Political ecology as an analytical tool in the Mezquital Valley, Mexico: A permanent struggle

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Article

Political Ecology as an Analytical Tool in the Mezquital Valley, Mexico: A Permanent Struggle

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Abstract: Solid waste for incineration and wastewater from the country's largest city, Mexico City (CDMX), are transported to the southern region of Valle del Mezquital (MV). This area also hosts an oil refinery, a thermoelectric plant (PEMEX-CFE), cement factories, industrial corridors, and mining operations, all of which harm environmental and public health. From a Political Ecology (PE) perspective, we examine the mechanisms of accumulation, emphasizing the allocation of property titles and the extraction of rent as an environmental reservoir. We also explore the power of socio-environmental movements to provide a comprehensive understanding of environmental conflict. Based on economic power structures, we identify a geopolitical configuration that deepens the spatial divisions between labor in the MV and consumption in CDMX, exacerbating health disparities. We conclude that an unequal geography has been built that produced capitalist and rentier landowners who are exempt from the externalities that have produced an environmental hell. The Mexican State is a key stakeholder, collaborating with the industrial elite in both legal and illegal spheres. Within this sacrifice zone, the inhabitants of the MV have resisted pollution and industrial accidents for over 50 years. Despite publicizing their struggle internationally and collaborating with academics, members of the movement have been assassinated.

Keywords: political ecology; sacrifice zones; social movements; heavy industry; wastewater; cement plants

1. Introduction

In 1977, research by Paul Leduc showed empirical evidence of land dispossession, the precarious labor conditions of the PEMEX-CFE petrochemical complex and lime factories, and the violence of the Mexican State (MS) under the orders of the industrial elites in the Mezquital Valley (MV) in Hidalgo, Mexico [1,2]. All of this contributed to the elimination of the Otomí people from the region. Since then, the MV was already receiving up to 70% of the wastewater from the deep drainage system in Mexico City (CDMX), one of the largest cities in the world [3–5].

Today, in a continuation of yesterday's ethnocide, an ecocide continues to claim the lives of residents due to the health risks posed by heavy industry and its recurring accidents, including spills, fires, and explosions. These events occur amidst socioeconomic conditions that are clearly inferior to the urban areas they serve: in CDMX, the indicators of marginalization and income are at least double, not to mention those of the business elites [6–9]. This benefit, extracted at the expense of the health of the inhabitants of the MV, sharpens the spatial divisions between labor and consumption, within the center-periphery model, and impacts health outcomes.

The MV serves as a reference for environmental injustice due to the time the population has been suffering violence, dispossession and disease, and due to the quantity and variety of pollutants that arrive and are generated in all of the environmental reservoirs. In this regard, it has been cited as one of the most polluted areas in Mexico [10–13].

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It is important to identify who benefits from the fact that the MV is the environmental reservoir of the area of greatest consumption in Mexico. In this regard, the accumulation mechanisms involved can be explained by the allocation of property titles and capital flows expressed in what certain authors describe as rentier nature, private and state landowners. It is also important to understand the description of the settlers who live this environmental sacrifice zone. Who are they? What forms of resistance have they developed, and how have they changed over time? What power do the settlers have to resist the socio-environmental degradation in the region?

2. Materials and Methods

The MV is made up of twenty municipalities belonging to the State of Hidalgo in the north-central part of Mexico. According to Quezada [14], it includes Zimapán to the north, Huichapan to the west, Actopan to the east and Tepeji del Río de Ocampo to the south.

Based on extractive logic, the region could be distinguished by its mineral wealth of manganese in the north and limestone in the south. In this sense, the mining and cement industry has encountered resistance from both poles. In addition, another distinctive feature of the region is that it was chosen by industrial elites and the MV to be the reservoir of urban and hazardous waste, like the emblematic case of Zimapán [15,16].

This article focuses on the southern municipalities of the MV comprising Atitalaquia, Atotonilco de Tula, Tula de Allende, Hidalgo and Apaxco in the State of Mexico, between 19.85° and 20.20° north and between 99.05° and 99.55° west (see Figure 1). This zone is characterized by a scrubland ecosystem called Matorral Cracicaule with abundant cacti and opuntias interspersed with shrubs such as mesquite Prosopis velutina and huizache Vachellia farnesiana. It has a semi-arid climate with annual rainfall of 300-600 mm and an average temperature of 16-22 °C. It is also possible to identify oak forests with lower temperatures in a smaller area, at a higher altitude. Notably, within a 13 km radius, there are at least 45 open-pit mines, ten cement and lime factories, the wastewater treatment plant (WWTP), an industrial zone and one of the most important oil processing facilities in the country.

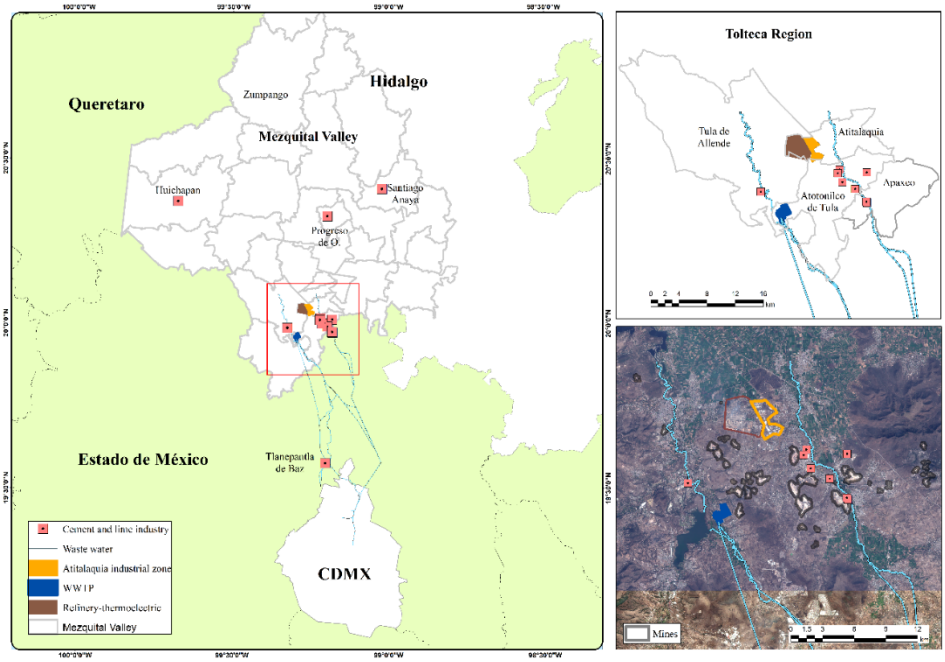

Figure 1. MV and the presence of cement factories and the PEMEX-CFE petrochemical complex.

Political Ecology is defined as a tool for framing and analyzing conflicts around the control of resources and how communities resist or adapt to state and corporate power [17–20]. This analysis is

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based on the unequal use of ecosystem components and the localization of emissions from their productive processes, generating capital accumulation through unequal geographic development.

2.1. Approach to Accumulation Mechanisms

We analyze the possible mechanisms that facilitate the accumulation of capital while simultaneously omitting responsibility for the externalities that are unacknowledged by the state industry as a service provider and the private capital in heavy industry. These externalities include landscape degradation, emissions that generate poor air quality, health risks due to the proximity of pathogens in wastewater and industrial accidents. All of these affect the health of the inhabitants, put livelihoods at risk, and generate resistance from the inhabitants who must face this sacrifice zone.

We approach the mechanisms of accumulation via dispossession by describing the context of obtaining property titles as a common thread under Huber's categories [17] of private owner, state owner and private rentier, to help understand the flow of capital. Luxemburg's ideas in Harvey [21] suggest that what may appear to be a simple property right turns out to be the appropriation of other people's property that contributes to accumulation; what appears to be a simple exchange of goods, hides exploitation; and what may appear to be equality is underpinned by class domination. Andreucci, et al. [22] assert that the state plays a fundamental role in land distribution, facilitating property rights to nurture the expansion and circulation of capital. This is why the contexts of land title allocation in sacrifice zones like the MV are important.

Huber's [23] concept of "rentier nature" highlights the commodification of ecosystem services, including pollutant reservoirs, which generate profits without contributing to restitution for environmental impacts. The application of Huber's rentier capitalist framework is very useful for this analysis. Focusing solely on landowners or owners of the means of production obscures the dynamics of capital accumulation of capital, especially considering that the MV serves as one of the most critical pollutant reservoirs for the country's highest consumption area, Mexico City. This dynamic demonstrates that the generated income is not retained locally and fails to improve residents' living conditions, exacerbating health inequalities.

2.2. Social Organizations Around the Conflict

It is important to identify the main social organizations of MV over time to describe forms of contention, connections between groups, and potential allies within social movements that, in some way, counteract the advance of a developmentalist model that avoids responsibility for environmental disasters. Likewise, understanding the perceptions of key stakeholders is essential in an environment where they are exposed to suspended particles of varied composition, including bacterial or viral aerosols they may inhale.

Recent research, by Saccucci [19], Vélez-Torres et al., [24] and Castillo [25] takes a gender-race-class approach to social power, identifying a toxic, violent, and extractivist environment, while reflecting the economic power of pesticide profits and the global market. The aforementioned authors go further by producing a feminist PE, delving into the resistance of the villagers.

It is important to note that PE aims to highlight forms of resistance and document the transformative efforts of stakeholders, ranging from reformist tendencies and self-management to the construction of alternative ways of life outside the current economic system [18,19]. To explore these topics, we consulted scientific papers, newspapers and web sources. Additionally, we conducted field visits and carried out occasional unstructured and semi-structured interviews.

In this context, social movement theory is used to assess organizational strength [26] during the interview design, incorporating aspects that align with current PE studies [19,24,25,27]. A matrix of the categories was built, including how stakeholders define their environment and perceive surrounding nature; how they define the problem and attribute blame; the tactics they employ; their links, leaders and predecessors; their action plans; and the construction of a conflict timeline.

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Interviewees were selected to provide contrasting perspectives on the socio-environmental conflict. Between January 2023 and October 2024, one randomly chosen inhabitant from each municipality not affiliated with social movements was interviewed. Additionally, at least one resident who was directly affected by major environmental issues such as the refinery, cement plants, or wastewater was included, along with one farmer using wastewater for irrigation. Representatives from each of the socio-environmental organizations (at least four), four professionals involved in the conflict, one public servant and industrial representatives were also interviewed. In the last stage, October 2024, five interviews were conducted focusing on obtaining property titles and rent payments to deepen the understanding of accumulation mechanisms. Notably, one of the authors has conducted participant research on cement companies in the MV since 2013.

3. Results

3.1. Regarding Accumulation Mechanisms

The cement industry in Mexico has historically been closely associated with the MV. In the early 20th century, two of the country's three cement plants were located there; today, there are eight. However, from 1960 to 1989, six cement plants operated simultaneously across just four municipalities (see Figure 1; [28]). According to Herrera [29], the MV remains the country's leading cement producer. In terms of the allocation of property titles for cement production, it is important to remember that international capital had already acquired large tracts of land by the end of the 19th century, purchasing them from a troubled nation and a 75% illiterate population.

Following the Mexican revolution, which aimed to achieve agrarian land distribution, cement ownership and production increased considerably due to strong ties with the MS, and the infrastructure demands of central Mexico. The most important hydraulic works of the past century serving CDMX were built with cement from the MV [30].

The 1992 amendment of Article 27 of the Constitution legalized and amplified the allocation of property titles and land rents for mining, benefiting the cement elite. This neoliberal policy converted the most productive zones into the property of capitalist landowners, allowing communal property to become privatized, expropriated, seized or leased to third parties through mechanisms designed and promoted extensively by the Ministry of the Interior. This shift is consistent with Arboleda's (2020) assertion regarding the state and the global market's demands for mineral extraction. Notably, the regulatory framework of the MS for the allocation of property titles and rents operates under a supposed equality between global capital groups with extensive technical and legal knowledge and indigenous groups and subsistence farmers.

Mining concessions became a legal tool for attracting foreign investment in resource extraction throughout Mexico, and in the south of the continent. Arboleda [31] and Huber [17] argue that capital requires a facilitating state to create rentiers and landowners. Currently, of the 47 open-pit mines and 6 cement plants in operation, only 20 extraction zones remain under communal ownership, meaning that comuneros receive rent from mineral extraction, while the rest are controlled by capitalist landowners. In this regard, the MS does not play a regulatory role in setting extraction prices. When talking about rent, the inhabitants mentioned the following:

quienes las explotan son grupos de ejidatarios o particulares que rentan y pagan muy poquito 6 pesos por tonelada (0.25 USD/TON).

The ones who exploit them are groups of ejidatarios or individuals who rent and pay very little, 6 pesos per ton (0.25 USD/TON).

Three of the world's most important cement firms: Cemex, Holcim and Lafarge, have established operations in this area, where the latter subsequently liquidated its liabilities, transferring some to Fortaleza, another cement company. These cement companies are known for their oligopolistic tendencies and their exceptional international capital accumulation [32,33].

Cement kilns are fueled by fuel oil, releasing metals, aromatic organic compounds and sulfur compounds into the environment. At the end of the 20th century, more profitable but highly toxic

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alternatives emerged in Mexico's cement industry: burning waste in cement kilns. This practice was enabled by an agreement between the National Chamber of Cement and the Ministry of Environment and Natural Resources [34–37].

The mechanism of capital accumulation has historically relied on the acquisition of property titles and securing low-cost rents based on Article 27 of the Constitution and the Mining Law, facilitated by the Ministry of the Interior. It may also be due to the increased logistical efficiency by reducing production costs and increasing capital gains. Notably, two of the leading cement landowners, Grupo Carso and Cemex, rank among the wealthiest entities in the Americas.

The refining and thermoelectric industrial complex built in Atitalaquia in 1976 also serves as a reservoir for air emissions. According to its installed capacity, it is one of the largest in the country, covering an area of 10 km2. The land was obtained through the expropriation of communal peasant properties by the MS, under promises of employment. In this context, the MS functions as a landowner rather than a facilitator of land titles in the conflict.

Since 1998, the refinery has supplied one fifth of the gasoline produced in Mexico, and its primary consumer of gasoline and electricity is CDMX [10,38]. In 2024, it was reported as the most profitable in the country, despite experiencing an explosion at one of its facilities [39]. Globally, the oil-based energy sector is well-documented as posing health risks to nearby populations, increasing mortality rates from neoplasms, respiratory diseases and especially cardiovascular diseases [40].

In terms of employment, just over half of the workers came from the region to help build the refinery, yet they received the lowest wages, as seen in the strikes and violence documented in recent decades [1,10,41]. As of 2024, it is common to find temporary workers in orange overalls under dual subcontracting agreements involving PEMEX, ICA FLUOR and an additional private company.

In 2020 the SEMARNAT approved the Environmental Impact Statement for expanding the gas-fired thermoelectric plant, and in 2024, a coker unit will start operating at the refinery [34]. This modernization promises better efficiency and production, but will it lower emissions?

These facilities function as an economic enclave that supports the neighboring industry and CDMX, Mexico's largest consumption area. Thus:

i) There are global industries such as textiles, metalworking, electricity, food, medicines, polymers, and agrochemicals. These also represent a danger due to accidents and industrial spills that affect the population. Regarding Atitalaquia and Atotonilco de Tula, two characteristics converge: the large installed capacity and its profitability due to its international status as Cargill (food) and Sigma Alimentos or as ATC/VELSIMEX (agrochemicals), considered the company with the highest industry turnover in Mexico.

ii) In CDMX, the capital accumulation ties between the large international business centers that intertwine or sustain different national and foreign activities are somehow sustained.

The MS again lowered its operating costs by generating precarious jobs and securing contracts with third parties in which the socially generated surplus value was not compensated, accumulating in companies like ICA FLUOR and other neighboring industries, making the territory more attractive to large capital. This contrasted with field visits and interviews with PEMEX employees.

For over 100 years, the wastewater from CDMX has been flowing into the MV, functioning as a wastewater reservoir [3,42]. The inflow consists of a mixture of domestic and industrial wastewater that feeds into the country's most important irrigation districts. The entity responsible for receiving payments for wastewater disposal is the Mexico City Water System (SACMEX), which serves 9 million people. From these payments, the MV does not receive a single cent.

Before reaching the irrigation districts, the wastewater passes through Atotonilco de Tula, home to the largest wastewater treatment plant (WWTP) in Latin America. The WWTP was established in 2010 through a public-private investment. The Environmental Impact Statement justified its construction due to its potential to reduce health risks, generate energy, and supply water to farmers. However, the EjAtlas platform [43] reports methane leaks, an explosion, and fly strike deposits affecting the skin of children and domestic animals, highlighting serious health hazards.

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Most of the time, it was operated by one of the construction consortia linked to Grupo Carso. Its accumulation mechanism stems from its private rentier nature rather than the surplus value generated by the socially necessary work to treat wastewater, since the plant is not in regular operation.

Since 1994, researchers have noted that it is the largest reuse framework worldwide for agricultural production using wastewater irrigation, covering just over 80,000 hectares [44–46].

The wastewater used to irrigate the fields in the MV is primarily used by farmers to grow fodder, to support dairy production in central Mexico. One of the main beneficiaries of this value-added process is Alpura, a national dairy company that purchases the forage at a price it sets independently. Farmers frequently exposed to wastewater lack their own machinery, often renting a tractor solely for plowing, while purchasing seeds and agrochemicals. This partial mechanization makes them dependent. An interviewee commented on this:

Sí, sí, claro, el precio del forraje en la región está en función de la demanda de leche de un establo que está por acá por Tequixquiac. Que es administrado por gente de Alpura, y que es el que fija los precios en la zona. Nadie más.

Yes, yes, of course, the price of forage in the region is based on the demand for milk from a ranch that is around here in Tequixquiac. Which is managed by people from Alpura, and they're the ones that set the prices in the area. No one else.

It is evident that farmers in the MV are not the primary beneficiaries because they do not have their own mechanical or hydraulic equipment. Their reliance on technical support ensures their dependence throughout the production processes, rendering them completely defenseless against the MS, which does not intervene to regulate production prices or protect farmers' health. It is well known that subsistence farmers are functional to capital because their minimal subsistence requirements enable them to be exploited and generate surplus value.

In terms of rent, the MS uses the Arco Norte highway and railway lines as the transportation route for the distribution of goods produced in the MV. The functionality of this road is outstanding because it connects the northwest with the southeast of the country. The road is managed and was built by Grupo Carso, the main landowner and landlord of the region.

3.2. Emergence and Evolution of Social Organizations Around the Conflict

Social organizations have been mobilizing for around 50 years, because it is impossible to become accustomed to seeing loved ones die or fall ill. There are two types of effects on the life and health of people in the MV that influence the mobilization and consolidation of organizations:

a) Occasional Risks: These involve immediate, large-scale incidents causing death or irreversible short-term effects, such as spills, fires, and explosions. Such events often catalyze the transition from movements to organized networks.

b) Permanent Risks: These are ongoing, low-intensity harms such as long-term exposure to pathogens from wastewater vapors and poor air quality linked to mining-cement and petrochemical industries. Some scholars describe these externalities as slow violence [47].

The consequences of these permanent risks are harder to convey to public opinion, resulting in less activation of self-organized groups. This is due to the population's socioeconomic conditions and the inadequate health infrastructure for diagnoses and record-keeping. The subtle nature of the harms means that the inhabitants may normalize skin irritations, chronic cough, or diarrhea—externalities that escalate into illness and death.

As a result of these risks, two waves of mobilization in the MV can be identified in the years 1973 and 2009. [2,36]. The interviews confirm that the deaths of workers caused by precarious labor conditions in the cement and oil industries triggered mobilizations in the region in the 1970s.

On March 21, 2009, on the borders between Apaxco and Atotonilco de Tula, 11 farmers reportedly died due to a hazardous waste spill from the Holcim subsidiary, according to local accounts. Fifteen days later, a methyl acrylate leak from the same company poisoned nearby

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residents. In response to these incidents, the Movimiento Pro-Salud Apaxco-Atotonilco was formed, building international networks and alliances. One of the most significant transgressive tactics was shutting down the Holcim subsidiary for more than two years. However, after constant attacks, the eviction took place in February 2012 by the MS.

An explosion in Atitalaquia on April 7, 2013, at ATC/VELSIMEX, an agrochemical company, poisoned approximately 6,000 people. In response, Caminado por la Justicia emerged, filing a complaint with the Inter-American Commission on Human Rights. In this instance, some activists were intimidated through legal tactics.

The frequent impacts, in addition to catalyzing mobilizations, created support networks, resulting in the Toxitour Caravan. This innovative initiative for media outreach and international observers united 50 organizations from six regions of Mexico. In 2019, the caravan toured the country's most polluted areas. In response, the MS pledged to implement environmental restoration programs and involved the National Council of Humanities, Science, and Technology. (CONAHCyT).

The persistent efforts of communities alongside professional networks to gather sufficient evidence in the MV led to the approval of a research project in 2021 by the National Research and Impact Projects (Pronaii) on Toxic Agents and Contaminating Processes, supported by CONAHCyT. Researchers from both the natural and social sciences provided support, cultural expressions such as murals, workshops, environmental sample analyses, phlebotomies and epidemiological studies.

The overflow of the Tula River in the MV on September 8, 2021, was to prevent the CDMX from flooding while ensuring that consumption was not lost [5]. It resulted in the deaths of 17 Covid-19 patients from a hospital, the evacuation of 1,000 people, affected 33,000 people, and damaged 10,000 homes.

On January 11, 2022, construction began on the Regional Center for Urban Solid Waste Treatment in Atitalaquia, reinforcing the MV's role as a waste reservoir to generate profit. In response, the community organized and set up a protest camp at the facilities and later occupied the municipal presidency of Atitalaquia. Five months later, an armed group shot and killed one of the activists, Jesús Bañuelos Acevedo. In response, the residents seized control of the Arco Norte highway, one of central Mexico's most critical transportation routes. Institutional threats were not long in coming.

Y me dicen "¿sabes lo que te quieren hacer?" Y digo: ¿no? Dice, "bueno, te van a meter preso y no vas a salir," dice. "Yo te aconsejo que no vayas," y dije, no carajo, pero esa citación decía que si no me presentaba a declarar (en las instalaciones penitenciarias) iban a venir a buscarme a la fuerza.

And they say to me, "Do you know what they want to do to you?" And I say, no? He says, "Well, they're going to put you in jail, and you won't get out," he says. "I advise you not to go." And I said, no damn it, but that summons said that if I didn't show up to testify (in the penitentiary facilities), they were going to come and get me by force.

Since 2009, organizations have mobilized their political power in response to life-threatening events such as industrial accidents, waste burning in cement plants, intentional flooding [5], the imposition of a landfill, repression, and fly infestations at the WWTP. These events have strengthened networks, especially between Apaxco, Atotonilco de Tula, Atitalaquia, and Tula de Allende. Since 2021, these organizations have been coordinated by the Colectivo de Comunidades en Defensa de la Vida y el Territorio en la Región Tolteca:

a) Unión Ecologista San Jerónimo Tlamaco A.C. was established in the 1990s in Atitalaquia.

b) Movimiento Ambientalista Pro-Salud Apaxco-Atotonilco was formed in 2009 in Apaxco and Atotonilco de Tula in response to incineration practices and accidents at the Holcim plant.

c) Colectivo Caminando por la Justicia was formed in 2013 in Atitalaquia following the explosion of the ATC/VELSIMEX factory.

d) Frente de Comunidades en Contra de la Incineración (FCCI was formed in 2013 and comprises 16 organizations from central and northern Mexico, including six from Hidalgo.

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e) Red de Conciencia Ambiental Queremos Vivir A.C. was created in 2017 and is mainly active in Tula de Allende. It addresses wastewater issues, including a flood caused by the CDMX government.

f) Todos Somos Tula emerged in 2021 following the September flood composed of affected community members.

g) No al Basurero en Atitalaquia was created in 2022 to oppose plans by the municipal and state governments to install a regional landfill to manage the waste from neighboring municipalities. This organization has suffered the murders of Jesus Bañuelos Acevedo and Abisaí Pérez Romero.

h) Museo Comunitario Atotonilli, is based in Atotonilco de Tula, and promotes cultural dissemination and engages in political participation.

It is important to highlight the role of professional allies who have supported the aforementioned organizations since 2009. Their contributions have helped raise awareness, create national and international networks, and secure recognition from the MS through mobilizations in parliament. They have also played a role in drafting legislative proposals, forming fronts, and expanding their partnerships. Most of this work focuses on addressing the use of Refuse-Derived Fuel (RDF) in cement plants.

Members of social movements generally expressed that they felt comfortable where they currently live and would not change their residence. The activists attributed this to their bonds of friendship and family and the need to continue fighting for future generations. They all described their environment as highly polluted, citing Cargill, cement plants, refineries, sewage, and industrial accidents that surround them. When asked hypothetically, residents and activists prioritized a healthy environment over public utilities and job availability. In contrast, professionals who live outside the MV emphasized that public utilities and the environment go hand in hand, and that one cannot choose just one option, and that jobs are very important.

Although the inhabitants of the MV do not obtain their livelihood directly from their environment, their struggle and the meaning they attribute to nature stem from the tangible reality of environmental degradation [48]. Their activism aligns with the concept of environmentalism of the poor, rooted in the value and meaning of nature, which, in this case, is a degraded ecosystem that was once healthy [48]. However, they continue to resist dispossession and toxic contamination of their environment.

We found no significant differences among the stakeholders interviewed regarding how they define the problem and assign blame. First, most mentioned that the main problem is poor air quality caused by cement plants and PEMEX-CFE operations, including waste incineration in cement kilns. They linked these environmental issues to respiratory diseases and cancer affecting family and friends. Field visits confirmed that the region's healthcare infrastructure is clearly concerning. As one interviewed professional stated:

Me parece una barbaridad que haya gente que tenga que ir, bueno, o sea, el municipio proporciona una ambulancia, pero es una barbaridad que los tengan que transportar de la región hacia el sur de la CDMX, para diálisis y luego de regreso. Es decir, después, regresar en ambulancia por más, como si fuera un colectivo, es decir, ¿una ambulancia para 8 personas? Y entonces a la primera, que ya regresó de su diálisis, le hacen pasar por el calvario de terminar todo esto, que ahí no haya un centro de salud, en condiciones de atender a la gente sobre los problemas que ahí se generan, eso es algo lamentable.

It seems outrageous to me that there are people who have to go, well, I mean, the municipality provides an ambulance, but it's outrageous that they have to be transported from the region to southern CDMX for dialysis and then back. That is to say, later, returning in an ambulance for more, as if it were a bus, I mean, an ambulance for 8 people? And then the first one, who has already returned from their dialysis, has to go through the ordeal of finishing all this, that there isn't a health center there, that's able to attend to the people because the problems that arise there; it's awful.

Interviewees also highlighted other problems, including wastewater from CDMX, the WWTP and deforestation along the banks of the Tula River. Activists placed the blame on the MS at all levels,

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not only for approving incineration practices in the region but also for the repression and abuse of power shown by the state and municipal governments. Likewise, some residents and professionals acknowledged shared responsibility for consumer behavior, for not demanding, and for a lack of community organization.

When asked which industry provides economic benefits to the region, professionals offered mixed responses, ranging from describing the very marginal benefits to stating that all companies provide a benefit. In contrast, activists and residents specifically mentioned PEMEX-CFE. Some interviewees reported abusive labor practices, such as temporary hiring to avoid granting seniority and the lack of social security protections. Regarding the mobilization tactics used by community social organizations, the response was unequivocal: all of them are deployed. Scheidel, et al. [47] identify 27 different types of actions; 19 were documented for this article, none of which are classified as violent.

Among all the stakeholders interviewed, including company and government employees, no one could envision a future with reduced pollution, whether from companies or production, or that improves their health conditions. However, some professionals expressed hope for the future. When invited to create a slogan about their perspective, most interviewees identified the better material and environmental conditions of CDMX inhabitants, summarizing their views as follows:

No somos mexicanos de segunda, nuestras vidas también valen [haciendo referencia a que los de primera son los habitantes de la CDMX] No somos mexicanos de segunda, ¿cuál es la diferencia entre un chilango [habitante de la CDMX] y yo?

We are not second-class Mexicans; our lives matter too [referring to those of first-class as the inhabitants of CDMX]. We are not second-class Mexicans, what makes a chilango [inhabitant of CDMX] different from me?

In general, the interviewees as a whole do not believe it is important to make new laws; they believe it is necessary to try to enforce existing laws. A smaller number of interviewees expressed that waste incineration in cement manufacturing should be prohibited by law.

4. Discussion

One of the core aspects of PE is building relationships and constructing arguments to expose the unequal distribution of responsibility in environmental conflicts where the livelihoods and health local inhabitants are at stake. In this context, adopting an integrative perspective becomes essential—recognizing the social power of self-organized groups, despite being deprived of means of production, health, and life. These groups demonstrate significant organizational capacities by forming regional support networks, diversifying their strategies of resistance, and generating practical knowledge that strengthens effective resistance in the future.

In this context, the economic analysis of a socio-environmental conflict may be one of PE's most valuable contributions. Leff [18] argues that developmental rationality clearly reflects the economic power of the private industrial sector, which expands territorially, creating an unequal geography of consumption. This dynamic divides those who consume from those who produce and become ill.

At this point, the MV can be identified as a key provider of cement, food, and energy for the country's highest consumption area, operating in clear synergy with the MS as a facilitator of capital accumulation through land dispossession, resource-based rents (from mines and farming) that favor capitalists, and precarious wages. Even emissions generate profit, as seen with the WWTP and the now-canceled landfill project.

Authors such as Andreucci [22] and Arboleda [31] describe the state as a facilitator of resource exploitation for capital expansion. Legislative changes, including reforms to Article 27 and its related laws, function as enabling mechanisms for the exploitation of natural resources, reinforcing the persistence of slow violence, as discussed by Scheidel et al. [47], Vélez-Torres [24], and Castillo [25]. However, examining a sacrifice zone like the MV exposes the ineffectiveness of current environmental legislation, as its externalities visibly result in illness and death.

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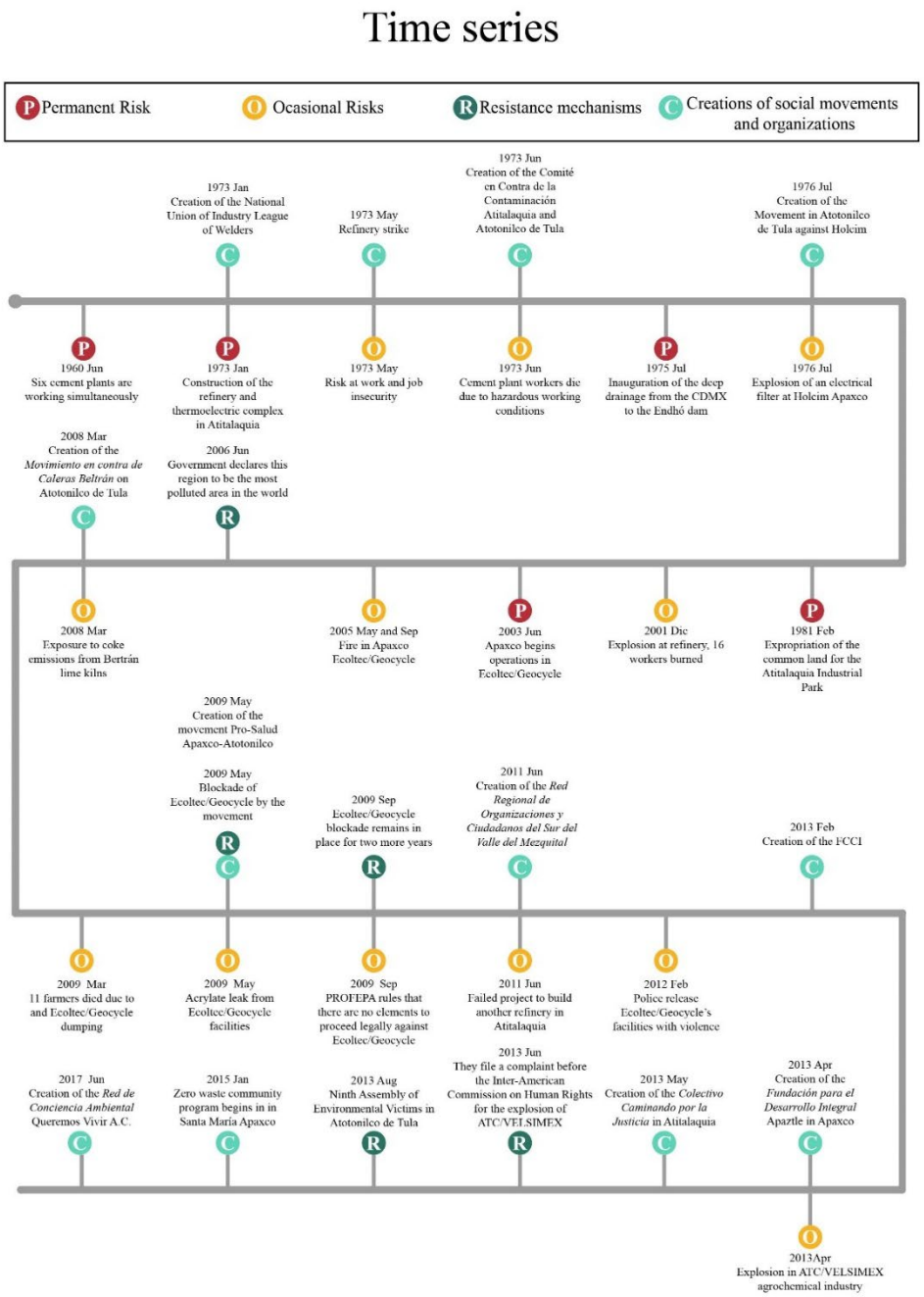
This research identified female leadership, as highlighted by Castillo [25], through the activity of women in self-organized groups. Four of the seven interviewees were women balancing family caregiving responsibilities while demonstrating distinct organizational skills in territorial defense. It also considers the perspectives of female professional allies who support the inhabitants of the MV. While a feminist PE analysis falls outside the scope of this paper, the findings suggest potential for future in-depth work on this topic.

Based on the interviews, the timeline shown in Figure 2 was constructed. "P" represents permanent risks, including the establishment and expansion of industrial zones, emissions from cement plants, infectious biological risks from wastewater, and the WWTP. "O" represents occasional risks such as industrial accidents, explosions, and induced floods. The response of self-organized groups is indicated by "C," symbolizing the creation of social movements, and "R" expresses the most prominent ways in which self-organized groups resist and gain recognition from the MS and the media. These actions include blockades, facility occupations, assemblies, networking, and conflict dissemination.



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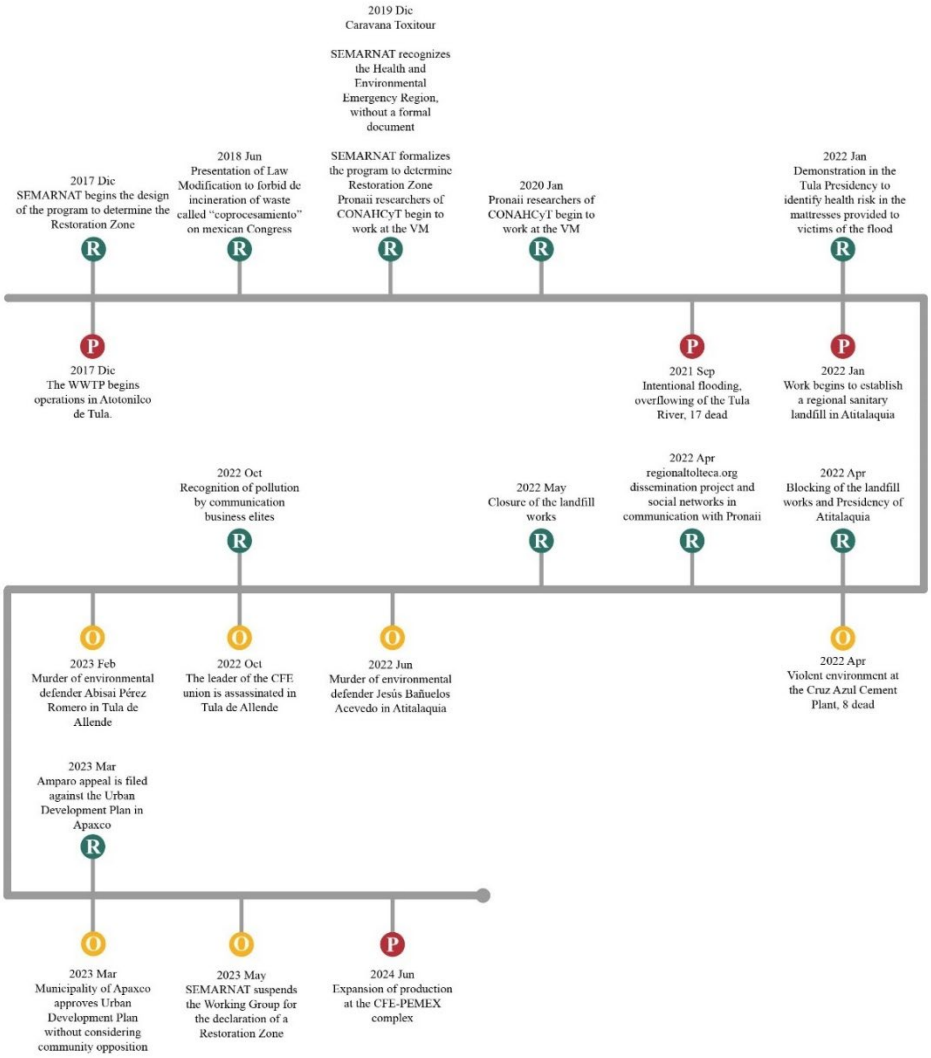

Figure 2. Timeline of the most important socio-environmental events from 1960-2024 on the MV.

Records from the 1960s reveal the ongoing risks posed by the cement industry. Between 1973 and 1976, the refinery in Atitalaquia was built, wastewater volumes increased, and the first socio-environmental movements emerged in response to pollution, industrial accidents, and occupational hazards. From 1981 to 2008, industrial accidents continued alongside the expansion of industrial parks, prompting the formation of additional environmental movements. From 2009 to 2013, the number of environmental movements matched the frequency of industrial accidents.

The formation of organizations and mobilizations began in 1973 in response to the cement industry. The last organization emerged in January 2022 following the opening of the ESMEX landfill in Atitalaquia. In total, nine organizations now comprise networks and advocacy fronts, all identified through media, news reports, and triangulation with structured interviews.

While the beginning of industry in the MV dates back to the first half of the 20th century, its consolidation as a permanent and intensifying risk occurred between 1960 and 2003. After this period, the manufacturing industry continued to expand, though heavy industry did not experience the same significant growth as in the previous stage— until 2017, when the Atotonilco de Tula WWTP began operations. In 2024, the federal government is set to complete final works aimed at boosting production at the CFE-PEMEX complex.

The period from 2009 to 2013 saw the highest number of industrial accidents, primarily linked to the cement industry, particularly at Holcim/Geocycle. These events triggered a cascade of

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interconnected movements. They converged around the explosion of ATC/VELSIMEX in Atitalaquia, the health risks associated with the Atotonilco de Tula WWTP, and the 2021 flooding of the Tula River.

The years 2022 and 2023 were marked by extreme violence in the MV, as identified in this analysis. The conflict within the Cruz Azul cooperative resulted in eight deaths. Although this heavy industry is highly polluting, Cruz Azul had earned community support through its investments in schools, sports facilities, and local employment in Tula de Allende. Following this, two environmental defenders and a union leader from the energy sector are murdered. None of the murders have been solved, highlighting governance problems in the MV. This is compounded by the presence of criminal groups involved in gasoline theft and land-rights extortion, fueling violent incidents such as shootouts and murders unrelated to environmental movements.

Since 2019; with the emergence of the Toxitour Caravan, the Mexican State has recognized social movements and their demands. This reflects what Almeida [26] describes as "good news," or successes for the movement to sustain itself. The impact is evident, as from 2019 to 2023 the MS has consistently referenced the conflict in the media.

Over the past 50 years, the forms of organization and protest have been extensive, aligning with the categories described by Scheidel, et al. [47] and Almeida [26]. A wide range of protests have been carried out, from peaceful protests that transitioned from movement into organization, to the occupation of industrial facilities and even the municipal presidency. Strategies also include legislative proposals and participating in research work are some of the most important.

5. Conclusions

Analyzing the socio-environmental conflict of the MV through the lens of PE highlights the economic traceability of extractivism, revealing that the region's high productivity— through the exploitation of its workers and natural resources— fails to benefit local inhabitants. Likewise, examining the metabolism of megacities like CDMX exposes socio-environmental injustice, where the well-being of certain consumption centers is prioritized at the expense of surrounding areas, whose water, air, and soil is contaminated [49]. This creates an unequal geography that separates consumption hubs from production and dumping zones, where economic value is not retained locally. Our research reveals a geopolitical configuration of environmental injustice that exacerbates spatial divisions.

The various legal processes through which the MS has acted as a facilitator for capital expansion have impacted the study area. Since the signing of the North American Free Trade Agreement (NAFTA) in 1992, the growth of industrial zones across the country has been promoted. The MS has allowed private enterprises to operate freely by setting product prices. (e.g., forage for dairy companies). Additionally, it has shown that the state employs neoliberal practices in labor hiring within state-owned companies and invests public funds for private benefit (e.g., WWTP and highways).

We have documented the characteristics of the social movements in the study area to highlight the complex organization of diverse social responses that mobilize their collective power against a toxic environment. These movements transcend borders by continuously renewing and expanding their partnerships and forms of protest, in contrast with traditionally violent social movements. The environmental struggle in the MV may be one of the longest-standing resistances to environmental injustice, spanning 50 years. The diversification of their protest and resistance strategies, along with the constant chemical risks they face, is one of the most important hallmarks of the movement and what allows them to persist over time.

The MS acts as a facilitator in two ways: by precarizing working conditions to increase the profitability of the oil industry, and by granting property titles, enabling the creation of industrial landowners (primarily cement companies). This process allows them to configure the space according production needs. Rent derived from environmental reservoirs becomes a hallmark of

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sacrifice zones, where pollutants are contained, and profits are generated without compensating for the resulting environmental and health damage.

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