress, and strawberries
    - Measures to change consumer behavior (intensive education campaigns on risks of eating raw vegetables; press coverage on cholera and typhoid; banned sale of raw vegetables in restaurants)
  - Emergency Control measures continued for several years
    - Typhoid rates dropped to 12 cases/100,000 population in 1993
    - A major cholera outbreak was successfully avoided

Source: Bartone, 1994; Ferreccio, 1995
Sanitation Plan for SMR

- Beyond the Emergency Control Program, the GoC also focused on longer-term structural measures to control pollution from urban wastewater and guarantee the sustainability of health, social and economic benefits
  - EMOS, with World Bank support, prepared a long-term Sanitation Plan for wastewater interception and treatment in the SMR
    - World Bank ESW on economic impacts of environmental issues in Chile included a policy cost-benefit analysis of wastewater treatment:
      - Concluded that annual health and agricultural benefits would significantly offset the annual cost of treatment
      - Policy-makers came to view wastewater treatment as a necessary and viable environmental infrastructure investment
    - EMOS’ original target was to reach 100% wastewater treatment by 2024
  - Policy reforms of the water sector, initiated in 1989, were designed to prepare the way for eventual privatization
    - A first step transformed EMOS into a state-owned stock corporation under private commercial law
      - Subject to a regulatory framework that mimicked the design of a concession with a private utility

Source: Bartone, 1994; Shirley et al, 2000
World Bank Support for the Empresa Metropolitana de Obras Sanitarias (EMOS)

- Second Santiago Water and Sewerage Project approved in 1986
  - First of 3 objectives:
    - “To support the first phase of a plan to alleviate sewage disposal and reuse problems with a view to reducing incidence of typhoid fever and other enteric diseases.”
  - Sewerage component ($44.6 million)
    - 70 km of trunk mains and 200 km of secondary sewers
    - Pilot WWTP Santiago Poniente
    - WWTPs for provincial cities in SMR
    - Technical assistance to help finalize wastewater treatment master plan
  - Results in 1995:
    - Sewerage coverage increased from 87% to 96%
    - Construction of first major interceptor of the Zanjón de la Aguada protecting 2,700 ha of irrigated land (Ortuzano and La Pava irrigation zones)
    - Relocated major sewage discharge to Canal El Carmen eliminating primary pollution of 10,000 ha of irrigated land
    - Santiago Poniente Pilot WWTP operational, plus one provincial city WWTP
    - In 1995, EMOS approves “Sanitation Plan for Greater Santiago, 1995-2024” calling for progressive sanitation of agricultural zones through wastewater interception and treatment

Source: World Bank, 1996
Impact of Privatization of EMOS

- The final major reform of the water sector aimed at attracting private sector investments to achieve universal water and sewerage services, including sewage treatment
  - In 1999, water and sewerage services in the SMR were fully privatized through the sale of 50.1% of EMOS’ shares to the private consortium AguasAndinas
    - Other investors include the Chilean State Development Corporation (CORFO) 35%; pension funds 10.1%; workers 2.8%; and small investors 2%
  - Under the terms of the privatization, AguasAndinas agreed to fully finance and implement the Sanitation Plan
    - The target date for reaching full wastewater treatment was cut in half
    - In under two years the first major WWTP, El Trebal, was built and operating, and the second, La Farfana, became operational in 2003
    - In provincial cities 9 WWTPs have been built and 13 operating in total
    - By the first quarter of 2012 the final major WWTP, Mapocho, will enter in operation and 100% of wastewater in SMR will be treated

Source: Larrain, 2009
Progressive Accomplishments to Date of Sanitation Plan for SMR

1995 – Santiago Poniente WWTP (less than 3% of wastewater treated)
2001 – Maipo interceptor and El Trebal WWTP (23% treated)
2003 – Final Zanjón interceptor and La Farfana WWTP (74% treated)
2008 – 13 provincial cities with WWTPs
2010 – Mapocho interceptor (87% treated)
2012 – Mapocho WWTP to be completed (100% treated)

Source: Larrain, 2009
El Trebal Sewage Treatment Plant

• Operational October 2001
• Capacity 4.4 m³/s
• Cost US$150 million

Source: Fuentes, 2009
La Farfana Sewage Treatment Plant

- Operational 2003
- Capacity 8.8 m$^3$/s
- Cost $315 million

Source: Fuentes, 2009
Mapocho Interceptor and WWTP

**Mapocho Interceptor**
- Completed 2010
- 28.5 km collector intercepting 21 major discharges
- Cost US$113 million
- Using existing spare capacity at El Trebal and La Farfana to treat intercepted flows

**Mapocho WWTP**
- Completion 1st quarter 2012
- Capacity 2.2 m³/s
- Cost ~US$140 million

*Source: Fuentes, 2009*
Impact of Sanitation Plan on Tariffs

- Average tariffs have increased due to the start-up of the new sewage treatment infrastructure.

- In 2008, the tariff was divided 52% for water and 48% for sewerage services. The latter was only 36% in 2003.

- Tariffs are adjusted every 5 years according to a formula based on marginal costs.
  - Chart shows tariffs in force since March 1, 2005.
  - Automatic interim adjustments based on inflation.

Sources: Shirley et al, 2000; Yayur, 2009
Impact of control measures on Typhoid Rate (cases/100,000 population)

Source: Chile Ministry of Health, 2010
Benefits of the Sanitation Plan

- It guarantees that 130,000 ha of agricultural land is now irrigated with safe water, helping to provide for:
  - Removal of restrictions on growing vegetables
  - Public health protection maintaining low levels of typhoid fever, hepatitis and diarrheal diseases, and avoiding cholera problems
  - Access to existing and new markets, thanks to meeting international standards for agricultural exports
  - A clean, pollution-free environment for future generations
Lessons Learned

- Over three decades Santiago achieved control over hazards of indirect wastewater use for irrigation
  - Confronted with hyper-endemic typhoid, early rudimentary crop restriction and education measures (1983) helped to halve the health impacts
  - Faced with the real threat of a cholera outbreak – and potential loss of agricultural exports – political resolve led to the implementation of comprehensive emergency control measures (1991) that drastically reduced typhoid rates and avoided the establishment of cholera in the SMR
  - Commitment to long-term structural changes:
    • Development of the Sanitation Plan for the SMR required a full decade of concentrated effort (1986-1995)
    • Carried out major policy reforms transforming the water sector and leading to privatization of EMOS (1989-1999)
  - Starting with pilot operations, full wastewater interception and treatment will be achieved after two decades (1993-2012), drawing heavily on the investment capacity of the private sector
    • Including US$610 million private investment in wastewater treatment plants
References


Epilogue
World Bank’s Track Record on Wastewater Irrigation

1. **Active partner with WHO and UNDP from 1981 to 1994**
   - Supported research on wastewater treatment and safety of use for irrigation and aquaculture, issued seminal publications on epidemiology of reuse contributing to establishment of 1989 WHO Guidelines; published 1994 Planning Guide
   - Co-developed DALY metric for 1993 WDR on Investing in Health – permitted eventual development of 2006 WHO Guidelines (QMRA)

2. **Examples of lending operations:**
   - **Israel Sewerage Project** (1972, $75M) a first for the Bank – financed sewage treatment and reuse facilities, supported development of Wastewater Treatment and Storage Reservoirs, instituted cost-sharing provisions and division of responsibilities between cities and farmers for wastewater irrigation
   - **Santiago Water and Sewerage II Project** (1986, $45M) financed major interceptors, design and construction of pilot treatment plant, and preparation of treatment master plan; plus ESW on economic impacts of wastewater irrigation
   - **Tehran Sewerage Project** (2000, $121M) financed 5.2 m$^3$/s wastewater treatment plant and allowed additional 15,000 ha of irrigation in Varamin Plains Irrigation Scheme
   - **Current Portfolio** includes 25 projects that address wastewater treatment and (possible) use in agriculture, but only 7 had major financial commitments (<0.5% of total sewerage and wastewater treatment portfolio)
     - Tunisia $19 million; China $10 million; Iran $3 million
The report “Sustaining Water for All in a Changing Climate” (World Bank, 2010) recommends wastewater reuse as a strategic principle, but points out the need to develop core skills in this area to prepare and supervise projects or engage in high-level policy dialogue with client countries on this issue.

A Bank wastewater irrigation agenda should seek to:
- Support client efforts to develop wastewater use policies, investment plans and programs within a broader IWRM framework
- Enhance the quality of policy dialog with clients and of project preparation activities focused on application of the 2006 WHO Guidelines and phased introduction of appropriate treatment technologies
- Leverage private sector resources
- Build up the capacity of Bank staff across key sectors (water, urban, agriculture, health, environment, social) to better respond to client demands – the current ad-hoc structure is not adequate
- Work with and build support among key external partners – clients, donors, specialized institutions (especially WHO and FAO), and NGO/CBOs
Recent World Bank ESW
