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Surveying Community Environmental Justice: Urban Runoff Patterns in Eastern Tijuana, México

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Abstract: In an urban region of eastern Tijuana, there are long-standing water runoff sites which community members have identified as having an impact on residents, including contributing to flooding. This community-based participatory research (CBPR) project in collaboration with the Colectivo Salud y Justicia Ambiental (CSJA) used the geospatial surveying tool Survey 123 to conduct community-based monitoring of five runoff sites. Results from 170 completed surveys showed that water runoff was present at these sites on forty-five percent of the days surveyed, although there was no significant relationship between the temporal factors studied and the water quality characteristics surveyed. These findings contribute to the field of border environmental justice by focusing on the understudied issues of runoff and urban flooding as environmental exposures that some communities experience disproportionately. Moreover, while there was a significant relationship between water runoff volume and precipitation events at the water runoff sites, there were sixty-five surveys collected that showed water present when there had been no precipitation event at the site. This finding supports the CSJA members' assertions that the runoff experienced in the study area is not always connected to precipitation events or pluvial flooding. This project's results contribute to policy advocacy by countering the policy narrative that this issue is simply a stormwater issue, and by identifying the specific runoff sites to be prioritized in this region.

Keywords: environmental justice; urban surface runoff; urban flooding; community-based water monitoring

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1. Introduction

The Colectivo Salud y Justicia Ambiental (CSJA or Colectivo) is an environmental justice organization that has been active in the border city of Tijuana (México) for more than twenty years. Their campaigns have addressed issues of hazardous waste dumping, air pollution and the stewardship of binational rivers. The Colectivo's membership is made up of twelve core members, some of whom have been active in the organization since its inception in the late 1990s. Some of the members are former maquiladora workers, and most of the members are internal migrants from other areas of México. The organization of the Colectivo's work area encompasses three urban communities in eastern Tijuana, México: Chilpancingo, Murua and Loma Bonita. This area is about 2.5 square kilometers, with a total population of 21,934, according to the 2020 census (INEGI 2020).

Since the early 2000s, the Colectivo's communities in eastern Tijuana, México have documented issues with urban surface runoff sites that create flooding. Urban surface runoff refers to water that is not up taken by existing water infrastructure, which is an issue of concern, as this runoff in urban residential and industrial areas is likely to contain hazardous materials (Choe et al. 2002). This urban surface runoff creates flooding of urban streets in this region, like in other areas around the world (Li et al. 2020). In the emblematic documentary *Maquilapolis*, filmed in 2000 and published in 2006, there are multiple scenes showing the visible impacts of these water runoff sites (Funari and De la Torre 2006). Unfortunately, urban surface runoff and flooding has continued with little to no change since the filming of *Maquilapolis*.

Environmental injustice involves disproportionate exposure to environmental ills and access to environmental goods (Pellow 2017), coupled with the systemic exclusion of marginalized groups from the environmental decision-making that impacts their lives (Pellow 2002). Conversely, environmental justice is the equal protection of all people from environmental risks (Bullard 1996). Organizations working in the border region have a distinctive conception of environmental justice that is based on the confluence of local and binational politics (Carruthers 2008). Border environmental justice is defined by the factors of social and economic integration across the border, the core–periphery relationship between the U.S. and México and fragmented environmental governance (Prado 2019). These specific elements create gaps in political accountability in the border region. The Colectivo's work area is a region that borders the city of Tijuana's largest industrial park, where the production of electronics, automotive parts, food products and more contributes to the economic production of the city (Grineski and Collins 2017). In this region, there is movement of workers from the residential neighborhoods to the factories in the industrial park, and movement of goods to different areas of the country, as well as across the border (Quijada 2010). The neighborhoods within the Colectivo's work area are therefore at the crossroads of community needs (such as reliable public transportation, clean and safe streets, access to food) and industry needs (such as reliable streets for trucking, infrastructure for necessary inputs like water and infrastructure for output like waste) (Grineski et al. 2015). Border communities that are in proximity to production centers experience this struggle for infrastructural development, due to these gaps in political accountability (Grineski and Collins 2017). The urban surface runoff experienced in this area is met with a lack of infrastructure, creating the conditions for the impactful flooding events documented in this research.

Environmental justice studies have framed the ways in which environmental resources are experienced differently by communities through the elements of distributive and procedural justice. Distributive justice points to "how harms and benefits are distributed and experienced", regardless of whether these disproportionate harms or benefits are the result of direct discrimination (Kaswan 2020, p. 22). When it comes to distributive justice, residents in the Colectivo's communities must contend with uneven exposure to wastewater from urban surface runoff, and the impacts on their livelihoods and quality of life presented by the subsequent urban flooding that this runoff creates. While distributive environmental justice analyses have focused on elements of water pollution, like hazardous spills and access to clean drinking water (Chakraborti and Shimshack 2022; Faroque and South 2022), urban surface runoff has not had the same attention (Ranganathan and Balazs 2015; Walker and Burningham 2011).

Procedural justice focuses on the ways in which governance processes have excluded marginalized communities from participation and recognition in the decision-making that affects their livelihoods (Schlosberg 2004). In the procedural justice realm, residents of the Colectivo's work area have participated in advocacy efforts for multiple years to address this issue, which have not been responded to with appropriate action. Advocacy efforts have been extensive, including petitions, meetings with different state actors and even a formal water sampling effort, but the state response has fallen short (Arredondo

2023). For example, residents invited public officials to tour the community to show them the issue, with no follow through (Gómez Sánchez 2023), and residents have made reports with Tijuana's Public Works agency, but have received no response to these reports (Arredondo 2023).

One important hurdle in this stems from contention over the source of this runoff and subsequent flooding. While some observations of urban surface runoff have previously been linked to precipitation events (Rözer et al. 2021), community members in this region have relayed their lived experiences, noting that this runoff and flooding are not exclusive to days when it rains. CSJA members and their interlocutors in the neighborhood have suspected that the runoff and flooding could be tied to urban industrial pollution from the manufacturing industry in the nearby Otay Industrial Park (Funari and De la Torre 2006). For example, multiple news outlets have reported on these sites in the Colectivo's work area, and documented this runoff as having characteristics, such as noxious odors and bright or dark colors, that are uncharacteristic of rain water (Arredondo 2023; Gómez Sánchez 2023). According to CSJA members, state actors have responded to this issue, assuring residents this is a pluvial infrastructure problem that is unrelated to industrial or residential water contamination. In other words, public officials and agency representatives have told CSJA members and other residents that the surface runoff is simply rainwater. This project provides a response to this procedural injustice, in order to engage in the environmental policy process using the results from a survey (Prado et al. 2024), and to respond to this narrative pushed forward by state actors by examining whether the surface runoff sites are only influenced by rain.

The three guiding research questions in the included monitoring project examine (1) the temporal patterns for runoff water's volume, color, and/or odor; (2) the profile of each runoff site, including which runoff site has the highest volume levels; and (3) the relationship between water volume in the runoff sites and precipitation days. We found that while there were no temporal patterns in the surface runoff, there were some differences between the different runoff sites. This is helpful in suggesting the prioritization of two main runoff sites in the advocacy efforts in this region. We also found that of the days we surveyed, there were 65 days in which water was present at the site on a day that it had not rained. This is an important finding for understanding the potential sources of this water pollution, and for countering the state's narratives around this being only a pluvial issue. The broader significance of this work includes framing urban surface runoff and flooding as a border environmental justice issue. This research also exemplifies the importance of community-based environmental justice research as an entry point for engaging in environmental governance processes.

2. Materials and Methods

Community-engaged research is an important approach for environmental justice work, as it is embedded in community expertise, and produces knowledge that is action-oriented (Raphael and Matsuoka 2024). Urban surface runoff and flooding are issues that has been difficult to document. Colectivo researchers have been witnessing and following their patterns for more than two decades. Their community expertise is invaluable for understanding where the most important locations are for surveying, where runoff is most visible, and what flooding patters are most impactful on neighborhood streets.

Moreover, this project is centered around documenting this issue for the purpose of pursuing action from local environmental authorities. The questions that guide this monitoring survey are geared toward understanding potential sources better, in order to inform the policy advocacy that the CSJA campaign should focus on. Therefore, the community-engaged nature of this project helped to both create a more pointed research design for this project, and to gear this research design toward creating policy action. CSJA's policy goals of this participatory project included contributing to three goals: (1) government action on identifying the sources of these runoff sites and flooding issues, (2) enforcement actions for industrial actors in the area that may be illegally disposing of wastewater, and (3) infrastructural changes to diminish exposure to runoff contaminants in the region. With the first goal, the Colectivo aims to use these data to impel a working group within the Secretaría de Medio Ambiente y Desarrollo Sustentable (Secretariat of the Environment and Sustainable Development), the state-level Baja California environmental protection agency, to investigate and regulate the sources of this urban surface runoff. Second, the Colectivo envisions that this working group can use these data on runoff sources to pursue enforcement actions on polluters. Last, Colectivo members aim to use the documentation of these runoff sites to identify how channelizing runoff could reduce resident exposure to this contaminated water through advocacy with the CESPT (the State Commission for Public Services of Tijuana), who are responsible for urban water infrastructure.

Community-based water monitoring projects come up against issues in deciding specific methodology approaches. One of these is the consideration around what kind of resources and tools are available to community researchers for their projects (Buckland-Nicks et al. 2016). Other studies examining surface water runoff patterns have used remote sensing (Ayad et al. 2020), collected water samples for chemical analysis (Peckenham and Peckenham 2014) and used satellite modeling (Kurczyn-Robledo et al. 2007). Other studies have used GPS-enabled images to take photographs of a site that is important to water quality (Bhatti et al. 2017) and used crowdsourced photographs to track flooding (See 2019). Our project team decided that our approach of rapid monitoring of water runoff and flooding, using Survey123 version 3.12, would be an easy-to-access approach, as the tools we needed were not costly and not overly technical to learn for the community data collectors. A second consideration is the ways in which the goals of the monitoring project align with the methodological approach (Buckland-Nicks et al. 2016). Two types of goals shared by community-based researchers in this study were to both create scientific data that are useful for the government, as well as raise awareness among community members to encourage them to engage in stewardship actions. Our monitoring goal in this project was to create scientific data that can be used to inform government action, by analyzing the characteristics of each runoff site, but most importantly by testing the presumption that the issue is simply one of rainwater runoff.

In order to inform the research team's knowledge of potential sources of the urban surface runoff, the monitoring project analyzed temporal patterns in the five urban surface runoff sites studied. First, we analyzed temporal patterns of urban runoff water characteristics that CSJA members theorized would have the biggest impacts on resident mobility and quality of life: water volume, water odor(s) and water color(s). The second research objective was to develop a profile of these water characteristics for each of the runoff sites; this can help the CSJA urban runoff campaign by providing an understanding of which of the runoff sites create the greatest health/mobility risk for community members in their work area. Last, we analyzed whether the water volume of all the runoff sites had a relationship with precipitation in the area.

2.1. Study Sites

Previous community-engaged research on environmental risks in the CSJA work area identified twelve contaminated water runoff sites in the area (Prado et al. 2021). We used this list as a starting point for identifying the runoff sites for this project. The research team acknowledged that twelve runoff sites might be too large a list for a sustained surveying project; therefore, we chose to limit the list of surveyed runoff sites to five. The five sites were chosen through community expertise, due to the following three factors: (1) they are sites that are more frequently seen with larger volumes of water, (2) they are sites that have an impact on busy areas of the region, and (3) they are sites that had geographical proximity to CSJA research team members, in order to increase accessibility to team members who did not own vehicles. The five contaminated water runoff sites are identified in Figure 1 below.

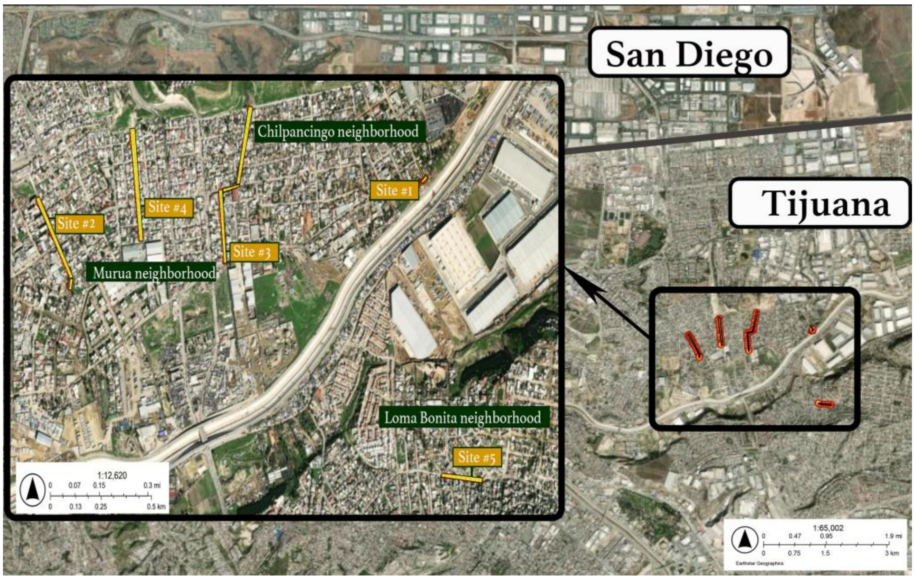

Figure 1. Contaminated water sites, CSJA work area, Tijuana, México.

Sites one and three are in the Chilpancingo neighborhood. Site one is in a residential nook. This site has two sources of water that feed the surface runoff; one is a channelized stream that residents suspect comes from both residential and industrial water sources. This site also leads into the Alamar River channelization, where there is no pedestrian crossing, so many people cross the channelization by wading through this runoff. Site three is the runoff site with the longest stretch on urban streets. The water comes down the mesa directly underneath the Otay Industrial Park, a large manufacturing center in the city. This water passes by a preschool and a health clinic, and leads into the Alamar River channelization.

Sites two and four are both in the Murua neighborhood. Site two's water flows from an unchanneled stream that also comes down from the Otay mesa. This runoff ends in a small, channelized stream at the edge of the residential area of Murua. Sources of this runoff have been discussed as being industrial and commercial. Site four's water has emerged from a large pipe that connects the residential area of the Otay Mesa with the Murua neighborhood. Residents suspect that this water comes from the residential neighborhoods in that area, though some believe that commercial sites are illegally dumping their wastewater in this area as well. Lastly, site five is located across the Alamar River, in the residential area of Loma Bonita. Loma Bonita has some irregular housing and more traditional services; the runoff site emerges from a channelized stream that breaks off into the street. This site's water runoff is discussed as having industrial and residential sources.

2.2. Data Collection Process

The community-engaged research collaboration between the Colectivo and university researchers not only shaped the project's questions, but also its data collection process. Community expertise was tapped to understand where monitoring pictures would be taken week by week, depending on where the biggest impact on community members was seen by Colectivo researchers. University researchers identified specific parameters for Colectivo researchers that could make the data more comparable/reliable throughout the surveying period. For example, university researchers identified that photos should be taken around the same time period each week, and that photo documentation should be taken in landscape format, and any additional video documentation in portrait format. Moreover, because Colectivo members designed this monitoring project in collaboration with university researchers, there was community buy-in with the data collection necessary to execute this project.

As found in previous surveys of community-based monitoring, adequate training is important to protect the integrity of the data collected (Conrad and Hilchey 2011). To prepare the CSJA research team for this project's data collection, the first author conducted training on surveying and the use of ESRI's Survey123 tool in October 2021. Survey123 is accessible via a web browser, and can be downloaded onto a smartphone with GPS capabilities. The application hosts surveys that allow users to upload images and geolocational data. This training consisted of presenting screen-capture videos of the Survey123 app to allow research team members to become comfortable with the interface. In this meeting, research team members practiced using the Survey123 mobile application by filling out the survey questions and uploading practice photos. The first author went through the survey questions, addressed anything that was unclear and gave a quick set of tips on how to take good pictures of the water runoff sites. All Colectivo organizational members were present at this training, except for two members, with whom the first author met individually to go over the training in that same week. The team members are all adults in ages ranging from 30 to 65 years old, and are all residents of the Colectivo's work area in eastern Tijuana.

Surveying the five key contaminated water runoff sites was important, as the research team wanted to gain a clearer picture of how these sites change throughout the week, and throughout different parts of the year. Therefore, we used two different data collection time periods. First, between November 2021 to May 2022, CSJA research team members surveyed the five sites once a week for that six-month period. Second, in August–September 2022, the team surveyed the five sites once a day for a four-week period. Data were collected by research team groups; each runoff site had two to three researchers responsible for its regular surveying, and these team members alternated weeks/days for data collection. The team members surveying were all members of the Colectivo, and members were assigned to the runoff site closest to their home or another location they frequented, for example, their grandchild's elementary school. One of the university researchers was the backup data collector for all runoff sites, though they only collected data a few times during the collection period.

Data collection was completed in two phases: Phase 1 surveys were collected once per week during a six-month period, and in Phase 2, the data were collected once a day during a one-month period. Data collection Phase 1 resulted in 86 once-weekly surveys from all five runoff sites between November 2021 and May 2022. Then, in August 2022, CSJA research team members collected 84 daily surveys from four runoff sites. After completion of Phase 1 of the data collection period, runoff site four was in the middle of a construction project, so the research team decided that this construction interfered with the accuracy of the runoff site data, and excluded that site from the second round of surveying. The research team collected a total of 168 surveys during this seven-month period. Table 1 shows a full summary of the survey data collection.

Table 1. Data collection results.

Data Collection Period 1: November 2021–May 2022		Data Collection Period 2: August 2022	
Runoff Site	**Number of Surveys**	**Runoff Site**	**Number of Surveys**
1	13	1	16
2	22	2	22
3	21	3	24
4	16	4	0
5	14	5	22
Total Surveys:	86	Total Surveys:	84

2.3. Data Collection Tool

Community-based water surveying employs community science, involving data collection on the ground in order to track and respond to issues of environmental concern for communities (Whitelaw et al. 2003). Some community-based water projects have used mobile applications for crowdsourcing data (Bernedo Del Carpio et al. 2021), or obtained photos through the photovoice method (Rimmler et al. 2023), as well as using social media to gather crowdsourced information and images (Cervone et al. 2016; Li et al. 2017; Sy et al. 2019). In our community-based participatory research meetings, the research team decided to use a short survey tool on the ESRI Survey123 application. This tool was chosen due to the fact that it included geolocation for future GIS analysis of the monitoring results. Second, the Survey123 interface was user-friendly for the research team members who used their private mobile phones for collecting data. Moreover, there is evidence of its effectiveness in community surveying on different socio-environmental issues, like water quality monitoring (Gunn et al. 2021), tourism disaster research (Kingsbury et al. 2021) and soil erosion (Hansen 2020; Mikhailova et al. 2022).

The water contamination monitoring survey tool was created in collaboration with all the members of the CBPR team. The survey tool was created to capture characteristics of the water runoff at that place in time. Water odor, color and volume were the key characteristics collected by the survey. When we use the word volume, we are referencing perception-based methods based on categories decided on by the whole research team, including the four options offered in the surveys. These four options are as follows: there is no water, there is little water, water covers half of the street or water covers all of the street. We used these categories as a way to visually measure the amount of water that could be seen on the street and normalized these data, rather than estimating gallons of water that might be harder to normalize across surveyors. Data collected by the survey included photos of the water runoff site at the time of each survey. The full set of questions and types of responses collected by the Survey123 tool are listed in Table 2 below.

Table 2. Monitoring survey.

Questions (English, Spanish)				
Does the water have an odor? *¿El agua tiene Olor?*	If there is an odor, describe that odor: *Si tiene olor, describa el olor:*	What color is the water? *¿De que color es el agua?*	What is the water volume at the runoff site? *¿Cómo esta el volumen del agua en el escurrimiento?*	Other details about the runoff site: *Otros detalles sobre el punto de escurrimiento:*
Response Type				
Yes/No	Write in answer. Coded as follows: (1) No Odor (2) Sewage (3) Stagnant Water (4) Rotten (5) Trash	Write in answer. Coded as follows: (1) No Color (2) Brown (3) Black (4) Green (5) Gray	(1) There is no water (2) There is little water (3) Water covers half of the street (4) Water covers all of the street	Write in answer.

2.4. Data Analysis

Survey data included both write-in responses and scale questions. In order to analyze the survey data, we first coded all the write-in responses; then, along with the scale questions, each response was assigned a numerical value. For example, when participants were asked to note the volume of water observed, a response of "there is no water" was coded as "25"; a response of "there is little water" was coded as "50"; a response of "water covers half the street", was coded as "75"; and a response of "water covers all of the street" was coded as "100". For the write-in answers for odor and color, we read through all the answers, coded them into five categories and assigned each color and each odor a numerical value. Using these coded data, we employed a combination of descriptive statistics and inferential statistical tests to answer the study's research questions. Research question five, through which we analyzed the profile of each runoff site, only used descriptive statistics; for all other research questions, we used a chi-square test of independence and descriptive statistics to present our results.

For research question one, we used chi-square tests to measure the relationship between the time variable (day of the week/month of the year) and the water characteristic variable (volume/odor/color) of the aggregated runoff site data. We chose the chi-square test of independence in order to analyze the relationship between the categorical variable of time (day of the week/month of the year) and the categorical variables of water characteristics (volume/odor/color). This type of hypothesis testing has been used to examine nominal categorical data to understand the significance of group differences (Rost 2024). First, we simplified the data to run three tests whereby we analyzed the day of the week with a numerical value (1–5), and simplified water volume to indicate whether there was water ("1") or was not water ("2") in the runoff site; whether there was odor ("1") or was not odor ("2") in the runoff site, and whether there was color ("1") or was not color ("2") in the runoff site. Similarly, to analyze the relationship between the water characteristics and the month of the year, we simplified the data to run three tests whereby we analyzed the month of the year with a numerical value (1–8), and simplified water volume to indicate whether there was water ("1") or was not water ("2") in the runoff site; whether there was odor ("1") or was not odor ("2") in the runoff site; and whether there was color ("1") or was not color ("2") in the runoff site.

Research question two, which included analyzing which runoff site had the highest volume of water, was answered with a chi-square test, analyzing the relationship between runoff site (1–5) and simplified water volume, to indicate whether there was water ("1") or was not water ("2") in the runoff site. This research question also examined the profile of each runoff site individually, to understand each site's average volume levels, water odor(s) and water color(s) through descriptive statistics. We also used the free-form comments in the survey to further highlight the characteristics of each runoff site, and we analyzed the photos taken in each survey to present examples of the volume level and colors visible in each of the five runoff sites. For research question three, we used a chi-square test to test the relationship between the water volume levels of all the runoff sites and daily rain data for the city of Tijuana. Rain data were coded as "rain day", with a numerical value ("1"), if there was more than 0.20 inches of rain recorded that day.

3. Results

Our community-based water runoff surveying provided key results to shape understanding of runoff sources and the impacts of these sites. First, there was no significant relationship between water runoff volume, odor, nor color and the day of the week the runoff sites were surveyed. Similarly, there was no significant relationship between the month of the year and water runoff volume, odor or color. We had hypothesized that if there were some clear patterns, we might be able to link these to some industrial or residential activity, but this was not the case. Second, runoff site number one had a significantly higher water volume than the other runoff sites. Moreover, runoff sites one and two are of most concern, as water runoff was documented in at least half of the surveys during the data collection period. Third, while the test results showed that there was a statistically significant relationship between the days that it rained and the survey indications that there was water present in runoff sites, there were 65 surveys in the data collection period which reported that there was water present at sites when there had been no precipitation. This is a starting point for understanding that the runoff water is not only a result of precipitation. Since there were no significant results when we analyzed the relationship between the day of the week and month of the year, with runoff characteristics (volume, odor, color), we report the findings of the last two research questions only in the following subsections.

3.1. Research Question 2: Individual Runoff Sites and Water Characteristics

The volume levels at the different contaminated water runoff sites varied greatly. For some of the water runoff sites, a few surveys indicated that there was no water present (runoff site one), whereas for other sites, a few surveys indicated that there was water present (runoff sites three and four). A chi-square test analyzed the relationship between the runoff sites and the number of surveys that indicated whether there was/was not water present. This test indicated that there was a statistically significant relationship between runoff site one and the other runoff sites with regard to volume, rejecting the null hypothesis, $X^2(4, N = 168) = 67.43$, $p = 0.001$ with a Cramer's V of 0.634, indicating a strong association. Therefore, runoff site one had the highest volume level throughout the surveying period.

In runoff sites one and two, water runoff was reported in at least half of the surveys. Water characteristics for the two sites with the most observed activity can be seen below in Figure 2. For approximately forty percent of the surveys, water runoff was observed at site five. Sites three and four were observed to have water runoff in only five surveys and one survey during the data collection period, respectively. Our study thus aligns with CSJA predictions indicating that the runoff sites of most concern to the community are sites one and two, which we will report on in this section.

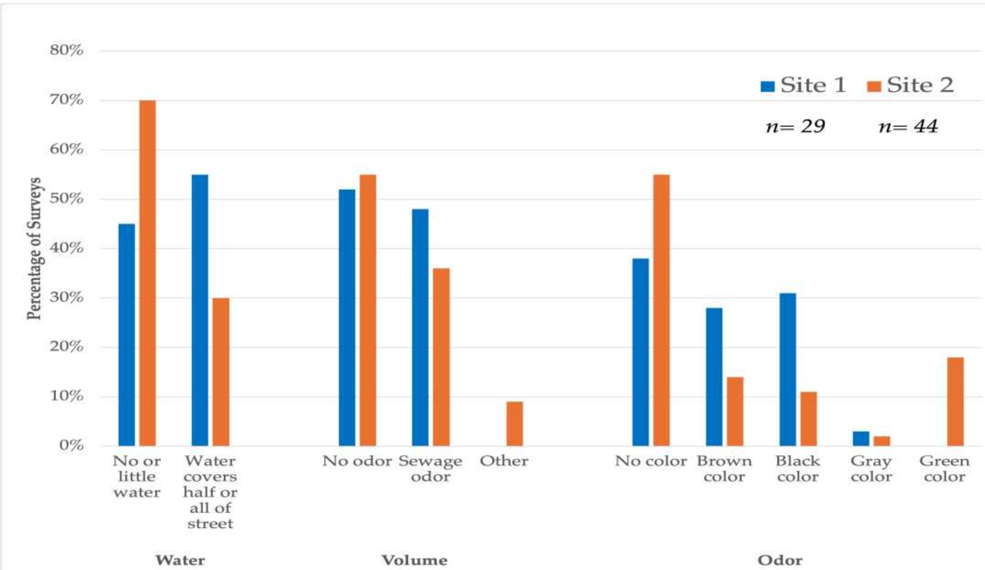

Figure 2. Sites 1 and 2: Volume, odor and color.

3.1.1. Contaminated Water Runoff Site One

Runoff site one is in the Chilpancingo neighborhood, about a block from the area's only park, Chilpancingo Park. It is at the end of a street that leads to the Alamar Creek channelized river bed. This runoff site is frequently observed to have trash and raw sewage that can at times fill the entrance to the Alamar channel. Community members in this region use the Alamar channel to move from north to south (and vice versa), from neighborhood areas to the Otay Industrial Park directly north of the Chilpancingo neighborhood, as there are no pedestrian crossings at any section of the Alamar Creek channelization project.

Runoff site one was the site that had a consistent presence of water runoff. For more than half (52%) of the time, the water runoff volume covered half of the street at this site. On one day, the water covered the entire street, and 44.8% of the surveys reported that there was just a little water. The primary odor from this runoff site was the smell of sewage. The water runoff colors were either clear (38%), brown (28%) or black (31%); on one day, the water was gray. Figure 3 below features sample photos from runoff site one's surveys.

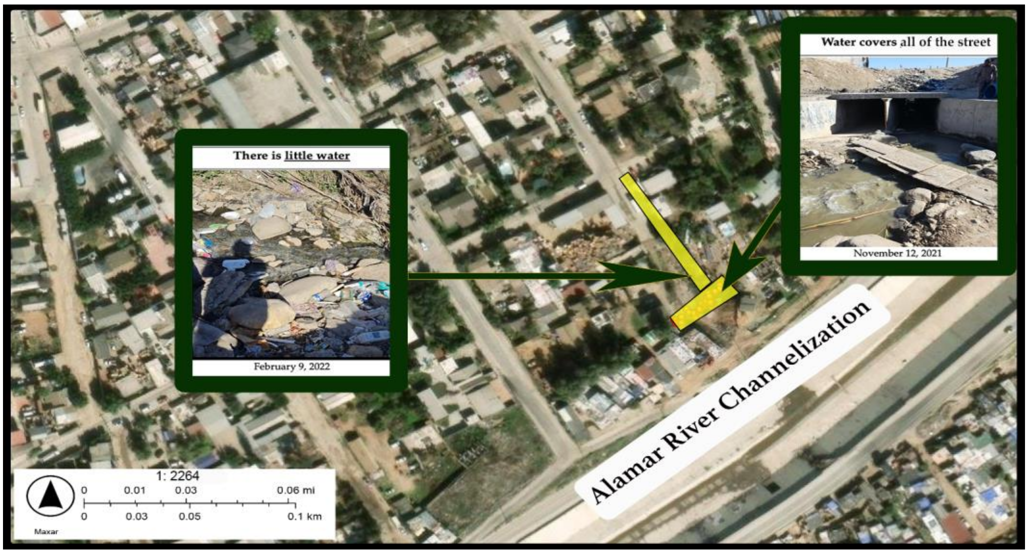

Figure 3. Site one sample photos from runoff surveys.

3.1.2. Contaminated Water Runoff Site Two

Runoff site two is in the Murua neighborhood, about two blocks from one of the community's main grocery stores. This runoff site starts at the end of one street and stretches for about six blocks total. This runoff site frequently has sediment and tires alongside water runoff. Community members in this area move throughout this runoff site to obtain food and access public transportation lines.

Runoff site two had the most surveys indicating that water covered all of the street, compared to all the other sites (see Figure 4). For half (50%) of the time, there was no water runoff. One-fourth of the survey dates indicated low amounts of water, although water runoff covered half of the street 18% of the time, and the entire street 11% of the time. When the runoff had an odor, it was mostly the smell of sewage (34%), stagnant water (7%) or a rotten odor (2%). In runoff site two, all the colors were represented: clear (55%), brown (14%), green (18%), black (11%), and on one day, the water was gray. Figure 4 features sample photos from runoff site two's surveys.

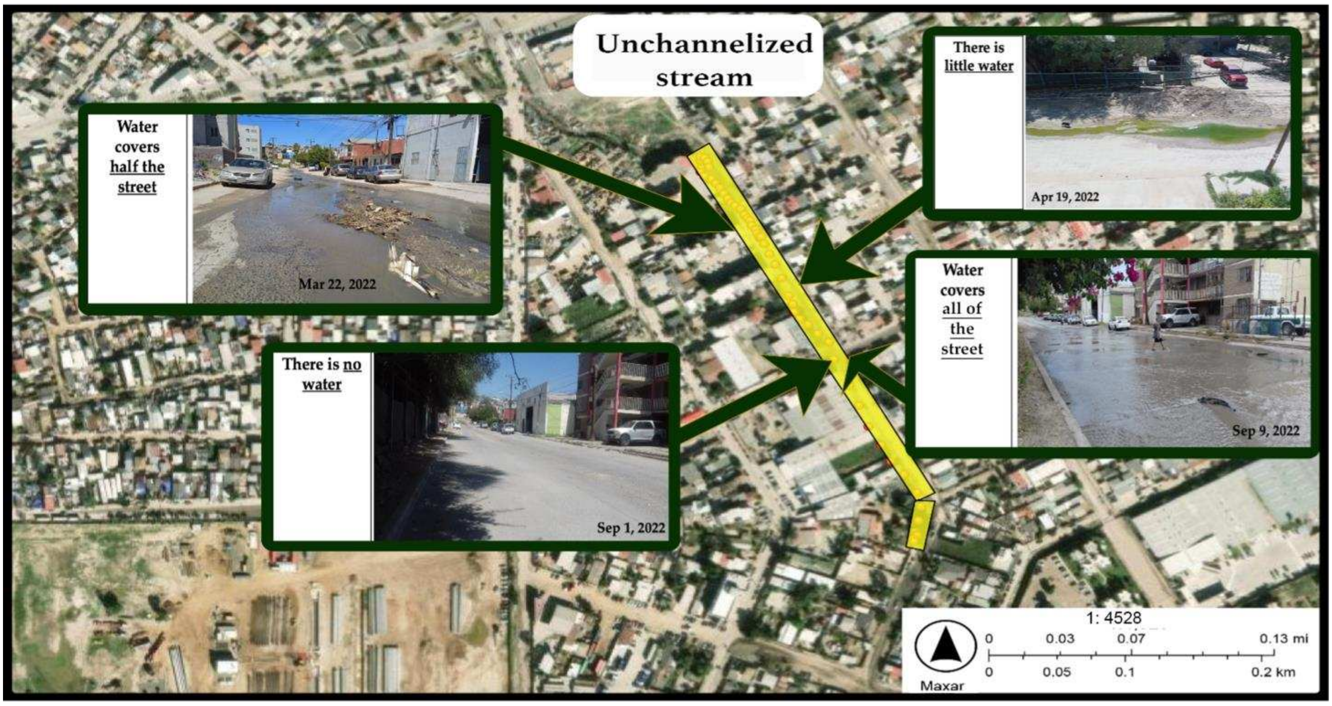

Figure 4. Site two sample photos from runoff surveys.

In the notes section of the water runoff site surveys, participants indicated that they saw a great deal of trash and sand (23% of surveys). One survey note section read the following: "it rained all night and that's why the street is full of water, yet the current is so fast that the water has brought boulders, sediment and a lot of sand into the street that is making cars get stuck" (29 March 2022). Participants also commented on the relationship between the rain and the water runoff site. One participant said, "it rained about two or three days ago, though you can tell that the water at this site isn't rainwater because of its smell and color" (8 March 2022).

3.2. Research Question 4: Relationship Between Water Volume and Precipitation

One of the key questions of this study is whether there is a relationship between the presence of water runoff and precipitation. Our chi-square test analyzed the relationship between the presence of rain and the presence of water runoff at all the sites. The test results showed that there was a statistically significant relationship between the days on which it rained and the surveys showing that there was water present at runoff sites (X^2(1, N = 168) = 5.94, p = 0.015 with a Cramer's V of 0.188). However, 65 surveys out of 168 also indicated there was water runoff present when it has not rained on the day of monitoring; in total, there were 75 days across all sites when water was present. Table 3 shows the total count of days when water was present and days on which it did not rain. Moreover, our survey showed that out of the 75 days on which there was water present at our runoff sites, 86% of the time, water runoff was present when there was no rain.

Table 3. Runoff site water volume and precipitation.

		No Water Present	Water Present	Total
No Rain Days	Count	90	65	155
Rain Days	Count	3	10	13
Total		93	75	168

4. Discussion

The findings from this project show critical directions for the CSJA team in their water pollution campaign. Our most important finding is that while there was a significant relationship between the days on which it rained and days on which there was water present at the runoff sites, rainy days were not the only days on which there was water runoff. There were 65 days on which there was water present at the runoff sites and it had not rained on that monitoring day. This is an important finding for policy advocacy as it counters the state narrative that this is simply a pluvial issue. Second, we found that runoff sites one and two were the ones documented to have higher levels of water volume consistently. This is an important finding for informing the prioritization of these two sites in advocacy efforts.

This project's findings contribute to the fields of environmental justice, border environmental justice and community-based participatory research. In the field of environmental justice, this project frames the issue of urban surface runoff within the scope of distributive environmental justice. While border environmental justice has intersected with issues of inequitable access to infrastructure, the issue of flooding in residential communities is important to address. Our data identifying the most critical flooding sites helps to anchor border environmental justice advocacy. Third, our community-based participatory research methodology uses community expertise to counter policymakers' statements on the root causes of the runoff and flooding in these neighborhoods.

First, the findings contribute to the environmental justice field by addressing the understudied issue of urban runoff and flooding. This is a distributive justice issue, as runoff and flooding exemplify uneven exposure to environmental risks and unequal access to environmental goods. First, there is uneven exposure to water contaminants for residents that are living near these surface runoff sites. Second, residents have disproportionate access to environmental goods through a lack of access to appropriate infrastructure that prevents flooding. These research findings help to shape our understanding of this region's experiences of runoff and flooding by exploring the temporal patterns of the runoff sites. Our project's hypotheses around temporal patterns, that the research team believed might point to specific stationary runoff sources, were not supported by the data. We found no relationship between the day of the week, nor the month of the year, and the volume of water runoff at the five sites. This finding suggests that there might be multiple sources of residential and/or industrial activities influencing the water volume at the runoff sites. The results regarding temporal patterns can be useful for future surveying and sampling of this environmental justice issue.

Second, our findings contribute to the border environmental justice field by using CBPR to identify the localized urban flooding sites that are the most critical for policy advocacy. The border context is ripe for inequitable access to infrastructure and environmental goods (Grineski et al. 2015), and there is an inequality that comes from urban flooding being framed by community members as a regular occurrence when there are structural issues at play (Plyushteva and Schwanen 2023). In other projects, community data collection has shown that images portraying urban flooding are important for understanding the precise patterns in urban regions (Helmrich et al. 2021; Wang et al. 2018). The analysis of which runoff sites have the most flooding revealed that two key sites (runoff sites one and two) showed the highest water volume and, at times, experienced flooding. Therefore, these two sites (Runoff sites 1 and 2) are the most important ones to focus on in the advocacy campaign to address this water contamination issue. This study's results suggest that a lack of equitable infrastructure needs to be a priority in the field of border environmental justice.

Our results provide images and characteristics for each localized runoff site at different volume levels, and these contribute new findings to the field of border water politics in

Tijuana, México. The city of Tijuana has been extensively researched for its issues with clean drinking water supply (Townsend and Eyles 2004) and the water pollution of its watershed and tributaries (Fox 2021; Laughery 2023; McLamb et al. 2024). In Tijuana, water runoff has mostly been studied for the characterization of its contaminants (Ayad et al. 2020; Calderón-Villarreal et al. 2022; de Jesus Piñon-Colin et al. 2020), and to measure the impacts of dams and urbanization on runoff volume (Biggs et al. 2022). The Colectivo's work area is of particular interest in terms of water contaminants, because of its proximity to industrial parks and its evidenced high pollution load (Estévez 2008; González Estévez and Sánchez Munguía 2013). While there have been large-scale, or regional, snapshots of urban runoff contamination in the city of Tijuana, our research addresses the need for more data on specific runoff sites that can shed light on their potential sources.

Lastly, this project expands the CBPR field by using geospatial surveying to document the lived realities of a community, enabling engagement in the public participation process. Previous statements from policy actors have indicated that this is simply an issue of stormwater runoff, yet our results show inconsistencies in the current policy approach. Our results show that while there is a relationship between these water runoff/flooding and precipitation events, there is water runoff and flooding when there has not been a precipitation event in the city on the survey date. Findings from our chi-square test support previous runoff research that highlights the role that significant precipitation events play in the flow of urban surface runoff (Azizi and Meier 2021; Azizi et al. 2022). However, our data also demonstrate that the runoff is not only coming from stormwater or rainwater. There were 65 surveys during the data collection period which reported that sites had water flow on a day when no precipitation was recorded. What this tells us is that the urban surface runoff in these sites is not coming only from stormwater. These findings are important for advocacy for procedural justice, as they highlight that the responses from policymakers arguing that this is simply a pluvial issue are challenged by the data.

Limitations and Future Research

One of the key limitations in this study is that we experienced, at times, a lack of consistency in surveying. Over time, the capacity that CSJA research team members had available for the weekly and sometimes daily surveying fluctuated, as seen in other monitoring studies (Eveleigh et al. 2014). Second, the data collection period was only within one year; there would potentially be more robust data to explore the precipitation patterns–runoff flow relationship if we had more years' worth of survey data. In future research, we will complete a second year of surveying on the top two runoff sites (sites one and two), with a bigger surveying team that can consistently collect weekly data. These data could help to clarify the question of how much of the flow at these sites can be attributed to stormwater.

Another limitation of this research is that we used daily precipitation data to label a site as having no precipitation, when rain data for the previous few days or even week could have been used to model whether precipitation outside of the same day could have impacted the runoff sites. In the future, we aim to look at historic rain data to determine whether rain over the previous several days impacts the runoff site. Moreover, we also aim to explore whether rain in upstream areas could impact flooding at the researched runoff sites.

Our third limitation is that our research team has not yet completed a biochemical analysis of the water runoff. Therefore, we are not able to fully understand the types of contaminants in the urban surface runoff experienced in these communities, as other runoff research projects have achieved (de Jesus Piñon-Colin et al. 2020). We will build on this project to create a community-based research plan to complete biochemical analysis of water quality at runoff sites one and two. For broader future work on issues of urban surface runoff and flooding in the border region, we hope to see research teams engage with this issue in areas that have mixed land uses, like eastern Tijuana, México. More localized, fine data on urban surface runoff sites will be helpful in providing more understanding on the ways in which urban communities interface with water pollution and flood risk.

5. Conclusions

Our project's findings are important in shaping understanding of urban surface runoff and flooding patterns in this region of eastern Tijuana. We found that while there were no temporal patterns in the surface runoff, there were some differences between the runoff sites. This is helpful for encouraging the prioritization of advocacy efforts in a context where there are limited resources for these activities. Moreover, we found that of the days we surveyed, for days where there was water present at the runoff sites, on about eighty percent of these days, it had not rained. This is an important finding for understanding the potential sources of this water pollution and for countering the state's narratives around this being only a pluvial issue.

There are some key limitations to this study, including a need for more consistent surveying, more long-term precipitation data and a biochemical analysis element to better understand the sources of this water contamination. Moreover, the broader significance of this work includes placing urban surface runoff and flooding as an important distributive justice issue in the border environmental justice field. This research also exemplifies the importance of community-based environmental justice research as a tool for public participation, as these data will be used as an entry point in the environmental governance process.

As noted by community-based monitoring researchers, one of the greatest challenges of this type of research is that the data may not be used in the decision-making process (Conrad and Hilchey 2011). In an effort to address this with our research, we are aligning the data results dissemination plans with the policy goals outlined by Colectivo organizers. The first policy goal is to influence the Secretariat of the Environment and Sustainable Development (SESD) to create a working group in order to begin investigative action to identify runoff sources. Our data dissemination plan includes presenting our monitoring findings at the Border 2025 water policy meeting. Border 2025 is a binational environmental policy forum and governing body that engages municipal, state and federal environmental governance actors, including the SESD. The research team has created a government-facing slide deck and presentation script to present at the Border 2025 water policy meeting, in order to request binational support for creating this working group. This strategy of "jumping scales" is a strategy used by border environmental justice activists to leverage international forums to place political pressure on Mexican environmental authorities (Prado 2019).

The second policy goal is to carry out enforcement actions on industrial actors in the area that may be illegally disposing of wastewater. These enforcement actions must follow the identification of runoff sources and the participation of Colectivo organizers in the SESD working group. Our third goal is to influence the CESPT to invest in redirecting runoff from surface streets to channels, thus reducing residents' direct exposure to runoff. The data collected from the monitoring can outline which runoff areas need to be channelized away from surface streets. Data informing this shift will be presented directly to the CESPT by Colectivo members through their Vinculación Ciudadana (Citizen Engagement) office, whom Colectivo advocacy has targeted in a previous water justice campaign.

On a more structural level, the protection of urban communities from exposure to contaminants should be a policy priority. As outlined by this issue, the roots of environmental justice also lie in the politics of knowledge production, where residents' concerns regarding their exposure to this wastewater and its impacts on their health are trivialized by environmental policymakers. Therefore, the work of just environmental protection requires that government actors take the concerns of community members in the region seriously, and engage their resources and expertise to address the issue of urban surface runoff and flooding as a priority.

Many of the industrial activities in this region of Tijuana are conducted by international companies, mainly from the United States. As mentioned earlier in this article, these activities are in competition for resources, infrastructure and policy action with community needs. The continuation of issues like runoff and flooding highlights priorities of international companies in highlighting the historical foundation of colonialism and extractivism of "periphery" nations for the purpose of building wealth for "core" nations (Wallerstein 1974). The issue tackled in this project additionally necessitates a level of accountability on the part of the municipal and state actors responsible not only for enforcing this environmental protection, but also for addressing the core–periphery relationship between the U.S. and México (Prado 2019). There is a dynamic in the border region that contributes to a lack of equal protection from environmental harms for certain communities due to this core–periphery relationship. The fact that community members have to deal with routine flooding is an unacceptable failure of environmental policy and enforcement, but also a function of this historical structure of inequality. Moreover, addressing this structure is key to making long-lasting change for communities like those impacted by runoff and flooding.

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References

Arredondo, Fabian. 2023. Viven desde hace 20 años con inundaciones en la colonia Campestre Murúa. *Síntesis*. Available online: https://sintesistv.com.mx/viven-desde-hace-mas-de-20-anos-con-inundaciones-en-la-colonia-campestre-murua/ (accessed on 20 August 2024).

Ayad, Mariam, Jingjing Li, Benjamin Holt, and Christine Lee. 2020. Analysis and classification of stormwater and wastewater runoff from the Tijuana River using remote sensing imagery. *Frontiers in Environmental Science* 8: 599030. [CrossRef]

Azizi, Koorosh, and Claudio I. Meier. 2021. Urban Pluvial Flood Risk Assessment: Challenges and Opportunities for Improvement Using a Community-Based Approach. In *World Environmental and Water Resources Congress 2021*. Reston: ASCE, pp. 350–61.

Azizi, Koorosh, Stephen Kofi Diko, Laura Saija, Mohammad Ghadir Zamani, and Claudio I. Meier. 2022. Integrated community-based approaches to urban pluvial flooding research, trends and future directions: A review. *Urban Climate* 44: 101237. [CrossRef]

Bernedo Del Carpio, María, Francisco Alpizar, and Paul J. Ferraro. 2021. Community-based monitoring to facilitate water management by local institutions in Costa Rica. *Proceedings of the National Academy of Sciences* 118: e2015177118. [CrossRef] [PubMed]

Bhatti, Muhammad Tousif, Arif A. Anwar, and Muhammad Aslam. 2017. Groundwater monitoring and management: Status and options in Pakistan. *Computers and Electronics in Agriculture* 135: 143–53. [CrossRef]

Biggs, Trent, Adam Zeigler, and Kristine T. Taniguchi-Quan. 2022. Runoff and sediment loads in the Tijuana River: Dam effects, extreme events, and change during urbanization. *Journal of Hydrology: Regional Studies* 42: 101162. [CrossRef]

Buckland-Nicks, Amy, Heather Castleden, and Cathy Conrad. 2016. Aligning community-based water monitoring program designs with goals for enhanced environmental management. *Journal of Science Communication* 15: A01. [CrossRef]

Bullard, Robert D. 1996. Symposium: The Legacy of American Apartheid and Environmental Racism. *St. John's Journal of Legal Commentary* 9: 445–74.

Calderón-Villarreal, Alhelí, Brendan Terry, Joseph Friedman, Sara Alejandra González-Olachea, Alfonso Chavez, Margarita Díaz López, Lilia Pacheco Bufanda, Carlos Martinez, Stephanie Elizabeth Medina Ponce, Cázares-Adame Rebeca, and et al. 2022. Deported, homeless, and into the canal: Environmental structural violence in the binational Tijuana River. *Social Science & Medicine* 305: 115044.

Carruthers, David. 2008. The globalization of environmental justice: Lessons from the U.S.-Mexico Border. *Society & Natural Resources* 21: 556–68. [CrossRef]

Cervone, Guido, Elena Sava, Qunying Huang, Emily Schnebele, Jeff Harrison, and Nigel Waters. 2016. Using twitter for tasking remote-sensing data collection and damage assessment: 2013 Boulder flood case study. *International Journal of Remote Sensing* 37: 100–24. [CrossRef]

Chakraborti, Lopamudra, and Jay P. Shimshack. 2022. Environmental disparities in urban Mexico: Evidence from toxic water pollution. *Resource and Energy Economics* 67: 101281. [CrossRef]

Choe, Jong Soo, K. W. Bang, and J. H. Lee. 2002. Characterization of surface runoff in urban areas. *Water Science and Technology* 45: 249–54. [CrossRef]

Conrad, Cathy C., and Krista G. Hilchey. 2011. A review of citizen science and community-based environmental monitoring: Issues and opportunities. *Environmental Monitoring and Assessment* 176: 273–91. [CrossRef] [PubMed]

de Jesus Piñon-Colin, Teresita, Ruben Rodriguez-Jimenez, Eduardo Rogel-Hernandez, Adriana Alvarez-Andrade, and Fernando Toyohiko Wakida. 2020. Microplastics in stormwater runoff in a semiarid region, Tijuana, Mexico. *Science of the Total Environment* 704: 135411. [CrossRef] [PubMed]

Estévez, Marnie González. 2008. Evaluación del Peligro de Contaminación del Acuífero del Arroyo Alamar. Master's thesis, El Colegio de la Frontera Norte, Tijuana, BC, Mexico.

Eveleigh, Alexandra, Charlene Jennett, Ann Blandford, Philip Brohan, and Anna L. Cox. 2014. Designing for dabblers and deterring drop-outs in citizen science. Paper presented at SIGCHI Conference on Human Factors in Computing Systems, Toronto, ON, Canada, April 26–May 1; pp. 2985–94.

Faroque, Sarker, and Nigel South. 2022. Water pollution and environmental injustices in Bangladesh. *International Journal for Crime, Justice, and Social Democracy* 11: 1–13. [CrossRef]

Fox, Alexandra Nicole. 2021. Assessment of Bacterial Contamination in the US Portion of the Tijuana River and Tijuana River Estuary. Ph.D. dissertation, San Diego State University, San Diego, CA, USA.

Funari, Vicky, and Sergio De la Torre. 2006. *Maquilapolis: City of Factories, Documentary*. San Francisco: Independent Television Service (ITVS).

González Estévez, M., and V. Sánchez Munguía. 2013. Riesgo de contaminación del acuífero arroyo Alamar en Tijuana, Baja California. *Región y Sociedad* 25: 103–26. [CrossRef]

Gómez Sánchez, Lucía. 2023. Vecinos del Murúa viven entre inundaciones de aguas negras. *Punto Norte*. Available online: https://puntonorte.info/2023/11/28/vecinos-del-murua-viven-entre-inundaciones-de-aguas-negras/ (accessed on 20 August 2024).

Grineski, Sara E., and Timothy W. Collins. 2017. Environmental justice across borders: Lessons from the US–Mexico borderlands. In *The Routledge Handbook of Environmental Justice*. London: Routledge, pp. 528–42.

Grineski, Sara E., Timothy W. Collins, and María de Lourdes Romo Aguilar. 2015. Environmental injustice along the US–Mexico border: Residential proximity to industrial parks in Tijuana, Mexico. *Environmental Research Letters* 10: 095012. [CrossRef]

Gunn, Geoffrey, K. Schnare, C. Lobson, A. Livingstone, B. Martin, and C. Paquette. 2021. *A Business Case for Investment in Canadian Community-Based Water Monitoring*. Winnipeg: International Institute for Sustainable Development, pp. i–49.

Hansen, Jacob L. 2020. Utilizing the Public on Public Lands: The Application of Community Science to Monitor and Model Erosion in National Forests. Ph.D. dissertation, East Tennessee State University, Johnson City, TN, USA.

Helmrich, Alysha M., Benjamin L. Ruddell, Kelly Bessem, Mikhail V. Chester, Nicholas Chohan, Eck Doerry, Joseph Eppinger, Margaret Garcia, Jonathan L. Goodall, Christopher Lowry, and et al. 2021. Opportunities for crowdsourcing in urban flood monitoring. *Environmental Modelling & Software* 143: 105124.

Instituto Nacional de Estadística y Geografía—INEGI. 2020. Censo the Población y Vivienda 2020. Available online: https://www.inegi.org.mx/programas/ccpv/2020/#Microdatos (accessed on 20 August 2024).

Kaswan, Alice. 2020. Distributive environmental justice. In *Environmental Justice: Key Issues*. Edited by B. Coolsaet. London: Routledge, pp. 21–36.

Kingsbury, Aaron, Ignatius Cahyanto, Eko Widodo, Natalia Puspita, and Agnes Harnadi. 2021. Adapting photovoice with ESRI Survey123 for tourism disaster research in Banten, Indonesia. *Current Issues in Tourism* 24: 2187–203. [CrossRef]

Kurczyn-Robledo, Jorge Alejandro, Thomas Kretzschmar, and Alejandro Hinojosa-Corona. 2007. Evaluación del escurrimiento superficial en el noreste del Valle de Guadalupe, BC, México, usando el método de curvas numeradas y datos de satélite. *Revista mexicana de ciencias geológi cas* 24: 1–14.

Laughery, Stephanie. 2023. Hazard Identification of Chemical Contaminants at US-Mexico Border Sites in the Tijuana River Watershed. Master's thesis, San Diego State University, San Diego, CA, USA.

Li, Luyuan, Pieter Uyttenhove, and Veerle Van Eetvelde. 2020. Planning green infrastructure to mitigate urban surface water flooding risk—A methodology to identify priority areas applied in the city of Ghent. *Landscape and Urban Planning* 194: 103703. [CrossRef]

Li, Zhenlong, Cuizhen Wang, Christopher T. Emrich, and Diansheng Guo. 2017. A novel approach to leveraging social media for rapid flood mapping: A case study of the 2015 South Carolina floods. *Cartography and Geographic Information Science* 45: 97–110. [CrossRef]

McLamb, Flannery, Zuying Feng, Damian Shea, Kesten Bozinovic, Miguel F. Vasquez, Chris Stransky, Richard M. Gersberg, Wenling Wang, Xiang Kong, Xin-Rui Xia, and et al. 2024. Evidence of transboundary movement of chemicals from Mexico to the US in Tijuana River Estuary sediments. *Chemosphere* 348: 140749. [CrossRef] [PubMed]

Mikhailova, Elena A., Christopher J. Post, Hamdi A. Zurqani, and Grayson L. Younts. 2022. Teaching Field Data Crowdsourcing Using a GPS-Enabled Cellphone Application: Soil Erosion by Water as a Case Study. *Education Sciences* 12: 151. [CrossRef]

Peckenham, John M., and Sarah K. Peckenham. 2014. Assessment of quality for middle level and high school student-generated water quality data. *JAWRA Journal of the American Water Resources Association* 50: 1477–87. [CrossRef]

Pellow, David N. 2002. *Garbage Wars: The Struggle for Environmental Justice in Chicago*. Cambridge, MA: MIT Press.

Pellow, David N. 2017. *What Is Critical Environmental Justice?* Medford: John Wiley & Sons.

Plyushteva, A., and T. Schwanen. 2023. "We usually have a bit of flood once a week": Conceptualising the infrastructural rhythms of urban floods in Malate, Manila. *Urban Geography* 44: 1565–83. [CrossRef]

Prado, Carolina. 2019. Borderland environmental justice and governance apertures. *Environmental Politics* 29: 1264–83. [CrossRef]

Prado, Carolina, Colectivo Salud y Justicia Ambiental, and Red de Ciudadanos para el Mejoramiento de las Comunidades. 2021. Border environmental justice PPGIS: Community-based mapping and public participation in eastern Tijuana, México. *International Journal of Environmental Research and Public Health* 18: 1349. [CrossRef] [PubMed]

Prado, Carolina, Zsea Bowmani, Chad Raphael, and Martha Matsuoka. 2024. Law, Policy, Regulation, and Public Participation. In *Ground Truths: Community Engaged Research for Environmental Justice*. Edited by C. Raphael and M. Matsuoka. Oakland, CA: University of California Press, pp. 133–54.

Quijada, Pedro F. 2010. Environmental History on the Western US-Mexico Borderlands: The Story of Tijuana's Ejido Chilpancingo and the Alamar River, 1938–2008. Doctoral dissertation, California State University, Los Angeles, CA, USA.

Ranganathan, Malini, and Carolina Balazs. 2015. Water marginalization at the urban fringe: Environmental justice and urban political ecology across the North–South divide. *Urban Geography* 36: 403–23. [CrossRef]

Raphael, Chad, and Martha Matsuoka. 2024. Community-Engaged Research. In *In Ground Truths: Community Engaged Research for Environmental Justice*. Edited by C. Raphael and M. Matsuoka. Oakland, CA: University of California Press, p. 31.

Rimmler, Shelby M., Sarah Shaughnessy, Ellis Tatum, Naeema Muhammad, Shaelyn Hawkins, Alexandra Lightfoot, Sherri White-Williamson, and Courtney G. Woods. 2023. Photovoice Reveals Residents' Concerns for Air and Water Quality in Industry-Impacted Rural Community. *International Journal of Environmental Research and Public Health* 20: 5656. [CrossRef]

Rost, Jim K. 2024. Analyzing Student Success Outcome Variables in Higher Education Utilizing the Chi-Square Test of Independence. *International Journal of Higher Education* 13: 100. [CrossRef]

Rözer, Viktor, A. Peche, S. Berkhahn, Y. Feng, L. Fuchs, T. Graf, and I. Neuweiler. 2021. Impact-based forecasting for pluvial floods. *Earth's Future* 9: 2020EF001851. [CrossRef]

Schlosberg, David. 2004. Reconceiving environmental justice: Global movements and political theories. *Environmental Politics* 13: 517–40. [CrossRef]

See, Linda. 2019. A review of citizen science and crowdsourcing in applications of pluvial flooding. *Frontiers in Earth Science* 7: 44. [CrossRef]

Sy, Bocar, Corine Frischknecht, Hy Dao, David Consuegra, and Gregory Giuliani. 2019. Flood hazard assessment and the role of citizen science. *Journal of Flood Risk Management* 12 S2: e12519.

Townsend, Kaya, and John Eyles. 2004. Capacity and transparency of potable water regulation in Tijuana, Mexico: Challenges for ensuring water quality at community level. *Health Promotion International* 19: 77–83. [CrossRef] [PubMed]

Walker, Gordon, and Kate Burningham. 2011. Flood risk, vulnerability and environmental justice: Evidence and evaluation of inequality in a UK context. *Critical Social Policy* 31: 216–40. [CrossRef]

Wallerstein, Immanuel. 1974. Dependence in an interdependent world: The limited possibilities of transformation within the capitalist world economy. *African Studies Review* 17: 1–26. [CrossRef]

Wang, Ruo-Qian, Huina Mao, Yuan Wang, Chris Rae, and Wesley Shaw. 2018. Hyper-resolution monitoring of urban flooding with social media and crowdsourcing data. *Computers & Geosciences* 111: 139–47.

Whitelaw, Graham, Hague Vaughan, Brian Craig, and David Atkinson. 2003. Establishing the Canadian Community Monitoring Network. *Environmental Monitoring and Assessment* 88: 409–18. [CrossRef]