Water Quality Problems in Nogales, Sonora

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This article presents the results of a transboundary water quality monitoring program at the two Nogales area in the Arizona–Sonora border region. The program was carried out jointly in 1990 by U.S. and Mexican institutions. The results show pollution problems due to deficiencies in Nogales, Sonora municipal sewerage system, causing not only sewage spills in several parts of the city but also creating occasional transboundary problems. The results also showed potential illegal dumping of industrial hazardous waste (VOCs) into Nogales' municipal sewerage system. All of the organic compounds found in the sewage samples are solvents frequently used by the border industry. Occasional brakes of pipes spill the pollutants into the Nogales Wash, a water stream that runs parallel to Nogales' main sewerage line. Samples of the municipal water system showed no traces of pollutants. However, two rounds of samples detected concentrations of VOCs in wells used to supply water by trucks to low income neighborhoods in Nogales, Sonora. Ironically, the pollution detected in these wells has a greater impact in low income groups of the city that pay three to four times more per liter of water they consume, than the rest of the inhabitants with clean water from the municipal system. — Environ Health Perspect 103(Suppl 1):93–97 (1995)

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Introduction

After the approval of the North America Free Trade Agreement (NAFTA), it is still pertinent to speak of health and environmental hazards at the U.S.–Mexico border. Environmental problems in this region are due to a combination of factors: They are the result of decades of unbalanced growth created by rapid economic and population growth and gaps in the supply of public services, combined with a low priority given to the protection of the environment by the federal government, and the lack of economic, technical, and human resources to enforce the protection of the environment.

Although there is no comprehensive diagnosis available on the state of the environment in the border region, recent academic studies and official reports provide an idea of the extent of the environmental crisis in Mexico and in the border region (1,2). Evidence of this crisis is also the growing number of environmental emergencies of anthropogenic origin in Mexico during the last years. Water pollution, particularly by hazardous substances, is an emerging problem in Mexico with important implications for public health. In fact, the management of hazardous substances and the control of hazardous wastes are among the critical environmental issues that Mexico currently faces at a national level. Official sources estimate that the annual generation of hazardous wastes in Mexico could be close to 14 million tons, but only a minimal part of them are legally disposed of (3). A major problem for Mexico is the small number of legal facilities authorized to dispose of hazardous wastes (only six legal recycling plants and one commercial landfill up to 1993). Two additional problems for Mexico are a) the lack of resources to enhance environmental enforcement at the federal, state, and local level; and b) the small number of available inventories of hazardous wastes generators, including an accurate description of the types, volume, and form of emissions in each source, and the final fate of the wastes (4). These obstacles hinder an effective protection of the environment and the public health, and the control and prevention of environmental contingencies.

The control of hazardous waste has a special importance at the U.S.–Mexico border region. Rapid industrial growth through the maquiladoras during the last 10 years, together with the lack of resources for environmental protection, has expanded the pollution created by the mismanagement of hazardous waste throughout the region. Evidence of this mismanagement is the discovery of illegal dump sites of hazardous waste within and outside the urban areas; water samples showing high concentrations of volatile organochlorate compounds (VOCs), heavy metals, and other pollutants frequently used by the border industry; and the lack of records on the final fate of hazardous wastes generated by a significant number of border plants during the last two decades. Although Mexico's official data show a significant increase in compliance with the Mexican environmental legislation by the maquiladoras in the last 2 years, a more comprehensive control at the local, state, and federal levels is still required.

These problems gained significant attention of the mass media in the United States and in Mexico since the environment became a key issue in the discussion of the NAFTA.

Illegal dumping of hazardous wastes into bodies of water and municipal sewerage systems is one of the main environmental concerns associated with the operation of the border industry at the U.S.–Mexico border. Evidence of this illegal practice has been documented in several Mexican cities in this area. Sewage samples in Mexicali, Tijuana, Nogales, and Matamoros show the presence of pollutants frequently associated with the border industry (5). In the two Nogales areas, some early studies detected the presence of organic compounds in sewage samples crossing the border. Those results encouraged several health institutions to carry out more detailed studies on the quality of water sources shared between the two Nogales. However, samples taken by subsequent studies did not cover in detail the Mexican city of Nogales, Sonora.
Water Quality in Nogales, Sonora

Two major water quality problems in Nogales, Sonora are bacteriological pollution associated with deficiencies in the municipal sewerage system and the potential pollution of wells used to supply water to low income neighborhoods of the city. Deficiencies in Nogales, Sonora sewerage system have also caused occasional spills of raw sewage across the border. Three key aspects in this problem are the lack of maintenance in sewerage lines, an increase in the domestic and industrial discharges beyond the capacity of existing lines, and the physical expansion of the city faster than the expansion of the sewerage system. These problems were responsible for sewage spills in different parts of the city during the last years. Despite recent efforts by the State Water Utility (COAPAES) to upgrade Nogales’ sewerage system, parts of the city still do not have sewerage or suffer periodical sewage spills. Some of these spills have flowed across the border into Nogales, Arizona. Binational negotiations to solve this problem led first to the construction of a binational sewage treatment plant serving the two Nogales in the late 1950s, and later to its subsequent expansions, the last of which was in 1991.

Several studies have documented water quality problems in the two Nogales areas. The first was carried out by the Arizona Department of Health Services (ADHS) through a sampling program that included the Santa Cruz aquifer shared between Mexico and the U.S. in the two Nogales areas (6). Samples taken by ADHS in May 1987 in Nogales, Arizona, confirmed the presence of VOCs in adjacent wells to the Nogales Wash stream just across the international border. The concentrations of most of these compounds did not exceed the levels recommended in Arizona, except for PCE. One year later, the Santa Cruz County Health Department (SCCHD) carried out a similar study in the same area (Santa Cruz County Health Department, unpublished data). Samples taken by these two studies in the Nogales Wash across the international border showed the presence of 18 organic volatile compounds in smaller concentrations than that allowed by state and federal standards, except for tetrachloroethylene (PCE), which concentrations exceeded federal standards.

Concerned with the presence of VOCs in the Santa Cruz aquifer, ADHS recommended a more detailed study under the Arizona Water Quality Assurance Resolving Fund (7). The results of that study confirmed the presence of VOCs in the samples taken in the Nogales Wash across the international border in Nogales, Arizona.

Prescott College and the Border Ecology Project (BEP) carried out the first water quality monitoring program covering VOCs in Nogales, Sonora, in 1988. This study also detected the presence of VOCs in some wells, including La Tomatera, later detected as one of the critical points in a subsequent analysis carried out by our project. The BEP and Prescott College study detected concentrations above the U.S. EPA federal standard in chloromethane, trichloroethene, and tetrachloroethene (Border Ecology Project, unpublished data). However, because of the limited number of sampling sites in this study, it was difficult to obtain a more clear picture on possible sources responsible for this pollution and its plume. Water samples in the Nogales Wash also showed high levels of coliform (the levels fluctuated between 17 and 2400 coliform bacteria per 100 ml.)

Other evidence of water quality problems in Nogales, Sonora, was documented by Sandy Tolan for the New York times in 1990 (8). Samples of sewage discharge outside Nogales, Sonora, taken by Tolan and analyzed in Arizona, showed the presence of VOCs, some of which were in high concentrations (toluene, xylene, methyl vinyl chloride, ethylbenzene, and 1,1-dichloroethene).

El Colegio de la Frontera Norte carried out a study on water management in Nogales, Sonora, in 1990 (9). At the same time, the Udall Center of the University of Arizona carried out a parallel project on Nogales, Arizona. Given the evidence of water pollution mentioned above, both institutions, together with Arizona Department of Environmental Quality (ADEQ), the Instituto Tecnológico de Sonora, and the Sonora delegation of Mexico’s Comisión Nacional del Agua, decided to carry out the first binational quality program in this area.

Monitoring sites were selected according to the following criteria: a) sites that could cover all the water bodies in the two cities (sources of water distributed by pipes or trucks, the sewerage system, the Santa Cruz aquifer, and surface water); b) priority was given to those sites considered critical for human health (different sources of drinking water), particularly those wells used for water supply; and c) priority was also given to those sites helpful in identifying the possible movement of pollutants within each city and between cities. Samples were taken and analyzed simultaneously on the two sides of the border. Figure 1 shows the selected sampling sites in Nogales, Sonora. Samples analyzed in Arizona by ADHS were bacteriologics, major cations/anions, metals, and VOCs. Samples analyzed in Sonora (Ciudad Obregón) by ITSON were major cations/anions and metals.

Duplicated samples, equipment blanks, and atmospheric blanks were also submitted to ADHS to evaluate laboratory accuracy and to minimize inadvertent sample contamination. For the bacteriologics, major cations, anions, and metals, the duplicate samples compared favorably with each other. For the VOCs, however, one sample was substantially different from the duplicate, while two samples were comparable. The dissimilar duplicates were collected separately from a sewerage line at two different times and the difference between them could be explained by temporal variability of water quality in the sewerage line. An equipment sample blank indicated no contamination, whereas an atmospheric sample blank indicated low concentrations of several volatile organic compounds.

Bacteriological Analysis

As expected, all samples collected from the sewerage system were heavily contaminated with bacteria (total coliform counts > 160,000,000). In addition, all samples collected from Nogales Wash were heavily contaminated with bacteria, with many samples showing contamination up to 160 million counts per 100 ml. Discharge from the Nogales International Wastewater Treatment Facility in Nogales, Arizona, had a total coliform counts reduced to 9000.

Water samples collected from the water system reservoirs in Arizona were uncontaminated and the Potrero Wash well field just across the international border showed no contamination. Only one drinking water well in Arizona was contaminated (Wingfield, with > 1600 total coliform counts).

Samples taken by our study in the municipal drinking water system in Nogales, Sonora, did not show the presence of bacteriological pollution. However, samples taken in some of the wells used to supply water to areas not covered by the municipal system did show concentrations of bacteria higher than the Mexican national standard in some wells. Wells at COAPAES (500), La Tomatera (30), Unidad Deportiva (220), Dabdoub (50), and Colonia Villa de Sonora (8) showed evidence of bacteriological contamination, with the COAPAES wells having the highest.
level of total coliform counts. Water from these wells is distributed by truck in low income neighborhoods for drinking purposes. The bottled water sample collected in Sonora showed no bacteriological contamination. Groundwater samples collected along the Santa Cruz River and away from the Nogales Wash and sewerage lines were uncontaminated or had very low levels of contamination. Some wells and piezometers located immediately adjacent to the sewerage lines or the Nogales Wash showed high levels of contamination (up to 500,000 total coliform counts).

Our project made an effort to estimate the number of inhabitants potentially in contact with bacteriological pollution in Nogales, Sonora. The results of the water quality program, together with the data from the 1990 population census were input into a geographic information system (GIS). Figure 2 shows the results of this GIS estimating the number of inhabitants potentially exposed to these pollutants (9).

Nitrate

Elevated nitrate levels (>5 mg/l) were observed in wells along the Nogales Wash in both Sonora and Arizona. Since the probable source of the nitrate was the effluent, neither the effluent nor the Nogales Wash was considered to indicate nitrate contamination.

Anions and Cations

Results for major cations and anions were difficult to interpret due to differences between ADHS and ITSON laboratory results, and due to lack of adequate charge balances between anions and cations. From ADHS data, elevated total dissolved solid concentrations (TDS) were detected in five effluent and piezometer samples (TDS > 500), yet the mass balances for these sites were very poor (16–220%). A single high nitrate value (335 mg/l) was reported at the Unidad Deportiva, but accidental acidification of the sample with nitric acid may have occurred at this site. No other values were of concern. Two elevated chloride ion concentrations (255 and 832 mg/l) were observed, but these were most probably laboratory errors.

Heavy Metals

Results of ADHS analysis indicated that levels for some metals, including chromium, iron, lead, manganese, and mercury, were present at several sites, but the metals concentrations were all associated with unfiltered samples.

VOCs

Our results on VOCs showed low levels of trihalomethanes (THMs) in the municipal water systems of Nogales, Sonora, which had been chlorinated. The concentrations of THM were below the maximum contaminant levels (MCL), but higher than the Health Based Guidance Levels of Arizona (HBGL). The samples collected in the Nogales Wash and in the municipal sewerage system of Nogales, Sonora, also showed the presence of VOCs. Samples collected in wells distant from the Nogales Wash and the main sewerage pipe lines did not show the presence of VOCs. Concentrations of VOCs were detected along the Nogales Wash and in the main sewerage collector running parallel to the wash. High levels of VOCs outside the industrial city south of Nogales, Sonora, led us to assume the existence of illegal discharges of polluted industrial waste water into the municipal
sewerage system (Figure 3). Compounds identified in the samples taken outside the industrial city were solvents used frequently by the border industry. The concentrations of VOCs in the Nogales Wash and in the sewerage lines decreased in the central and northern parts of the city. Lower VOC concentrations were detected at the international border.

Concentrations of VOCs were also detected in wells in Nogales, Sonora. Three of these wells, used to supply water by truck to low income neighborhoods, showed the presence of trichloroethane (TCA), tetrachloroethylene (PCE), trichloroethylene (TCE), dichloroethylene (DCE), and dichloroethane (DCA). The concentration of some of these compounds was smaller than the Mexican standard, while others were higher (Table 1). In La Tomatera well, where the drinking water bottle plant is located, samples were also taken from bottled water showing the presence of TCA.

To verify the results of samples taken in June 1990, a new round of samples was taken in the same wells in October 1990 (Table 1). The results still detected the presence of VOCs. This led us to believe there could be a stable source of pollution affecting them. Our project could not identify the source, but we considered that sewage intrusion could be a possible source of pollution in these wells. The deficiencies detected in the sewerage lines near the wells and the detected levels of VOCs in the municipal sewage support this hypothesis. Other potential sources of pollution could be the illegal discharge of industrial wastewater by those plants near the wells, or the location of illegal landfills of hazardous wastes in the area. In any case, it is important to have a detailed follow-up of this situation by the public authorities.

An effort was made by our project to identify the potential hazard areas in the city and the potential number of inhabitants in them. Using the same GIS created for Nogales, Sonora, we input the VOC results and isolated the number of inhabitants potentially exposed to them (Figure 4). We included the areas with sewerage maintenance problems linked to the main collector where significant concentrations of VOC were detected in the southern part of Nogales, Sonora (11). We also included those areas with water supplied from the polluted wells.

**Table 1.** Polluted urban well with VOCs and nitrate in the city of Nogales, Sonora, 1990.

| Sample Date          | 1,1-DCA | 1,1,1-TCA | TCE  | PCE  | NO₃ |
|----------------------|---------|-----------|------|------|-----|
| June 1990 Sampling   |         |           |      |      |     |
| Unidada Deportiva well | ND     | <0.5      | 2.2  | 5.7  | 7.1 |
| Coapaes well         | 2.2     | >15       | 4.2  | >15  | 12.6|
| La Tomatera well     | 1.8     | >15       | 4.2  | >15  | 12.8|
| October 1990 Sampling|         |           |      |      |     |
| Unidada Deportiva well | ND    | >15       | 2.2  | 5.7  | 7.1 |
| Coapaes well         | 2.2     | >15       | 4.2  | >15  | 12.6|
| Duplicate sample     | 1.8     | >15       | 4.2  | >15  | 12.8|
| La Tomatera well     | 1.3     | >15       | 4.2  | >15  | 12.8|

Abbreviations: 1,1-DCA, dichloroethane; 1,1,1-TCA, trichloroethane; TCE, trichloroethylene; PCE, tetrachloroethylene; NO₃, nitrate; ND, not detected. Data from Sanchez and Lara (9).

**Summary**

In summary, the results of our project showed important water quality problems in Nogales, Sonora, with potential important health consequences. Sewage-related problems appear as a major source of concern for residents of Nogales, Sonora. The high number of sewage spills in diverse parts of the city represent a health hazard.
for a significant number of inhabitants. The fast urban growth has surpassed the capacity of the municipal sewerage system, overloading existing lines and causing their rupture. The lack of urban planning and economic resources to finance the construction and maintenance of an infrastructure are two factors that explain the deterioration of the municipal sewerage system. Interviews with the health authorities in Nogales, Sonora, corroborated the importance of gastrointestinal diseases in this city. Despite the recent efforts by the state government to upgrade the sewerage system, the number of problems detected in our field work led me to believe that a more permanent solution will be achieved only in the mid term or long term. The illegal discharge of hazardous wastes into the municipal system add to the problems and health risks created by the deficiencies in urbanization and underdevelopment. Health hazards were also detected for those inhabitants with water supplied by truck (approximately 11% of the population). The presence of VOCs in three wells used to supply these inhabitants with water increases the level of hazards to which they are potentially exposed. A more detailed study on this matter should also be carried out. Since part of the population with municipal drinking water service also depends on other sources of water (water distributed by truck) due to the deficiencies in the operation of the municipal system (approximately 10% more of the population), the number of inhabitants exposed to polluted water could be potentially higher. Ironically, the social groups with lower income have to pay three or four times more per liter of poor quality water than the other social groups in the city with access to the municipal water system.

Conclusion

The problem of water pollution is one of Mexico’s big challenges. Problems associated with the supply of public services and incomplete urbanization are endemic in Mexico as in other developing countries. They are also one of the major health hazards, as evidenced by the outbreak of cholera and other water-related diseases in the past several years. The results of our study in Nogales, Sonora, showed that water quality problems are associated with fast urban growth with large gaps in the supply of public services, particularly sewerage and drinking water, and to the deficiencies in the maintenance and operation of these services. However, industrial growth has aggravated this situation. For almost two decades the border industry operated with little pressure to protect the environment and public health. As a result, one of the major environmental problems in all border communities is the deficient control of industrial hazardous wastes. The illegal discharge of these wastes into the municipal sewerage system aggravates the pollution of surface water and wells. Health hazards due to sewage problems are also aggravated by deficiencies in the supply of drinking water in Nogales, Sonora. Although our results did not detect pollution in the municipal water system, more than 20% of the population relies on other sources of water. The pollution of wells used to supply water by truck to these inhabitants and the lack of control in the quality of water delivered have to be considered health hazards. In fact, the presence of VOCs detected by our study in some of these wells calls for a systematic follow-up on the water quality of these wells.

Controlling these problems must be oriented to improving urban management in order to reduce the existing gap in the supply of key public services, water and sewerage, and to improve the maintenance and operation of existing facilities. Most of these actions are likely to get support from the North America Development Bank (NADBANK), created as a result of the NAFTA parallel negotiations, and from a recent loan from the World Bank to Mexico to improve the state of the environment at the U.S.–Mexico border. Promised investments through the NADBANK are oriented to improving the infrastructure at the U.S.–Mexico border. However, it is not clear at this point how long these investments will take and how are they going to be distributed by sectors and geographic area.

The control of illegal industrial discharges into the municipal sewerage system should be considered a high priority for all the border communities. Mexican legislation requires the pretreatment of all industrial discharges since the late 1970s. The same requirement was also incorporated into the new federal environmental law, in the state environmental laws, and in the new federal water law. However, Mexico’s major problem is environmental enforcement. Short-term structural actions to improve environmental enforcement have to be taken by Mexico. One of those actions could be to require all industrial areas, like the three in Nogales, Sonora, to collect and recycle wastewater from their plants. This would improve water management in the city, and at the same time it would reduce the number of potential illegal discharges into the municipal sewerage system.

Finally, it is important to incorporate a social approach to the study of the pollution problems at the U.S.–Mexico border. Our efforts to estimate the number of people potentially exposed to pollutants and their location in the urban area are a small step in this direction. It is clear that water management is not only a technical problem, as it is considered in Mexico and other developing countries, it is mainly a social problem with tremendous implications on the well being and income of the vast majority of the inhabitants in these countries.

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