Too Close for Comfort? The Proximity of Industrial Hazardous Wastes to Local Populations in Tijuana, Baja California

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This article assesses the location within Tijuana, Baja California, of those industrial hazardous wastes reported in compliance with the law in 1998. Although only a little more than 10% are high risk and very high risk, the plants generating the riskiest wastes hire the most employees and are clustered next to areas of population density and the highest concentrations of children younger than 14. Patterns of proximity are explained in terms of the decisions of key people such as maquiladora *managers, engineers, and urban developers. The majority of workers prefer their workplace located close to home, although parents with children at home express much less preference. Longtime residents and those with better jobs live farther away. The actions of civil society groups to inform and empower affected communities are reviewed, especially in the case of abandoned hazardous waste. Policies for avoiding and reducing risks and directions for future research are recommended.*

Very little is known about which industrial hazardous wastes are generated where in Mexican cities such as Tijuana, Baja California. *Maquiladoras* have been increasing in size and number in Mexico since 1965, and they are legally required to return imported hazardous materials to the country of origin unless they are rendered nonhazardous. However, neither business nor government very actively attended to this legal requirement until the late 1980s. This is due in part to what Barry (1994) called "the fierce resistance on the part of the maquiladora industry to share information about the quantity and nature of the chemical substances they use" (p. 61).

Mexico passed its first federal environmental law in 1988, which meant that there was little environmental inspection or regulation of maquiladoras for the first two and a half decades of their operation. Authorities appeared to become more committed to better industrial compliance with environmental law after public attention was focused on the U.S.-Mexico border during debates over the North American Free

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Trade Agreement in the early 1990s. Another reason data have not been available for public information or research is that Mexico has not had effective "right to know" laws (Corliss, 2000).

The lack of publicly available information about industrial hazardous waste means that Mexicans do not know exactly what dangerous substances are generated where, making it extremely difficult to guard against the negative effects of exposure or plan for emergencies. This paucity of data stands in stark contrast to the situation in the United States, the location of most maquiladora owners, where the Emergency Planning and Community Right-To-Know Act of 1986 created a Toxics Release Inventory. Anyone can now query this database online to find out which hazardous substances are generated in U.S. communities (see http://www.scorecard.org/general/tri/tri_gen.html).

The remainder of the article is divided into four sections. In the next two, we discuss the underlying theoretical concepts for this study, as well as the data and methodology used. The third section presents the findings. A picture is sketched of industrial hazardous waste generation and its proximity to local populations to fill some of the gaps in our knowledge. Then, we look at the social and political context to understand how factories became situated close to areas with particular populations. Workers' role in the creation of the spatial relationships between home and work is then investigated. The last section of the article makes policy recommendations aimed at avoiding the realization of the risks presented by industrial hazardous waste and suggests directions for future research.

The focus of this research is Tijuana because between 1986 and 1999, more hazardous waste imported to the United States was generated in this city than in any other Mexican border city (Kopinak, 2002, p. 101). Until 1997, the greatest quantities of hazardous waste imported to the United States from Mexico had been generated in the central part of the border, in Ciudad Juárez, and at the eastern end, in Matamoros. However, from 1997 on, the installation of large, Asian-origin electronics plants in Tijuana, Tecate, Mexicali, and San Luis Rio Colorado made the western end of the U.S.-Mexico border the location of the largest generators (see Figure 1). Not only was the generation of hazardous waste reterritorialized as more industries crossed borders and regions, but it also tripled in quantity.

This is part of the globalization process, which at the western end of the U.S.-Mexican border has been driven by the relocation of Asian-origin electronics production to Mexico, where it forms an industrial corridor producing computer monitors and TV tubes in the cities from Tijuana through San Luis R. C. (Kopinak, in press). The spread of export processing industries to less developed countries such as Mexico means an increase not only in their production of finished products but also wastes. Maquiladoras are industrial plants in Mexico that began produc-

Figure 1: Cities and *Municipios* at the Head of the Baja California Peninsula

ing exclusively for export in 1965, being allowed to import their supplies and equipment into Mexico duty free, process the materials there, and export the products with taxes paid only on the value added (Kopinak, 1996, pp. 7-18). The fact that more hazardous waste has been generated in Tijuana maquiladoras than in any other border city is consistent with the fact that in 1998, Tijuana was home to two thirds or more of the plants, employees, and value added produced by maquiladoras in the state of Baja California. In 2000, Tijuana was home to approximately 22% of the country's maquiladoras.[1]

However, the capacity to safely manage hazardous waste has not yet been developed in Mexico, especially at the northern border, where cities have grown very rapidly without adequate infrastructure. Antonio Sandóval, the Baja California representative of the Federal Prosecutor for Environmental Protection (PROFEPA is the Spanish acronym), said in January 1998 that the sewage generated by the maquiladora industry represented the most serious contamination problem in Tijuana and that finding a solution was one of his office's highest priorities ("Aguas residuales," 1998). This is complicated by the fact that Tijuana is the

1. INEGI Estadísticas Económicas. Industria Maquiladora de Exportación, Mayo 2001.

municipio[2] with the second smallest land surface in this area, so the approximately 1,000 maquiladora and nonmaquiladora industries that were located there in 1998 were very densely concentrated in a small space (see Figure 1).

Theoretical Considerations

To illustrate the locations of the generation of hazardous waste and the groups of people to which it is closest, we make use of geographic information systems, a tool from geography. A geographic information system has the advantage of being able to visually represent the results of complex analyses of large databases. Although this analysis is preliminary, it is useful to review some of the theoretical ideas on which it is based to appreciate its value. In the discussion that ends the article, recommendations are made for future research that would more fully utilize this tool.

Longley, Goodchild, Maguire, and Rhind (2001) said that "smoothness and irregularity turn out to be among the most important distinguishing characteristics of geographic data" (p. 98). Like much of Southern California, Tijuana was built over a historically active system of seismic faults, making most of its landscape jagged and irregular (see Figure 2). The first settlement occurred in the lower bed of the Tijuana River, which flows from the southeast to the northwest. The two sides of the river valley are characterized by very different geographic features. To the northeast of the river is a flat mesa 150 meters above sea level, called the Mesa de Otay, which dominates the valley. To the southwest are numerous deep canyons, making this area unsuitable for urbanization. Nevertheless, the city has spread rapidly in both directions, creating great vulnerability to flooding and landslides in many neighborhoods.

This irregularity has an important impact on the way that things that are near to each other might be related. Tobler's first law of geography says that "everything is related to everything else, but near things are more related than those far apart" (Longley et al., 2001, p. 61). However, this law must be applied with care in irregular landscapes because the degree of spatial heterogeneity in the landscape affects how those areas close to each other may be related. Spatial heterogeneity will influence the estimation of how far industrial hazardous wastes that are not confined may be carried by the air and in water. In other words, we have to take into account the lay of the land, direction of prevailing winds, and

2. *Municipios* are areas defined under Mexican law for the purposes of public administration. They may contain one city if that city is large, as in the case of Tijuana, or several cities.

Figure 2: Tijuana's Physical Setting
Source: Winckell et al. (2000, p. 20). Used with permission.

so forth to know which areas might be exposed to the risks presented by industrial hazardous waste.

Winckell et al. (2000, pp. 17, 40-44) argued that the current lack of seismic activity in Tijuana does not reflect the real state of danger that threatens the city and that an significant earthquake is quite possible. Should there be an earthquake at the 6.5 level of magnitude on the Richter scale, they argued, the location of most Tijuana industries is not good, with 99% of maquiladora plants and their employees located in the areas predicted to suffer damage. The degree of damage would depend on the seriousness of the earthquake, but they estimated that 19% of the maquiladora plants and 20% of the workers would be exposed to the highest risks. Sectorally, they predict that 21% of the plants and 25% of the workers in the electrical and electronics industries would be exposed to high risks. Because this is the most prominent industrial sector in the area, they concluded that an important part of the city's productive capacity would be paralyzed for a considerable period and that

> a refinement of these risks is recommended, taking into account the industries that handle hazardous materials, due to the danger that these substances pose, which might occur via explosion, spillage, or after an earthquake. The lack of reliable information in this regard makes such an assessment impossible in this work. (p. 44, authors' translation)

This article attempts a greater understanding of such risks with the analysis of data unavailable to earlier authors.

Sociological concepts also inform this study because economic globalization and the growth of new industrial regions are understood not

only via economics and geography but also by taking into account the subjective, the microsocial, and everyday life (Lindón, 1997, p. 179). For example, Winkell et al. (2000, p. 41) explained their assessment of risk not only in terms of geography but also as a result of decisions made by key people in the history of maquiladora growth in Tijuana, responsible for choosing the type of construction for buildings that house maquiladora plants. In this article, we will look at where and why different types of construction were utilized for maquiladora industries.

Not only are maquiladora owners important actors in understanding the proximity of local populations to hazardous waste generators, but the attitudes, characteristics, and behavior of their employees must also be taken into account. Environmental sociologists such as Pellow (2002) have noted that the "majority of environmental justice research utilizes communities as the primary unit of analysis" (p. 11). However, he argued that the community and workplace must be studied together because the same groups of people who are exposed to environmental risks in the community are also likely to confront similar risks at work. These groups tend to be the poor, people of color, and immigrants. He also pointed out that to understand environmental inequality, researchers must go beyond a focus on the representatives of corporations and government and study other stakeholders as well, including residents, workers, and environmentalists. This article includes evidence from each of these groups, addressing the question of how each contributes to the proximity between the sites of riskiest waste generation and local populations and how they may also engage in activities that would safeguard those closest (Pellow, 2000, p. 97).

Baja California's population was approximately 2,475,997 in 2000, half of whom lived in Tijuana. The rate of growth in this city is higher than in the rest of the country because it has historically been a receiving area for migrants. Following Pellow's (2002) suggestion cited above about how immigrants tend to be exposed to environmental risks in both the community and the workplace, it is predicted that recent migrants to Tijuana, especially those from deindustrializing areas of Mexico, will live closer to the factories in which they work than will longer term residents. It is also predicted that women will live closer because their work in the home might make it convenient. As Burawoy (1985) has noted, "at the same time as [workers] produce useful things, [they] produce the basis of their own existence and that of capital" (p. 123).

Data and Method

To address the question of where in Tijuana hazardous waste is generated, data were gathered from government sources in both Mexico and

the United States. An index of risk was then constructed to differentiate the dangers represented by the substances found. To find out how closely industrial hazardous waste was located to residential populations, the hazardous wastes were mapped and overlaid with mid-1990s census data of population and age group density. A secondary analysis of a survey of workers was carried out to find out about how close to work they lived and why. The remainder of this section elaborates on the data sources and considers their strengths and weaknesses.

GOVERNMENT SOURCES

By Mexican law, generators of hazardous waste must report twice annually to the Secretaría de Medio Ambiente, Recursos Natuales y Pesca (SEMARNAP, renamed SEMARNAT in 2001). Data were requested for this study from SEMARNAP in Tijuana and Mexicali in October 1998 on the type and quantity of hazardous waste generated in Baja California during that year. Only the Tijuana office agreed. Plant representatives brought the reports to the SEMARNAP office as hard copies, where they were then stamped as received and filed. SEMARNAP's Tijuana personnel recorded data from each report made to them in 1998 for this study, taking approximately 1 year of part-time work by several people.

This research is unique in being the first to have access to such data, although it is not without its drawbacks. The data appeared incomplete, with several companies listed as "not generating" any hazardous waste in 1998, even though this was difficult to believe in the case of very large plants known to have been operating during that year. SEMARNAP does not verify the reports industry submits; inspection is the task of PROFEPA. SEMARNAP is not responsible for ensuring that companies are reporting the truth or that they have not in fact generated any hazardous waste when they fail to report.

To supplement this information, the U.S. Environmental Protection Agency's (2001) *Haztraks* database was used. This was done for plants that were listed as "not generating" hazardous waste in 1998 by SEMARNAP but were listed by the Environmental Protection Agency as importing hazardous waste from Mexico to the United States during that same year. A limitation of the *Haztraks* database is that it includes only hazardous waste that is imported into the United States. If a company buys hazardous material in Mexico for use there, it does not have to be exported by law. For these reasons, we consider the results of the dangers represented by these data to be underestimates. However, we also considered the data valuable due to the difficulty of constructing a database with the plant as the unit of analysis.

The database begun at Tijuana's SEMARNAP office lists plant name and waste generated in kilograms for the following substances: spent oils, pitch or tar, heavy metal slag, liquid waste, sludge, solids, spent sol-

vents, and corrosive substances. More variables were then added to this database. We assessed which plants were legally registered as maquiladoras and which were not. The latter were often domestically owned manufacturing companies and auto mechanic garages. These data were then integrated with other variables such as address, product, and so forth, which had been collected for previous work done to map the location of plants by sector and size (Kopinak, in press).

INDEX OF RISK

An index of risk was constructed, comprising four separate criteria: type of danger, concentration, effects on health, and emergency response. First, the environmental risk criteria are those deemed hazardous under Mexican law: corrosive, reactive, explosive, toxic, inflammable, and biologically infectious (CRETIB) (see Diario Oficial de la Federación, 1993). Then, risk at work is defined under Mexican law as particular threats to safety and health in the workplace and includes the specification of the concentration of particular substances that are dangerous to the worker's health and safety (see Diario Oficial de la Federación, 1994a, 1994b). The third criterion evaluates whether the results of exposure on health might be short-term acute, long-term acute, medium-term chronic, or long-term chronic effects. The final criterion gauges the possible reactions to emergency exposure—whether a rapid and efficient response, an efficient but slow response, a slow and inefficient response, or a very slow and inefficient response is likely.[3] Each of these criteria was taken into account in assessing the productive process at a plant and coding a level of risk that would reflect all four factors.

The index has four levels—minimal, moderate, high, and very high—which were used to code all reports of hazardous waste generation in Tijuana in 1998. A hazardous waste report was assessed as having minimal risk, for example, if it had only one danger (out of the five possible CRETIB), a low level of concentration in the workplace, acute short-term effects on health caused by exposure, and a rapid and efficient response in case of emergency. The risk was assessed as very high if there were five or more dangers, a very high concentration in the workplace, chronic long-term effects on health caused by exposure, and a slow and inefficient response in case of emergency.

The index of risk assumes that all hazardous wastes are handled properly and according to the law. It does not include any consideration of hazardous wastes that are handled improperly, such as liquids or solvents from a production process that go down the drain. This does hap-

3. This was adopted from the 1996 *Guia Norteamericana de Respuesta en Caso de Emergencia*, published by the U.S. Transportation Department, Transport Canada, and the Secretaria de Comunicaciones y Transportes de México.

pen given that measurements taken at the South Bay Waste Water Treatment Plant often show spikes of hazardous materials. For these reasons and others, the index underestimates the risks of industrial hazardous waste.

The assessment of risk in this article refers to the possibility for damage that industrial hazardous waste presents. The extent to which these risks are actually realized is not assessed in this article. This is quite appropriate, however, because the idea of possible damage is embedded in the definition of hazardous waste. The Environmental Protection Agency (see http://oaspub.epa.gov/trs/trs_proc_qry.alphabet?p_term_nm=H) defines it as

> a subset of solid wastes that pose substantial or *potential* threats to public health or the environment and meet any of the following criteria:—is specifically listed as a hazardous waste by EPA [Environmental Protection Agency];—exhibits one or more of the characteristics of hazardous wastes (CRETI). . . . A waste with properties that make it dangerous, or *capable* of having a harmful effect on human health and the environment.[4] (italics added)

SURVEY OF WORKERS

To assess the role maquiladora employees play in the proximity of industrial hazardous waste to residential communities, we carried out a secondary analysis of a random survey of 767 direct workers employed in 102 Tijuana maquiladoras in the electronic (41.3%), clothing (24.4%), and other (34.3%) sectors. Some works focusing on rotation have been completed, which partially analyze the data (Barajas & Sotomayor, 1995; Carrillo & Santibáñez, 1993). These data were appropriate for the current study because the survey was administered to a large, random sample of workers and it is the only one available containing information on the places where workers lived. Respondents were asked in which *colonia*, *fraccionamiento*, canyon, or section of the city they lived, and what colonia was next to it.[5] The locations of the 102 maquiladoras where they were employed was also known.

Incorporating an analysis of these data makes the study a multilevel one, with data based on the individual as the unit of analysis linked with that using the plant as the unit of analysis. The survey also included

4. Note that the acronym for hazardous wastes is CRETI in the United States and CRETIB in Mexico, due to the fact that biologically infectious waste is defined as hazardous in Mexico but not in the neighboring country.

5. Mexican cities such as Tijuana are divided up into internal regions called *delegaciónes* and then into smaller spaces called either *colonias* or *fraccionamientos*. The latter tend to be middle-class areas, and only one worker in the sample lived in the same fraccionamiento as his or her plant. This case was added to the closest value, living within the same colonia as the plant.

other items hypothesized to be relevant for understanding the relationship between where workers lived and worked, such as their gender and family situation, their place of birth, their reasons for choosing the plant where they worked, and so forth.

We examined the location of the colonias where respondents lived in relationship to the plants where they worked in approximately half of the original questionnaires to conceptualize the spatial relationship between workers' homes and workplaces. When workers lived in the same colonia as their plant, home and work were defined as most closely located in space relative to each other. The next closest distance from home to work was defined as homes located in a colonia adjacent to the colonia in which their plant was located, with the two colonias sharing a common border. As will be seen in the analysis below, these first two categories may be collapsed into one category, which is considered the smallest distance between home and work because workers employed in industrial parks cannot very easily live in the industrial parks. The closest they may be able to live is in the adjacent colonia.

Next, workers might not live in the same colonia as their plant, or adjacent to it, but could be seen to be living in the same zone as their plant considering connectivity via transportation routes. The spatial relationship between home and work was considered further away if workers lived within the same *delegación* as their plant, but close considering transportation routes. The next furthest category was living within the same delegación but far away from the plant considering transportation routes. The last two categories were living in a different delegación than the plant but close via transportation routes and living in a different delegación and far away via transportation routes. We created a new variable, called distance between home and work, and coded all surveys on this new variable, giving each respondent one of the above values for the variable.

Frequencies of the different values were computed and showed considerable variation, with the respondents spread across the values. The frequencies are reported here from the farthest to the closest distance between home and work. Almost a third of respondents (31%) lived farthest away from their workplace, in a different delegación than the plant and poorly connected by transportation routes. A little more than a tenth (11.5%) lived in a different delegación than their plant but were close via transportation routes. More than a fifth (23.5%) lived within the same delegación but close when considering transportation routes. Another third of the sample lived even closer, with 13.7% in the same zone as the factory, 14.8% in an adjacent colonia, and 5.6% within the same colonia as the plant.

OTHER SOURCES OF INFORMATION

As noted above, data collected from government sources contained information on only those companies complying with the law by reporting how much hazardous waste they generate and import to the United States from Mexico. Such companies may very well be those that would guard against the risk of hazardous waste, because they have complied with the reporting requirement and know they are legally responsible to do so. There is no inventory of those who violate the law even though they should be considered to get a full picture.

Tijuana is also the home of the worst case of hazardous waste abandoned on the border, the former maquiladora Metales y Derivados. As the findings will indicate, it is in the same industrial park as the largest cluster of hazardous waste generators who reported to SEMARNAP. In October 1999, the subdirector of PROFEPA in Tijuana said that the case of Metales y Derivados was only one example of the many companies found to be illegally contaminating their sites and communities that have not proceeded effectively (Tejada, 1999). The case was investigated by the secretariat of the North American Commission for Environmental Cooperation (CEC), and a factual record of everything that is known about this case was published. Information from this factual record is included due to its very high reliability, to show what can happen when companies are less environmentally responsible. The goal is to balance the information from those who comply with the law with additional information about those who have not.

Environmental activists and maquiladora workers are quoted to include the voices of those we are studying. Newspaper articles are used to update information and as illustrations to give a sense of the concreteness of place.

Findings

PROXIMITY OF INDUSTRIAL HAZARDOUS WASTE TO PEOPLE IN THE WORKPLACE

The findings regarding how much hazardous waste at what risk level was reported by which plants has been reported previously and is summarized here (Kopinak, 2002, 106). In 1998, there were 348 reports of hazardous waste generation, which totaled 23,590,219 kilograms. After coding all plants by level of risk, and dividing them into maquiladora and nonmaquiladora regimes, the results indicate that almost half of all kilograms (49%) fell into the moderate-risk category, and 40.5% fell into the

minimal category. Only a twentieth of all kilograms (4.9%) were high risk, and 5.6% were very high risk.

Those plants that were not maquiladoras were responsible for only a very small quantity, 4% of all kilograms of hazardous waste reported, and 8% of all reports. Moreover, 92% of nonmaquiladora plants' hazardous waste is at the minimal-risk level. Maquiladoras generate all of the hazardous waste coded as having very-high risk, 98% at the high level, almost all at the moderate level, and 91% at the minimal level.

A relatively small number of plants generated high- and very-high-risk hazardous waste. Four plants made two reports each in the high-risk category, 2 making metal components for electrical products, 1 making furniture, and 1 making motorbikes. Other single reports came from 7 furniture makers, 6 electronic equipment plants, 4 making plastic products, and single plants in other areas such as optical lenses, films, and jewelry. Very-high-risk reports were turned in by even a smaller number of plants, with 4 of the 17 plants turning in two reports each. These plants made optical lenses, plastic cabinets, and covers for electrical equipment and did electronic assembly and manufacturing of all kinds. Single reports in the very-high-risk category were turned in by plants making surgical instruments, metal washers, and electrical equipment.

Although Tijuana is known for having more small-size plants than other industrial border cities, plants generating high- and very-high-risk hazardous waste were large. Plants generating high-risk hazardous waste had an average of 845 workers per plant, and plants generating very-high-risk hazardous waste had an average of 1,718 workers per plant. Plants at the moderate level averaged 367 workers per plant, and those at the minimum-risk level 159. Because they are bigger, plants that generate high- and very-high-risk hazardous wastes could expose more people to greater risks than the typical Tijuana plant, which employs fewer workers and generates hazardous waste with lower risks.

High-risk reports contained more than one toxic substance, most often solids, although spent acids and liquid waste were also present much of the time. Pitch was not one of the wastes generated by high- and very-high-risk plants, and corrosives were generated by only 1 high-risk plant and 2 very-high-risk plants. The dangers presented by the substances in the 37 high-risk reports were also multiple, with all coded as toxic, 33 coded with one or more substances that were both toxic and flammable, and 4 reports containing substances that were corrosive. All of the high-risk reports listed solids, 13 of them solvents, and 12 of them spent acids and liquid waste. Each high-risk report also warranted multiple danger codes, with all being coded toxic and both toxic and inflammable for at least one substance, and 2 being coded corrosive.

PROXIMITY OF INDUSTRIAL HAZARDOUS WASTE TO LOCAL POPULATIONS

While the previous section showed that only about 11% of the hazardous waste generated was at the high- and very-high-risk levels, this was quite concentrated spatially. The Ciudad Industrial area was the place with the largest cluster of high- and very-high-risk hazardous waste, with 24% of all kilograms reported as generated at the two highest levels. This industrial park is located on top of the Mesa de Otay and was designed and built as an export platform during the 1970s. Plants here tend to be large and produce capital and intermediate goods for export and also for the consumption of people living in the densely populated colonias surrounding these parks. Nueva Tijuana, for example, which is to the northwest of Ciudad Industrial and between it and Frontera Business Park, is a residential community for people who work in the industrial parks.

Figure 3, which is a map of hazardous waste by risk, layered over population density, shows that the colonia Nueva Tijuana falls into the second highest population density category for the city's colonias, with a population of from 4,842 to 12,936 people. Ciudad Industrial is indicated in Figure 3 by vertical bars, and the area to the south and west of this industrial park also has the second highest population density.

A common strategy of managers trying to deal with high turnover in the labor force is to move out of industrial parks and into residential neighborhoods so that workers live closer. Figure 3 shows two plants at the moderate-risk level on the northern edge of Nueva Tijuana and one plant at the high-risk level to the east of Ciudad Industrial in the colonia Torres del Matamoros, which also has the second highest population density.

The delegación in which these parks are located is the Mesa de Otay. Industry prefers tabletop land over the steep slopes that characterize much of the city because the latter make access and delivery difficult and expensive. The Tijuana airport is also located on top of the mesa, next to the industrial parks, and one generator at the high-risk level and another at the very-high-risk level are at the airport. Hazardous waste generated on the high mesas can blow and/or flow downward to the residential districts below.

One case in which the very-high-risk potential of hazardous waste generated in Ciudad Industrial has been realized is the former site of the maquiladora company Metales y Derivados, which is in the southwest corner of Ciudad Industrial. This plant was closed for violations in 1994 by PROFEPA, the government agency responsible for enforcing Mexican environmental law, whereupon the owners abandoned the facility. The parent company, New Frontier Trading Corporation, is based across

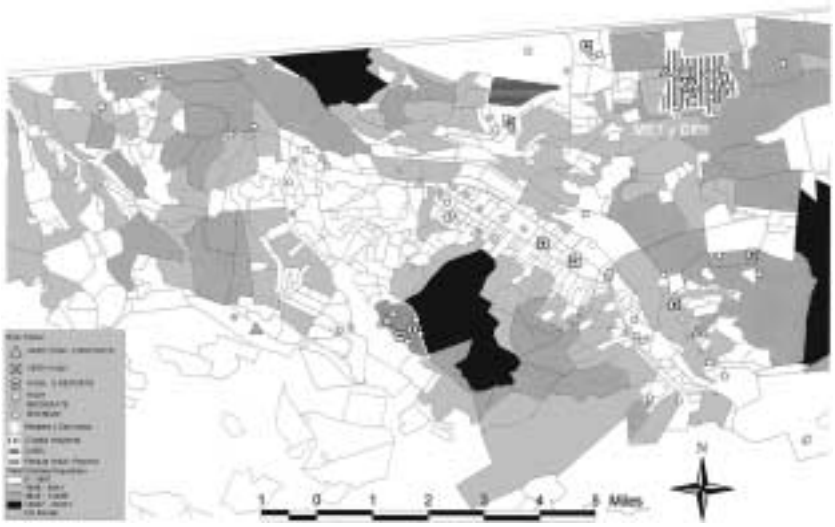

Figure 3: Locations of Hazardous Waste (1998), Classified by Contamination Risk Factors/Total Population

the border in San Diego, where the owners live and do business with impunity. According to the factual report of the CEC, the volume of hazardous waste still remaining above ground in 2002 was 7,265 cubic meters. It is estimated that the volume of contaminated soil below ground was an additional 4,094 cubic meters. The contaminants are highly toxic lead, arsenic, and cadmium (CEC, 2002, pp. 32, 33). The site has not been remediated; nor have the contaminants been effectively contained to stop them from blowing in the wind or flowing away with the rain.

In a study of Nogales industrial hazards, Cervera (1998, p. 57) used the distance of 500 meters to establish zones of risk around industrial sites, but topography must be taken into account. The irregularity, or spatial heterogeneity, of Tijuana is important in understanding who might have been exposed since 1994. The abandoned factory sits 135 meters from the edge of the Mesa de Otay, with the residential community of colonia Chilpancingo 45 meters below (CEC, 2002, pp. 20, 23).

Approximately 1,000 families live in this colonia, and many residents argue that the incidence of cancer and skin ailments is higher than would be expected by chance due to the brownfield site. Evidence provided by PROFEPA indicates that it poses a major health risk and that the influence of the contamination is approximately 2.5 kilometers in the direction of the prevailing wind, which blows to the northwest most of the time and to the southeast less often (CEC, 2002, pp. 25, 37, Figure 2). The

area to the northwest contains other factories in which workers could be exposed, mobile food vendors who circulate through the industrial park several times a day, and the residential community of Nueva Tijuana just beyond. Colonia Chilpancingo lies to the southeast and is bordered on its south side by Alamar Creek.

Another study of blood levels in children has suggested that the wind may carry the pollutants to residential communities to the northeast. Colonia Chilpancingo is located in the Cañon del Padre, a large ravine adjacent to the southern edge of the Mesa de Otay, with the Alamar, which flows from Tecate into the Tijuana River, at the bottom of it. Metales y Derivados had been identified as a potential polluter of the Alamar in 1992 and, earlier in 1987, had removed piles of lead oxide and lead slag it had dumped into the creek (CEC, 2002, p. 36). The fact that these very risky hazardous wastes have sat, mostly unconfined, on the top of a mesa adjacent to residential neighborhoods for 8 years (at the time of writing) is an indicator of the failure of mechanisms set up to regulate the management of industrial hazardous waste.

Returning to the analysis of data on legally reported hazardous waste generated in 1998, Parque Industrial Pacifico is found to be the location of the second largest cluster, with 15% of the total at the high- and very-high-risk levels. This industrial park is very close to highly populated residential areas, and some people live within a few hundred feet of plants in the park. Figure 3 indicates Parque Industrial Pacifico with diagonal bars in the center of the map, with the adjacent colonias to the east, Camino Verde, Ampliacion Camino Verde, and Anexa Sanchez Taboada, having the densest populations of the city's colonias, from 12,937 to 33,421 people each. Since the mid-1990s, when the census data illustrated in these maps were collected, housing has been built to the southwest of Parque Industrial Pacifico as well.

Other plants generating almost 29,000 kilograms of high- and very-high-risk hazardous waste are located right across the street from the state university of Baja California (horizontal bars illustrate where the university is in Figure 3), on the eastern edge of the Parque Internacional Tijuana. There was a great deal of opposition to building this industrial park right next to the university when it was developed, and the generation of high-risk hazardous waste on the side facing the school is cause for concern.

The so-called spine of Tijuana, the wide roads that parallel the canalized Tijuana River, contains two more very-high-risk hazardous waste generators, two high-risk generators, and several moderate- and minimal-risk generators. Figure 3 shows this area to be the least densely populated, with from 0 to 1,607 people living in the colonias and *fraccionamientos*. However, the plants generating hazardous waste there are adjacent to many stores and businesses frequented by shoppers and heavy traffic. If waste is dumped in this location, it is likely to end up in

the Tijuana River, which carries it across the border, where it settles in land on the U.S. side and drains into the Pacific Ocean.

What kinds of high and very high risks are posed by these hazardous waste generators? Among those coded as producing hazardous waste of very high risk, the Asian-origin maquiladoras tend to specialize in the making of plastic cabinets for electronic appliances, more than the U.S.-origin plants in this same category. They produce far more liquid waste, sludge, and solids than U.S.-origin very-high-risk hazardous waste generators and about the same amount or less of solvents. Without adequate ventilation and the use of protective gloves and glasses in the workplace, short-term negative effects of working with such plastics include irritation of the eyes, nose, skin, and throat. Long-term effects include damage to the lungs and asthma, as well as cancer of the liver and lung.

There has been insufficient attention by researchers to the health impacts of maquiladora employment. However, a small but growing literature is beginning to address this issue (Cedillo, Harlow, Sánchez, & Sánchez, 1997). Almost all maquiladoras in Tijuana, and especially those in the electric and electronic sectors, use organic solvents and heavy metals. Organic solvents have negative effects on the nervous system, have carcinogenic effects, and can negatively affect the blood, liver, kidney, and cardiovascular systems. Exposure to heavy metals can lead to skin disorders, lung cancer, acute gastrointestinal symptoms, osteoporosis, respiratory disorders, and other problems. The degree of damage is dependent on the toxicity of a hazardous substance, the form and duration of exposure, and the dose and concentration to which one is exposed.

Other factors, such as diet, may influence how negatively one may be affected if exposed to hazardous materials. Those who are undernourished are more likely to suffer negative consequences. Carruthers (2000) administered dietary questionnaires and took blood samples from women maquiladora workers in Tijuana and Ensenada. The results indicate that more than half of the women studied did not consume sufficient foods with adequate nutritional value and that all women workers of childbearing age should be taking multivitamin and mineral supplements, as well as being encouraged to eat a wide variety of foods. The food choices of the women maquiladora workers studied were "severely constrained by poverty and by the fact that at least one meal a day is prepared for them at their place of employment" (Carruthers, 2000, p. 22).

It is disturbing to find that colonias with the highest concentrations of children younger than 14 years of age are located right next to the clusters of plants generating high- and very-high-risk hazardous wastes—to the south and west of Ciudad Industrial, below the Metales y Derivados site, and next to Parque Industrial Pacifico. Figure 4 shows that Ciudad Industrial and the abandoned Metales y Derivados site are ringed to the south and east by the highest concentrations of children younger than 14

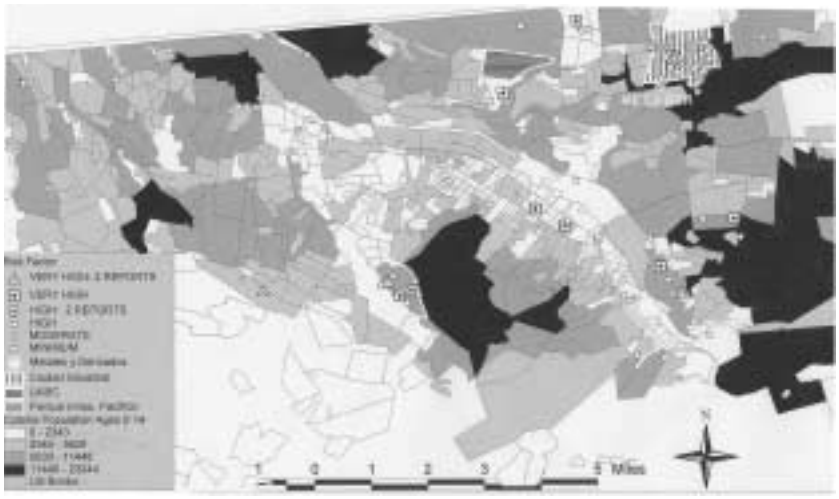

Figure 4: Locations of Hazardous Waste (1998), Classified by Contamination Risk Factor w/0-14 Population

in Tijuana, from 11,449 to 23,244 children per colonia. Figure 4 also shows that the colonias adjacent to the eastern and southern side of Parque Industrial Pacifico have the highest concentrations of children in the city. Children suffer a much higher risk than adults do when exposed to hazardous waste. They are negatively affected by exposure to smaller amounts, and exposure can have more permanent negative effects. Exposure to lead is particularly harmful, causing hyperactivity and mental retardation in children.

Researchers have been urged to not only "uncover where the people and hazards are located; [but] also provide a social and political context for environmental policy and environmental struggles" (Pellow, 2002, p. 13). In the remainder of this subsection, we interpret the above findings via a political economy of maquiladora growth in Tijuana. We show that only a partial explanation is afforded by the general arguments usually made about the chaotic result of the lack of regulation inherent in rapid industrialization and the less developed character of cities such as Tijuana. Particular individuals and occupational groups can also be understood as responsible for consciously planning and executing urban and industrial growth in a way that intentionally caused this proximity.

The Tijuana government began to regulate industrial location only in 1984 and has not always enforced zoning regulations that would maintain a greater distance between industrial plants and densely populated areas. Medina (1992) found that in the late 1980s, only one quarter of all manufacturers in Tijuana were located in areas officially zoned for

industrial land use. Of the workers surveyed in the early 1990s, more than half (56.8%) worked in plants in industrial parks or centers. The remainder worked in plants located in areas where there are not necessarily great distances between factories and homes: 29% in *fraccionamientos*, or middle-class neighborhoods, and 13.6% in a *zona popular* (working-class neighborhood) or colonia.

Regulation of industrial land use by public authorities has improved somewhat. In Ensenada, in the last half of the 1990s, government authorities gave some export processors (i.e., maquilas, pitex, altex[6]) commercial permits to locate warehouses. The company managers understood the permits to allow industrial land use and set up fully functioning assembly and manufacturing units in areas without adequate space for transport, security measures, fire protection, or evacuating workers quickly in case of emergency. At the end of the decade, authorities were pointing out that these firms did not have permission for industrial land use and asked them to relocate themselves to protect their employees and neighbors and to ensure the orderly growth of the city ("Industriales," 1999).

One of the reasons for the lack of regulation of industrial land use in the beginning of maquiladora growth in Tijuana, from 1966 to 1970, may have been the indifference of local authorities, who were more concerned with the traditional business and service economies. They tended to see the maquiladora program as imposed by the federal government from the center of the country. Individual firms established maquiladoras as cost-reduction centers, often housing their plants in old buildings that had previously served as barns or chicken coops (Quintero, 1997, p. 67). These were established in the delegación of La Mesa, on low-lying land, which had wells for irrigated farming until the mid-1950s, when water became scarce (see Figure 2). When maquiladoras later became more permanent, the first industrial parks arose around these pioneering plants, and local entrepreneurs became interested in investing.

Once industrial parks began to grow in the 1980s, local entrepreneurs became involved in land speculation, and it became public policy to include workers' housing in the plan for new parks such as Ciudad Industrial, which would contain plants built for industrial use (Negrete, 1988, p. 67). Alegría, Carrillo, and Alonso-Estrada (1997, pp. 197-199) have shown how the contemporary maquiladora boom is not without local roots, arguing that entrepreneurs in Mexico's northern border cities have imported commercial products from the United States since the

6. The pitex and altex programs are Mexican laws passed after maquiladora legislation was introduced in 1965, and they offer foreign companies many of the same advantages of the maquiladora legislation (i.e., tax exemption), in an attempt to attract more investment. Companies coming to Mexico under the pitex and altex legislation remain small in number and engage in similar activities as maquilas.

1930s. They contributed to maquiladora growth by negotiating border development policy and transferring surpluses from one sector to another in their own investment portfolios.

It should be noted that whereas many of the older buildings housing maquiladoras in La Mesa that were not designed for industrial use would not withstand flooding or earthquakes, neither would many of the new ones especially designed for this purpose. Winckell et al. (2000, p. 41) said that the most recently constructed factories made of welded metal and held up by vertical posts are too light to withstand the considerable lateral forces an earthquake might present. Nor do they consider block walls or prefabricated structures to be sufficiently solid.

Land speculation also increased prices so that the best land, that which was stable, flat, and easily accessible, could be afforded only by maquiladora companies. It is especially desired by large companies that wish to minimize movement of supplies and products and be close to suppliers that they might require to locate within the same industrial park. Topography is especially important because the deep canyons make transportation and communication difficult.

Tijuana is also famous for its engineers, who have "endogenized" maquiladoras by convincing multinational corporations to bring more production and skilled jobs to the city (Contreras, Alonso-Estrada, & Kenney, 1997). A small group of male engineers, educated in the same local public schools, established themselves in a few plants in the early 1980s, before Tijuana maquiladoras boomed. These individuals constructed a social network, which they managed adroitly to encourage investment, selling multinational corporations an optimistic bill of goods about the stability of the Tijuana labor force, which they confidently argued they could deliver. In the early years of Tijuana's industrialization, they taught engineering classes in the Tecnológico (Technological Institute) and maintained close ties with other nearby public schools and many new educational institutions that trained maquiladora personnel. This small, tightly knit network participated in both education and maquiladora production, which resulted in the spatial relationship now observed between the educational and production systems, that is, the closeness of schools to important industrial zones, especially Ciudad Industrial. Hualde (in press) said that "this physical proximity helps in the daily interaction and mutual understanding of the individuals who participate in each one of the systems" (p. 136, authors' translation).

As Ruiz et al. (1998, p. 57) argued, there are many zones in Tijuana that suffer from a lack of services, weak infrastructure, multiple sources of contamination, and unstable topography, which predispose them to flooding and mudslides during heavy rain. Not only does dust blow and sludge flow down on the residential colonias from Ciudad Industrial, but the river itself carries wastes coming from other industries as far away as Tecate. There are three rivers in Ciudad Industrial/Nueva

Tijuana that flow into Alamar Creek (Negrete, 1988, p. 68). Many of the residential areas along the riverbank are irregular; that is, they have not been planned or serviced by the city administration. People have just moved in and constructed dwellings in many areas as well as this one, resulting in the fact that 45% of the state's housing is irregular ("45% de las viviendas en BC," 1999). During the heaviest 1998 rain, people living along some parts of the Alamar had to be moved to safer areas.

WORKERS' ROLE IN CREATING THE SPATIAL RELATIONSHIP BETWEEN HOME AND WORKPLACE

Maquiladora employees made up a little more than 29% of the economically active population in the city in 1997. Maquiladora workers outnumber technicians and managers by about five to one. Research based on information from only the top 20% ignores an important part of the population influencing urban structure.

In fact, the majority of workers surveyed expressed a preference for living close to their workplace. When asked what they liked best about the location of their plant, more than half (56.3%) said its location close to their home, whereas only 3.2% said what they liked best was the plant's distance far from home. When asked why they had chosen to work where they did, workers responded that it was due to the plant location more than a fifth of the time (21.5%). This answer was a close second to work environment (22.8%) and more frequent than wages (15.7%), hours of work (12.8%), relatives working in same plant (7.7%), friends working in the same plant (6.9%), and bonuses (2.4%).

Women reported living close to work somewhat more often than men, with 52.5% of women being in the four closest categories, while 45.8% of men were, a difference of 6.4%. The gender gap widens a bit when we look only at heads of households, with women heads living in the four closest categories 50% of the time, and men heads 42.6%, a difference of 7.4%. Women said that what they liked best about their plant was its closeness to home 58.6% of the time, more often than men, at 53.3%, a difference of 5.3%. However, considering only those respondents who had one or more of their children living at home with them, the level of preference for living close to work falls greatly, even though the gender gap increases, with 38.7% of women, compared to 25.4% of men, answering that the best thing about the location of their plant was its closeness to home, a difference of 13.3%.

This decline in the level preferring to live close to work is due to the fact that most of the respondents without children were very young people who lived at home with their parents. Less than 5% of respondents reported studying at the same time as they worked, and these people were slightly less likely than expected to think the best thing about the location of their plant was its closeness to their home. Thus, the reason

for young workers without children's preferring to live close to their place of work does not have to do with the reasons schools were located close to plants generating hazardous waste, as Hualde (in press) has demonstrated is true for managers.

Gender alone accounts for a small difference in preferences for living close to work. However, it interacts with other variables such as a worker's relationship to the head of the household, whether the worker's children are present at home, and age in ways that support the argument that production in the workplace and reproduction in the home are linked.

Whether workers have family and friends in a city who might help with housing also depends on whether they have migrated and from where they have come. Almost a fifth (18.3%) of the sample had migrated from Mexican states that experienced deindustrialization and/or economic recession in the 1980s and had sent large numbers of their inhabitants elsewhere.[7] These people were overrepresented among those who lived in the same colonia as their plant, making up 48.3% of all those who lived there, which is the closest category. Interestingly, they were somewhat underrepresented among those who said the best thing they liked about the location of their plant was its location close to home.

New migrants to Tijuana are less settled and probably have less choice about where to live. They may be living in the closest area to the workplace because getting a job and finding a place to live are the first two priorities of newcomers. This is supported by the finding that those who had lived at their current address for the shortest time tended to live closer to the workplace. Workers with 1 year or less at their current address lived in the three closest categories of the variable measuring distance between home and work 37% of the time, whereas the proportion for those who had lived where they did for up to 5 years was 25.2%, and for those with 5 to 10 years' tenure at their current address, it was 19%. Of those who had lived at their current address for more than 10 years, 41.9% lived farthest from work, outside of the delegación where their plant was located and far away via transportation routes.

Respondents with better jobs tended to be overrepresented among those living farthest away from their plants. Almost a third of all workers lived in the farthest category, in a different delegación than their plant and far away considering transportation routes. Although good jobs were not held by many respondents, because this was a random sample of workers and not technicians or administrators, those who worked in more desirable jobs such as the warehouse, quality control, design, tagging, and computer testing lived farthest away approximately two thirds of the time or more.

7. These are people from central Mexico, the states of Aguascalientes, Guanajuato, Hidalgo, Mexico, Morelos, Queretaro, and the Distrito Federal.

When asked about the most important working conditions, respondents ranked wages as most important (34.4%), health and safety second (18.5%), company transportation third (12.5%), credit for housing fourth (11.7%), company cafeteria fifth (9.6%), and promotions sixth (9.0%). The value of credit for housing was sensitive to how far away workers lived, with those living farthest away from their place of work naming this as the most important working condition 46.3% of the time. Only 3.8% of those living in the same colonia as their plant named credit for housing the most important working condition. Those who live closer to their plant may rent more often than expected because the value of land near plants is very high and may not be affordable for workers even if they have credit to buy housing. Those living farthest away must consider that there is more possibility of investing in their own home.

These findings from the survey of workers suggest that although the majority of workers prefer their workplace to be close to their home, the perception of how close is comfortable may vary. The fact that more established workers (i.e., those who had lived at their current address the longest and those with better jobs) lived farther away indicates that when workers have resources and stability, they choose to be farther away. On the other hand, those less advantaged, such as migrants from areas of the country with high unemployment, may live close to their workplace because they have few other options when they are newcomers.

In maquiladora centers at Mexico's northern border such as Tijuana, there has been rapid urban expansion, usually before services are installed. However, industrial parks are often better serviced than other areas of the city to encourage investment. Workers living close to work may be able to take advantage of such services. Those who lived closer to work had better infrastructure. More than half (53%) of the entire sample said they had running water at home, but three quarters (75%) of those living in the two categories closest to their plant said they had water at home. Only 39.5% of the sample reported having their houses connected to sewers, whereas 54.1% of those living in the two categories closest to work lived in houses connected to sewers. There was also a greater proportion of those who lived in the three closest categories to their plant (70.9%) who said they have public telephones in the colonia where they lived, compared to the sample as a whole (59.9%). The consistency of the direction of these findings indicates that in developing societies with insufficient infrastructure, there may be some advantages to living close to work.

We turn now to the social and political context to interpret these findings. Surveys are snapshots of reality at one point in time, and it is advisable to qualify their results with other evidence to understand why workers might prefer to live close to their workplace and why there are high concentrations of children younger than 14 years of age near the

highest risk hazardous waste, especially those around Ciudad Industrial and the former plant of Metales y Derivados.

We point to the fact that maquiladoras pay low wages, even though the cost of living is high in Tijuana. Because the average maquila wage in Tijuana is lower than that of the region, maquiladora workers are more likely than those in other sectors, such as services and business, to be classified as moderately and extremely poor (Palomares León, 1996). Many workers cannot afford to buy or rent housing for their families and so have illegally invaded lands that have no services. Even when they can afford to rent or buy housing, there is not sufficient available. In 2000, it was estimated that Tijuana needed 11,360 lots and 33,870 houses to meet demand in that year (Guzmán, 2000). Local governments receive very little from taxation and thus have few resources to invest in infrastructure. Those with the fewest resources end up on the poorest land. This means that the most available and affordable place to live for many maquila workers, especially those who have moved to Tijuana recently, is often below the mesas on which the industrial parks are built or on the slopes of the mesas.

When asked why people live so close to the contaminated Metales y Derivados site, Connie Garcia of the Environmental Health Coalition, a nongovernmental organization affiliated with the community group in colonia Chilpancingo, which is actively organizing to try get the brownfield site cleaned up, said that

> the most transient workers live closest to the river because this land is free. As newly arrived migrants, they don't have any money. They have a lot of children. They locate near the river even though there is a government sign saying that this is not a safe place to live due to flooding. This is not a natural river but infrastructure built by the city. It is called Canal Street and is an artificially built stream that comes down from the mesa from Metales. They think it is industrial waste because it smells like it is. It runs even when there's no rain, and as soon as there is a drop of rain, it gushes, leading local people to believe that industries are always dumping a little bit of industrial waste into it and that as soon as it rains, they dump a whole lot more in. The amount of water flowing is not proportionate to the amount of rain that falls. The municipal government is paving and channeling it so it won't run into their homes any more. There are about 80 families living here, and they have dug wells themselves, about 15 to 20 feet deep, even though the water is contaminated. Whenever it rains, someone stays awake all night on guard to warn of floods, so the water doesn't come into their houses. (C. Garcia & A. Simpson, personal communication, February 22, 2002)[8]

8. The Colectivo Chilpancingo Pro Justicia Ambiental is an affiliate of the Environmental Health Coalition.

Workers may also prefer to live close to their workplace to save money on transportation. When looking up from colonia Chilpancingo to the top of the mesa where the Metales y Derivados site is located, footpaths can be seen cutting across the slope, which are used by Chilpancingo residents to walk to work daily, passing by the brownfield site. In response to community protests, PROFEPA put a 2-meter-high chain link fence around the Metales site in May 2002 to prevent people from cutting through the abandoned plant and to prevent the homeless from camping there. Unfortunately, the fence is not effective in confining the contaminants.

Maquiladora plants prefer to hire workers who are relatively young and thus likely to be in the period of their lives when they are raising children. In the past, Tijuana maquiladoras hired people between the ages of 16 and 28 years. However, with the greater availability of workers due to downsizing and plant closures resulting from the U.S. recession starting in 2000, they can now be more selective. Many now advertise for workers who are younger than 28 years.

During the floods of 1998, the government relocated many of the people whose housing was threatened by the rains caused by El Niño. Since then, some have moved back to the area because their relatives live nearby. The community of people who live in colonia Chilpancingo at the bottom of the mesa predated the arrival of industries and the building of the industrial park Ciudad Industrial. The members of the Colectivo Chilpancingo Pro Justicia Ambiental, who have organized to protect themselves from contamination such as that coming from Metales y Derivados, argue that they have a right to a clean and healthy environment. Many of them recall that within their own lifetimes Alamar Creek was clean enough to swim in. They do not oppose industrialization but insist that industry be clean.

Another reason for the proximity of workers' homes to plants is the fact that workers often do not understand the risks involved. One nongovernmental organization that is educating maquiladora workers is Factor X/Casa de la Mujer. They conducted their first 14-week course in Tijuana on occupational health, labor rights, and gender in 1998. The course put information about workplace toxins into the hands of women workers and trained them as *promotoras* to educate and organize others. By 2002, their courses had expanded, with women coming to Tijuana from several Mexican cities to learn how to be promotoras. The following dialogue, quoted from the transcription of the first course (from the seventh session of the course Training on Health and Safety at Work, which focused on hazards in the workplace, July 18, 1998, Tijuana), illustrates how important such education is, even if the worker lives far away from the workplace. It also gives us a concrete example of how workers' simultaneous production of commodities and their reproduction of

their own labor power, referred to in Burawoy's (1985) quotation above, may put them in a very risky situation.

> Student: On the assembly line, at [Company X], where I was working, a very strong contaminant was used and they gave everybody laundered clothing. Everything had to be sterile. But some women working there didn't leave their clothes at work—we were supposed to leave them there because of the contamination. I told them that the toxics got into the cloth and that they were taking it home with them, but they said they preferred to wash their clothes themselves because that uniform that they had been given was new. . . . Most of us are ignorant and don't understand the safety rules or any of that, because they were saying, "No, it's that it's my uniform, they gave it to me," although it began to seem strange to them because the company even had washing machines to wash them.
> Instructor: Why did we say that it was important that the uniform should be left there after being taken off?
> Student: So you don't bring the contamination home, where it could hurt you or your kids.
> Instructor: It is the company's responsibility to train workers so that they know why that clothing has to stay there and shouldn't be brought home, since people don't know why the clothing has to stay there and they take it home. It's clear that the company has the responsibility because people don't know. (authors' translation)

Finally, workers may prefer to live close to their workplace due to the long length of the working day, so that they can spend more time at home or elsewhere. The working week in Mexico is legally set at 48 hours, which was intended to be worked during a 6-day period. However, U.S. managers usually prefer to work a 5-day week instead. They do not work on Saturdays but have lengthened the workdays from Monday to Friday in Tijuana, Nogales, and other maquiladora centers (Kopinak, 1996, p. 137). Government authorities have permitted this practice, with the result that the working day is 9½ hours or more. Given the fact that public transportation in Tijuana is inadequate, workers may prefer to live close to work so as not to lengthen an already long working day.

Discussion

The findings of this study indicate that whereas only a little more than a tenth of industrial hazardous waste has high or very high risks, it is generated in plants with the highest number of employees, putting large numbers of people in dangerous situations in the workplace. Moreover, these plants are clustered together adjacent to colonias with dense populations and the greatest concentrations of children younger than 14 years

of age in Tijuana. Although this situation is partly due to the failure to adequately regulate land use, there are also several groups of people who have actively constructed the situation.

Maquiladora managers find proximity to their workers convenient because it helps lower high rates of turnover among workers as well as tardiness and absenteeism. Engineers who also teach in technical schools have encouraged the proximity. Urban developers have designed the most modern industrial parks to ensure that the labor force is close by, placing housing next to industries. The majority of workers also say that the thing they like best about their workplace is that it is close to home.

However, when we analyze which workers live closest to work and their level of preference for doing so, the degree of closeness and support for proximity between home and work varies in interesting ways. Those who have better jobs and who have lived at their present address longer live the farthest away. It is migrants from economically depressed areas of Mexico who live closest, although they do not necessarily prefer to do so. Given the finding that the riskiest hazardous wastes are located adjacent to the areas with the highest concentrations of children younger than 14 years, it is noteworthy that workers who are parents with children living at home preferred living close to work much less often than the sample as a whole. Young and very young workers who live at home with their parents are the most enthusiastic about living close to work.

The social construction of this situation by several groups of people with different interests, including urban planners, plant managers, engineers, and maquiladora workers, is strong evidence against the idea that corporations or state agencies unilaterally impose hazards on a target population, what Pellow (2000) called a "perpetrator-victim scenario" (p. 97). The production of environmental inequality in developing areas such as northern Mexico is much more complicated. The industrially developed part of the country has historically been in the center, with the north only lightly populated until the maquiladora era. These industries were not at first taken very seriously by Mexican authorities, because they were seen as a temporary foreign enclave of the economy. In the 1970s, when community leaders began to realize the long-term character of export processing industries, and their capacity to enrich landowners and developers, the Mexican economy was entering a deep economic crisis, which would lead to increasing unemployment. By the end of the 1980s, the official discourse had changed to a valuation of maquiladora industries as a way of connecting the Mexican economy to external markets and bringing much needed jobs and modernization (Kopinak, 1996, pp. 7-18). This historical process contributed greatly to prioritizing foreign investment and the generation of jobs in official public policy while postponing attention to environmental impact.

Similarly, workers in the Mexican labor force have had to deal individually with unemployment by migrating to newly expanding cities and reestablishing themselves in different occupations, where they may not immediately be aware of the risks involved. Another way for families to cope with the decline of real wages is to send more young people into the labor force earlier, perhaps before they have had a chance to learn all they need to know about the workplace and labor process. When Mexican workers become aware, they have been ready to organize in nongovernmental organizations such as Factor X/Casa de la Mujer and the Colectivo Chilpancingo Pro Justicia Ambiental. In fact, the Mexican environmental movement grew stronger throughout the 1980s and the 1990s, and its active lobbying of government is responsible for important steps forward in environmental regulation (Cohen & Méndez, 2000).

A recent example of their efficacy was the reform of federal environmental law in December 2001, which provides for the construction of a pollutant release and transfer register (PRPT) in Mexico that is similar to those in Canada and the United States. Unlike our experience with the 1998 data collected from SEMARNAP, in which the agency assumed that a company did not generate any hazardous waste if it did not report it, "SEMARNAT must pull together an initial list of industries—to keep track of who is not reporting—and specify penalties for noncompliance" (Malkin, 2002).

Several Mexican nongovernmental organizations were crucial in getting this legislation through the Camera de Diputados, including Mexico Citizen Presence and the Cooperativa Ecologista de Jalisco. Nauman (2002) said that "the executive branch basically abandoned its bills to Congress without backing them up with adequate lobbying muscle. Had it not been for organized civil society lobbying, the mandatory emissions reporting reform to the LGEEPA would not have passed." These nongovernmental organizations will have to play an active role in implementing the legislation because policy makers are still deciding who must report, which chemicals, at what levels of concentration, and how to measure pollutants. The Colectivo Ecologista de Jalisco has already been training industry representatives in toxic methods reporting.

Baja California also reformed its state-level environmental legislation in 2001, called the Ley de Protección al Ambiente Para el Estado de Baja California. Article 38 states that

> when considering which areas are appropriate for industrial use next to residential areas, only the promotion of low-impact and low-risk industries should be allowed, as well as those which have the best technology available, raw material that generates the least contamination, and they should also install and operate highly efficient systems of control. In the

> determination of land use that defines urban development programs, topographical, climatological, and meteorological conditions will be considered to ensure the appropriate dispersion of contaminants. (authors' translation)

However, the implementation of this law will also require vigilance by civil society organizations because authorities have always been able to exercise their own prerogatives in the application of the law.

The Good Neighbor Environmental Board (2001, p. 43) has recommended that Mexican authorities be encouraged to revise hazardous waste laws to establish finite and enforceable time limits for storage at generator facilities, recycling facilities, and transport and treatment facilities. If hazardous waste could not be stored indefinitely, as is now the case, then there would be less present should an earthquake occur. This recommendation is important because the laws decreed by the Mexican federal government to regulate maquiladora industries have done exactly the opposite, allowing for longer stays of imported materials in the country. For example, in the 1989 maquiladora decree, Article 10 states that raw materials, pamphlets, and bins might stay in Mexico for no longer than 1 year. In the 1998 decree, Article 8 says these things can stay in the country for 18 months. The 2000 decree does not mention how long these things can stay in the country but specifies that other things such as tools and equipment can stay in the country for as long as the program goes on (Ricardo Santes-Álvarez, personal communication, June 20, 2002).

PROFEPA should increase its inspection rate, which we found to be 10% in 1998, to prevent plants from illegally dumping waste into the sewerage system or burying it. To do this, it will need more resources, particularly personnel. There is often inadequate follow-up by inspectors to ensure that companies found to be in violation carry out the necessary reparations. In 2002, PROFEPA's official director said that this agency, which is responsible for the enforcement of Mexican environmental law, had only 40 inspectors for the entire state of Baja California (Cárdenas, 2002). If we take into account only maquiladora and nonmaquiladora industries, of which the state has approximately 1,000, and assume a 5-day work week, each inspector would have to do a dozen inspections a day to cover just the industries. We argue that there must be more inspectors to ensure compliance with the law, but given the cutbacks in Mexican government budgets, an adequate number may not be hired soon. Given this lack of official vigilance, workers and the neighboring population need to be better educated so that unethical handlers of toxic materials cannot take advantage of them.

We support Durazo and García's (2000) suggestion of blood tests of adjacent populations, especially children and older students in the technical schools surrounding industrial parks where the riskiest hazardous

wastes are located. We suggest that the engineers who were responsible for the proximity of schools to plants go further to help ensure the health of the skilled workers with whose education they are concerned and actively promote blood testing.

A source of funds to help carry out such policies might be a tax on hazardous materials entering Mexico for use in maquilas because they are no longer as temporary as they were at the initiation of the maquila program in 1966. An institution assessing environmental concerns along the border has suggested that the duty-free classification of most hazardous materials imported into Mexico for use in maquila industries be reconsidered now that such industries appear to be more permanently established in Mexico (Good Neighbor Environmental Board, 2001, p. 41).

Without such changes, the border, which is so porous to business, will continue to be a shield behind which violators of environmental law can hide with impunity (CEC, 2002, p. 42). While industrialization develops via regional and global expansion and consolidation, the industrial hazardous wastes that are generated would tend to remain quite local. In his development of a global sociology of environmental change, Sklair (2000) argued that although globalization has prompted incredible growth via export-led development in areas such as the U.S.-Mexico border, it also contains two contradictions that threaten its persistence. The first is the fact that the number of the poor, many of them employed full-time, is rapidly increasing. As new immigrants, they are not politically integrated, and as low wage earners, they have little buying power. The second contradiction is that export-led development thrives in environmentally unsustainable conditions and may threaten the ecological survival of its host community. Sklair suggested that one resolution might be empowering the growing numbers of powerless and dispossessed, that is, those who work in export-producing industries, with greater knowledge about environmental hazards of the industries in which they work and promoting their more effective participation in community decision making. This strategy, which is currently being followed by the nongovernmental organizations discussed in this article, would allow maquiladora employees to make more informed decisions about where they might live and give them more leverage in community participation.

Researchers might assist by making more information available to the public. Much more specific measurements of the appropriate distance from home to work can be planned for the new data, which should be available at the beginning of 2004 and beyond, once the PRPT is implemented. By that time, the Environmental Protection Agency should also have updated its *Haztraks* database to go beyond 1999, which is where it currently ends. The research presented here is only a beginning. The geographic information system could be put to much greater use, illustrating what a safe buffer zone around the riskiest sites might be. More spe-

cific measures of spatial relationships between home and work could be made, instead of the more general qualitative measure we constructed for this study. Having data available for several years would allow for a time series analysis, which would not only update the current findings but facilitate more active planning for the future. The best way of doing this would be to involve all stakeholder groups—local residents, maquiladora employees, nongovernmental organizations, and business and government.

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References

Aguas residuales generadas por industrias, prioridad de PROFEPA. (1998, January 29). *El sol de Tijuana*, pp. A3, A6.

Alegría, T., Carrillo, J., & Alonso-Estrada, J. (1997). Restructuring of production and territorial change. *CEPAL Review*, *61*, 187-205.

Barajas, M. D. R., & Sotomayor, M. (1995). Rotación de personal en la industria maquiladora de Tijuana: Mujeres y condiciones de vida en Soledad González [Turnover of personnel in the maquiladora industry in Tijuana: Women and living conditions in Soledad Gonzalez]. In Olivia Ruiz, Laura Velasco & Ofelia Woo (eds.), *Mujeres, migración y maquila en la Frontera Norte* (pp. 189-213). Tijuana, Mexico: El Colegio de la Frontera Norte.

Barry, T. (1994). *The challenge of cross-border environmentalism: The U.S.-Mexico case*. Albuquerque, NM: Resource Center Press.

Burawoy, M. (1985). *The politics of production: Factory regimes under capitalism and socialism*. London: Verso.

Cárdenas, L. A. A. (2002, March). Presentation at the San Diego Environmental Protection Agency Open House.

Carruthers, J. (2000). *Dietary and red blood cell folate in women from urban-industrial areas of Baja California, Mexico*. Unpublished master's thesis, San Diego State University, CA.

Carrillo, J., & Santibáñez, J. (1993). *Rotación de personal en las maquiladoras de exportación en Tijuana*. Tijuana, Mexico: Secretaría del Trabajo y Previsión Social y El Colegio de la Frontera Norte.

Cedillo, L., Harlow, S., Sánchez, R., & Sánchez, D. (1997). Establishing priorities for occupational health research among women working in the maquiladora industry. *International Journal of Occupational and Environmental Health*, *3*, 221-230.

Cervera, L. E. (1998). Problemática ambiental urbana en Nogales [Urban environmental problems in Nogales]. *Ciudades*, *38*, 55-64.

Cohen, M., & Méndez, L. (2000). *Maquila y movimientos ambientalistas. Examen de un riesgo compartido*. Mexico City: Grupo Editorial Eón.

Commission for Environmental Cooperation. (2002). *North American environmental law and policy series: Vol. 8. Metales y Derivados final factual record*. Montreal, Canada: Editions Yvon Blais.

Contreras, O., Alonso-Estrada, J., & Kenney, M. (1997). Los gerentes de las maquiladoras como agentes de endogeneización de la industria [Maquiladora managers as agents of industrial endogenization]. *Comercio Exterior*, *47*(8), 670-679.

Corliss, D. (2000). Regulating the border environment: Toxics, maquiladoras, and the public right to know. In L. A. Herzog (Ed.), *Shared space: Rethinking the U.S.-Mexico border environment* (pp. 295-312). La Jolla, CA: Center for U.S.-Mexican Studies, UCSD.

Diario Oficial de la Federación. (1993, October 22). NOM-053-ECOL/93. Available from: www.semarnat.gob.mx/dgmic/rpaar/rp/definicion/definicion.shtml

Diario Oficial de la Federación. (1994a). NOM-STPS-1994. Available from: http://uninet.mty.itesm.mx/legis-demo/indices/indstps.htm

Diario Oficial de la Federación. (1994b). NOM-114-STPS/1994. Available from: http://uninet.mty.itesm.mx/legis-demo/ indices/indstps.htm

Durazo, L., & García, C. (2000). El derecho a la información ambiental sobre contaminantes [The right to environmental information about contaminants]. *El Bordo*, *5*(3), 44-68.

45% de las viviendas en BC están asentadas en areas irregulares. (1999, March 22). *El Mexicano*, p. 13A.

Good Neighbor Environmental Board. (2001). *Fifth report of the Good Neighbor Environmental Board to the president and Congress of the United States*. San Diego: California Environmental Protection Agency.

Guzmán, S. (2000). Los dilemas del desarrollo sustentable: Limitantes para alcanzar el desarrollo sustentable en Tijuana [The dilemmas of sustainable development: Factors limiting the achievement of sustainable development in Tijuana]. *El Bordo*, *5*(3), 15-36.

Hualde, A. (in press). Todos los rostros de la industrializacion [All sides of industrialization]. In M. de la O & C. Quintero (Coordinators), *Globalización, trabajo, y maquilas* (pp. 111-154). Mexico City: Fredrick Ebert.

Industriales "engañados por autoridades." (1999, June 11). *El Mexicano*, p. 15D.

Kopinak, K. (1996). *Desert capitalism: Maquiladoras in North America's Western industrial corridor*. Tucson: University of Arizona Press.

Kopinak, K. (2002). Environmental implications of New Mexican industrial investment: The rise of Asian origin maquiladoras as generators of hazardous waste. *Asian Journal of Latin American Studies*, *15*(1), 91-120.

Kopinak, K. (in press). Maquiladora industrialization of the Baja California Peninsula: The coexistence of thick and thin globalization with economic regionalism. *International Journal of Urban and Regional Research*.

Lindón, A. (1997). El trabajo y la vida cotidiana: Un enfoque desde los espacios de vida [Work and daily life: A focus from life spaces]. *Economía Sociedad y Territorio*, *1*, 177-197.

Longley, P., Goodchild, M., Maguire, D., & Rhind, D. (2001). *Geographic information systems and science*. New York: John Wiley.

Malkin, E. (2002, Spring). Pollutants see the light in Mexico. *Trio: The Newsletter for the North American Commission for Environmental Cooperation*. Retrieved from http://www.cec.org/trio/stories/index.cfm?varlan=english&ed=7&ID=93

Medina, M. (1992). *Localization industrial manufacturera en la ciudad de Tijuana*. Tesis que para obtener el grado de maestria en Desarrollo Regional. Unpublished master's thesis, El Colegio de la Frontera Norte, Tijuana, Mexico.

Nauman, T. (2002, March 7). *Balance sheet: Tallying up Fox's environmental record* (Americas Program Analytical Article). Silver City, NM: Interhemispheric Resource Center. Available from: www.americaspolicy.org/briefs/2002/0203foxenv.html

Negrete, J. (1988). *Integración e industrialización fronterizas: La Ciudad Industrial Nueva Tijuana*. Unpublished manuscript, El Colegio de la Frontera Norte, Tijuana, Mexico.

Palomares León, H. (1996). *Pobreza urbana y movilidad ocupacional en Tijuana, B.C.* Unpublished master's thesis, El Colegio de la Frontera Norte, Tijuana, Mexico.

Pellow, D. (2000). African-American labor at the margins: Exploring the emergence of environmental health hazards in the workplace. *Research in the Sociology of Work*, *9*, 95-114.

Pellow, D. (2002). *Garbage wars: The struggle for environmental justice in Chicago*. Cambridge, MA: MIT Press.

Quintero, C. (1997). *Restructuración sindical en la frontera norte*. Tijuana, Mexico: El Colegio de la Frontera Norte.

Ruiz, B., & Aceves, P. (1998). Pobreza y desiqualdad social en Tijuana [Poverty and social inequality in Tijuana]. *El Bordo*, *1*(2), 8-66.

Sklair, L. (2000). Global capitalism and sustainable development: Exploring contradictions. In L. A. Herzog (Ed.), *Shared space: Rethinking the U.S.-Mexico border environment* (pp. 17-40). La Jolla, CA: Center for U.S.-Mexican Studies, UCSD.

Tejada, I. (1999, October 14). No hay ministerios públicos en delitos ambientales. *Frontera*.

U.S. Environmental Protection Agency. (2001). *Haztraks*. San Francisco, CA: Author.

Winckell, A., Le Page, M., Chávez, G., Vela, R., Castañeda, R., & González, C. (2000). *¿Y si un terremoto de magnitude 6.5 se produjera en la falla de La Nación? Aportes para un escenario sísmico en Tijuana*. Tijuana, Mexico: El Colegio de la Frontera Norte y Institut de Recherche pour Développement.

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