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The effects of urbanization on aquatic ecosystems in peri-urban protected areas of Mexico City: The contradictory discourse of conservation amid expansion of informal settlements

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A R T I C L E I N F O

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A B S T R A C T

Years of population growth and urban expansion have affected ecologically forested areas outlying Mexico City. To control the growth and the negative impact on natural areas, the Conservation Land act of 1987s declared protection of non-populated forest areas. However, this initiative has been overshadowed by the growing demand of affordable housing. The expansion of housing in protected areas has been coupled with unclear guidelines from local authorities in restricting domestic growth. This study focuses on the Magdalena River micro-basin, which is key to freshwater provisioning to Mexico City. The objective of this research is to show the socio-ecological effects of urbanization and the lack/misguidance of local governance on the Magdalena River. Ecological quality was assessed through identifying hydro-morphological quality and bioindicators such as macroinvertebrates and macroalgae. This information was paired with social data collected through an archival study of historical literature, and interviews with residents who are both lawfully and unlawfully living within protected areas. The results show that the ecological quality of the Magdalena River is undergoing significant changes because of an influx of nutrients and external alterations made to the riparian zone. Pollution from housing, restaurants, and trout farms are the factors most directly related to the changes. Additionally, we encountered little to no federal/local policy aimed at controlling inputs and altercations to the river. Our study has shown that urbanization within the micro-basin negatively alters the biological diversity. The growth further facilities the increase of fecal bacteria posing a risk to human health. Social data from interviews and the literature review showed the ecological importance of the area to the local people. In the past there have been two cases of restoration efforts made by the municipal government, but their intentions for restoration ultimately failed. In both efforts were poorly planned and were not communicated with local people nor did they include local participation. As a consequence, the locals have a general distrust of the external stakeholder. Apart from local development misinformation and unwelcome restoration intervention, there is a long history of governmental authorities incurring acts of corruption and bribery. Many unauthorized settlements are unaware or have not been educated about the environmental impact they are having on ecosystems and are often overlooked or excluded when it comes to creating policy. In conclusion, local participation and approval is essential to the creation of a successful management plan, thus it is important governmental officials seek their involvement. Conservation land within the micro-basin is insufficient to protect the ecological integrity of ecosystems as both landowners and local authorities are facilitating unsustainable practices that transit between the vision on paper of a sustainable city and the lack of concrete facts to achieve it.

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1. Introduction

The transition from rural to urban land leads to dramatic change that has the potential to decimate the productivity of aquatic ecosystems that provide benefits to human populations (Hardoy et al., 2013). This process of change is known as, urbanization, and if not foregone with caution it can be very damaging to the environment (Pauchard and Barbosa, 2013). The urbanization phenomenon not only reduces the physical size and productivity ecosystems, but also alters the how indigenous communities use natural resources in which they are highly dependent (Farley and Voinov, 2016; Knüppe and Knieper, 2016). Indigenous populations often have strong cultural and historical ties to the land they inhabit, contributing to the awareness they have about the impacts their actions have on local ecosystems (Méndez-López et al., 2014; Comberti et al., 2015). When expanding urban areas in the past, government officials and policy makers have had a tendency to overlook the needs and practices of local people who have worked their land for generations. Seeking local knowledge of land is an important step to take when working to redevelop/expand socio-ecosystems and create adequate conservation plans (Figueroa et al., 2016). However, socio-environmental relationships within communities do not always have an ancestral/traditional history, they are a product of the need for affordable housing. People have pushed to the city limits in search of housing often resulting in urban sprawl encroaching on protected conservation areas and the destruction of natural resources (Aguilar and Santos, 2011a).

In large cities of Latin America, urban growth has occurred rapidly and without considering the socio-environmental consequences, neither through a political, institutional or conceptual framework (Hardoy et al., 2013; Pauchard and Barbosa, 2013).These cities grow with a tendency to segregate the low-income groups in the peripheral areas with unequal access to quality housing and to basic services/resources (CEPAL, 2016). In Latin America, two urban land markets coexist. There is the formal market that expands through legal property regulation and licensed developers. Adversely, there is an informal market that functions without property land titles, permits, and with costs unregistered within the real estate market. Informal markets play an important role locally in accommodating the demand for housing of low-income groups, as it is their only affordable housing option. However, these unauthorized communities tend to find themselves established with protected areas (Aguilar and Santos, 2011b; Jordán et al., 2017). Many decisions of land use and conservation in Latin America are extrapolated from information/research in Europe and North America. Conservation modeling from external frameworks has generated non-functional strategies for urban expansion in Latin America given the differences in legal systems, socio-economic level of populations, and cultural relationships with nature (Hardoy et al., 2013; Pauchard and Barbosa, 2013). Therefore, it is necessary to amass socio-ecological information that supports decision-making about expansion in a Latin American context.

Mexico City is without exception to the impacts of urbanization, as it is the largest city in North America and 5th in the world (United Nations, 2018). In this megacity, informal urbanization processes have been responsible, in part, for the loss of forest mass and contamination of surface water. (Carmona-Jiménez and Caro-Borrero, 2017). A local study in Mexico City demonstrated that the urbanization processes in forested areas has irreversible consequences such as; local water availability, quality, and slow absorption rates resulting in floods (Mazari-Hiriart et al., 2014). The discourse concerning conservation land[1] is diverse, but there are two main narratives present. Some actors fight for continued preservation and restoration, while others encourage the development of informal housing and the expansion of urbanized land (Aguilar and Santos, 2011a; Aguilar, 2008).

This article deals with two questions common in the field of Latin American socio-ecological perspective of conservation explores them at a local context in the Magdalena River micro-basin. First, what are the hydro-physical effects of urbanization on aquatic ecosystems and biological diversity within the Magdalena River Micro-basin? Second, how does local socio-historical discourse influence conservation management and resource governance? Urban expansion has a high ecological cost, but the specific impacts on conservation land bordering Mexico City is unknown. Furthermore, we are aware of the political and historical processes that favor the urban expansion of these areas (see Aguilar and Santos, 2011b for complete description), but remain unaware of local governance processes and perspectives. The objective of this research is to show the socio-ecological effects of urbanization and demonstrate the lack of local governance[2] on Magdalena River micro-basin. The data found is intended to act as basis for inventing future recovery plans with social and ecological context relative to the Magdalena Micro-basin.

2. Study area

Mexico City has failed to create urbanization plans for generations, yet remnants of local ecosystems remain as they are protected by the ratification of the Conservation Land Act of (1987)[3] . These areas are meant to preserve the historic forests and mountain rivers surrounding Mexico City. Though these areas are legally protected, many face heavy urbanization pressures. The areas have become highly valued, not only for their ecological role but for the growing need for housing within the city. The ever expanding metropolis of Mexico City has pushed the poorest people to the boundaries of conservation land which has led to the invasion of protected mountainous areas (Varley, 2019; Caro-Borrero et al., 2017). Informal settlement is prompted by the lack of access to low-income housing, and the lack of governmental authorities enforcing laws prohibiting development within conservation areas. Additionally, informal settlements are often legalized and are seen as a solution. Ultimately encouraging urban encroachment as there are little to no repercussions[4] (Aguilar and Santos, 2011b). Mexico has the longest history of legalizing of informal housing in Latin America, 2.5 million housing units were formalized to have legal status between 1974 and 2013 (Varley, 2019).

The Magdalena River is one of the peri-urban effluents of Mexico City affected by urbanization is geographically located on the south western edge of Mexico City (Legorreta, 2009) (Fig. 1). The Magdalena micro-basin is one of the main water catchment areas in Mexico City, contributing to 15 % of surface water supply (Mazari-Hiriart et al., 2014). The predominant vegetation in the area includes forests of *Pinus hartwegii* Lindl., *Abies religiosa* (Kunth) Schldl. & Cham. and *Quercus* spp (Castillo-Argüero et al., 2016). The Magdalena River has a longitude of 28.2 km that runs along two different administrative zones: the first of

[1] Mexico City is divided into two major land uses: urban land and Conservation Land or Suelo de conservación in spanish, the latter incorporates the areas and natural reserves essential to achieve ecological balance and improve the quality of life in Mexico City, rescuing those vital areas for its ecological protection, and limiting urban growth over wooded and unpopulated areas (DOF, 1987).

[2] Governance is defined as the process of socio-political direction that increases the interactions between social and governmental actors (Kooiman, 1993).

[3] Conservation Land surrounding Mexico City is home to 2.2 million inhabitants and 700,000 of them make direct use of natural resources. These people are integrated in 47 urban–rural settlements representing 8% of the population in Mexico City. The Conservation Land area encompasses 92 agrarian communities and *ejidos* (shared/communal property system) who legally own 55,186 ha. Timber logging is prohibited, land-use change is also forbidden.

[4] The most common method used for occupying *ejidal* and communal lands is to purchase lots from a supposed owner who has not complied with all the legalities pertaining to such transactions (Aguilar and Santos, 2011a).

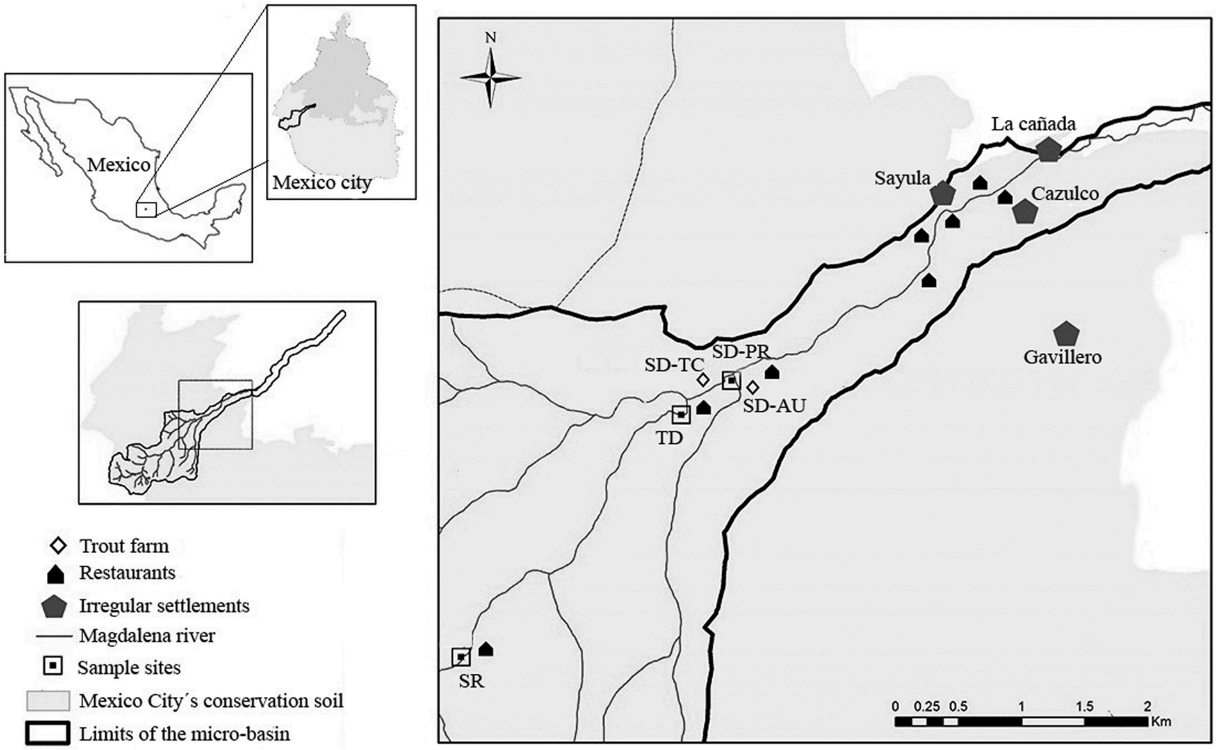

Fig. 1. Geographic location of the micro-basin of the Magdalena River, sampling sites, and informal settlements studied. Code sites according to Table 1.

them is the conservation area containing 52 % of the river's area. The second zone is the urban area, containing 48 % of river area (SMA, 2012). In the natural area springs and surface runoff feed the river, while the urban area is fed by the runoff of wastewater acting as an open drainage system (González et al., 2010).

In respect to the human impacts on the micro-basin, previous studies recognized signs of degradation from the upstream section within the conservation area. These impacts within the rural area are mainly due to soil erosion, channel damming, loss of forest cover, clandestine logging and agricultural activities. The middle section is too within the conservation area and is affected by the presence of informal housing settlements, unregulated tourism activities, and the discharge of wastewater from restaurants and trout farms. Finally, in the urban section, contamination is caused by discharges of wastewater and solid waste deposits ranging from plastic cups to car parts (Mazari-Hiriart et al., 2014; Caro-Borrero et al., 2015).

In recent years, local and federal government strategies have encouraged the construction of gabion dams and rectangular ditches (2 m long, 0.5 m base and 0.5 m deep) known locally as Tinas Ciegas[5]. The impact of gabion dams is evident. The dams diverge the flow of headwaters into the river, impacting substrate composition. Substrate alterations change hydrological dynamics, and therefore habitat provisioning for aquatic organisms (Caro-Borrero et al., 2015). The topic of restoring the Magdalena River has been predominate over the last two decades, yet few restoration efforts have been successful due to conflict/miscommunication between policy makers and local communities (González et al., 2010). The diverse set of stakeholders has made it difficult to find a cohesive solution to restoring the Magdalena river. Many of the people living in proximity to the river are marginalized and with little resources, the conservation zone represents their patrimony and their cultural history. Many locals fear losing their river, yet they are unknowingly contributing to its degradation.

3. METHODS I: evaluating hydrology

An ecological quality assessment was completed along the main river channel and a nearby trout farm that directly discharges used water into the to the river[6]. The sampling sites are located within the Conservation Land and were selected by the degree of visible anthropogenic influence (Table 1). A control site with minimal human intervention was also sampled to validate our assessment of ecological status (Caro-Borrero et al., 2015).

3.1. Physical, chemical, and ecological quality assessment

Sampling was carried out between 2015 and 2016 during different seasons: the rainy season (June-November), dry/cold season (December-February) and warm/dry season (March-May). The following physical, and chemical parameters were recorded *in situ* with a Hanna Multiparameter probe 991300 (Dallas, USA): water temperature, specific conductivity, and pH. Oxygen saturation, (YSI-85 m, YSI, Ohio, USA) current velocity, (Global Water FP111, Texas, USA) and stream discharge (Gore, 1996) was recorded/calculated. At each sampling site, 500 ml samples of water were filtered *in situ* and analyzed in the laboratory according to the criteria established in the official Mexican guidelines and international standards (DOF, 2003, 2000; APHA, 2005). Nitrite nitrogen, nitrate nitrogen, ammonium nitrogen, dissolved inorganic nitrogen (DIN) and soluble reactive phosphorus (SRP) were analyzed with a DR 3900 laboratory Spectrophotometer (Hach, Loveland, CO; Hach, 2003). The criteria used to examine water quality and its viability for human uses were those of the Mexican Water Standard (DOF, 2003, 2000). Hydromorphological quality and anthropogenic activities were evaluated according to the manual by the United State

[5] The *Tinas Ciegas* with a water collection volume of 0.5 m^3 per tank, constructed following the contour lines, which capture runoff and conserve humidity for trees or forest plantations.

[6] Biological communities were not sampled in the fisheries because the ponds are artificial and only contain trout.

Table 1
Location and environmental characterization of sampling sites in the micro-basin of Magdalena river.

Site and Location	Altitude m.a.s.l.	Site/ Season	T °C	pH	K_{25} (μS/cm)	DO (%)	Q^3 (mgL^{-1})	NO_2	NO_3	NH_4	PO_4	HQ
Reference site		SR-CD	5.3	6.6	77	9.4	0.368	0.004 ±0.001	0.833 ±0.23	0.110 ±0.01	1.105 ±0.179	162
	3,048	SR-R	10.7	7.8	61	7.4	0.732	0.003 ±0.001	0.017 ±0.006	0.007 ±0.006	0.503 ±0.116	162
N 19°15’50.6’’W 099°17’41.5’’		SR-WD	7.2	7.5	81	9.9	0.163	0.002 ±0.001	0.026 ±0.005	0.060 ±0.000	0.030 ±0.034	162
Third dynamo- disorderly tourism		TD-CD	5.6	6.7	81	9.9	0.228	0.004 ±0.001	1.150 ±0.05	0.105 ±0.018	0.830 ±0.164	126
	2,831	TD-R	11.8	7.8	77	7.5	0.449	0.002 ±0.001	0.023 ±0.005	0.013 ±0.005	0.363 ±0.058	126
N 19°16’52.4’’W 99°16’42.5’’		TD-WD	7.7	7.7	87	9.6	0.342	0.002 ±0.000	0.023 ±0.005	0.080 ±0.017	0.346 ±0.190	126
Second dynamo-discharge trout farm		SD-TC-CD	7.2	6.4	85	7.4	0.051	0.005 ±0.002	0.483 ±0.332	0.135 ±0.021	1.070 ±0.348	65
	2,775	SD-TC-R	12.7	7.8	80	7.4	0.043	0.006 ±0.002	0.013 ±0.006	0.007 ±0.006	0.930 ±0.095	65
N 19°17’02.5’’W 99°16’28.7’’		SD-TC-WD	8.9	7.9	96	8.1	0.016	0.002 ±0.000	0.026 ±0.006	0.073 ±0.006	0.290 ±0.133	70
Second dynamo-urban discharge		SD-AU-CD	6.2	6.6	82	8	0.026	0.013 ±0.006	0.533 ±0.152	0.117 ±0.028	0.810 ±0.156	34
	2,564	SD-AU-R	12.2	7.7	79	7.3	0.053	0.004 ±0.002	0.017 ±0.006	0.013 ±0.006	0.923 ±0.126	34
N 19° 17’ 02.9’’ W 99° 16’ 27.6’’		SD-AU-WD	10.3	7.8	86	8.3	0.065	0.003 ±0.000	0.026 ±0.011	0.076 ±0.006	0.766 ±0.039	34
Second dynamo-discharge restaurants		SD-PR-CD	8.2	6.6	85	9.4	0.026	0.005 ±0.000	0.800 ±0.100	0.112 ±0.007	0.863 ±0.064	94
	2,693	SD-PR-R	14.3	7.8	82	7.5	0.037	0.003 ±0.001	0.020 ±0.01	0.027 ±0.006	0.933 ±0.140	94
N 19°16’0.3’’W 99°16’27.6’’		SD-PR-WD	9.7	7.8	90	8.0	0.268	0.002 ±0.000	0.020 ±0.000	0.070 ±0.010	0.630 ±0.230	94
Trout farms		T-CD	7.1	7.0	91	5.5	0.001	0.005 ±0.001	0.833 ±0.346	0.110 ±0.015	0.700 ±0.084	0
	2,767	T-R	12.8	7.8	80	7.4	0.001	0.002 ±0.001	0.020 ±0.010	0.010 ±0.010	0.313 ±0.068	0
N 19° 17’1.7’’ W 99° 16’ 28.9’’		T-WD	9.9	7.8	89	8.1	0.001	0.003 ±0.000	0.030 ±0.000	0.080 ±0.010	0.620 ±0.058	0

Seasonality: CD, cool dry; R, rainy; WD, warm dry. T, temperature; K_{25}, specific conductivity; DO, dissolved oxygen; Q^3, discharge. Nutrients in mg $L^{-1:}$ NO_2, Nitrite nitrogen; NO_3, Nitrate nitrogen; NH_4, Ammonium nitrogen; PO_4, Orthophosphate; HQ, hydromorphological quality.

Environmental Protection Agency[7] (Barbour et al., 1999).

3.2. Biological indicators

3.2.1. Bacteriological sampling

One-liter samples were collected in sterile polypropylene flasks for bacteriological analysis, stored at 4 °C, and processed within 24 h of collection using the membrane filtration technique (APHA, 2005). Membrane filters (cellulose acetate, 0.45 μm, Millipore MF type HA) were placed in Petri dishes with 2.5 mL of membrane fecal coliform agar medium and incubated at 35 °C for 24 h and with Kenner fecal Streptococcus agar for fecal enterococci and incubated at 44.5 °C for 48 h (APHA, 2005). In the case *of Salmonella*, 100 ml of sample were filtered and a dilution of 1:10 because there typically is little to no presence of this bacteria in conservation areas. (Mazari-Hiriart et al., 2014). The culture medium SS Agar used for *Salmonella* only allowed us to consider them as presumptive, since specific identification requires other techniques that were not used in this research.

[7] This evaluation included quantitative and qualitative parameters regarding relative quantity and variety of natural structures in stream, type and condition of bottom substrates, patterns of velocity and depth in stream, amount of sediment accumulated in pools, the degree to which channel is filled with water, channel alterations in the stream shape, amount of vegetation protection of stream bank and measures the width of natural vegetation from the edge of the stream bank out through the riparian area.

3.2.2. Macroinvertebrates sampling

Taxa collection was conducted at each sampling location and was performed along 10 m transects. A Surber-type D-net with 250 μm mesh and a 30 cm width was used to capture taxa following a multihabitat criterion. Sediment was removed by kicking river substrate during a five-minute period. Organisms were removed from the net into a tray for extraction. Organisms were also caught by manual examination and extraction from the submerged faces of large rocks, pieces of dead wood, and leaves. At least 100 individuals were collected from each sample site and preserved in 70 % alcohol. Individuals were separated out under an Olympus SZX7 stereoscopic microscope and identified to family level (Bueno-Soria, 2010; Merritt et al., 2008). Finally, we assigned the taxa into Functional Feeding Groups (Cummins et al., 2005).

3.2.3. Macroscopic algae sampling

Algae was collected at the same sites as macroinvertebrates, and consisted of five quadrats, each separated by 2 m. Quadrats were positioned within each site on areas with >1 % of algal cover. Their direction and localization were chosen randomly in an interval between 0° and 180°. This procedure was repeated along the sampling quadrats (in an upstream direction). The abundance of macroscopic algae (percentage cover) was evaluated with a circular sampling unit of 10 cm radius (area 314 cm^2) (Bojorge et al., 2010; Necchi et al., 1995). The algae was identified to species level by reference to taxonomic keys and bibliographic resources (Anagnostidis and Komárek, 2005; Carmona-Jiménez and Necchi, 2002; Carmona-Jiménez and Vilaclara, 2007; Ettl and Gartner, 1988; Komárek, 2013; Rieth, 1980; Wher and Sheath, 2003). For taxonomic analyses, an Olympus BX51 microscope with an SC35 microphotography system was used.

3.3. Data analysis

We ran a Principal Components Analysis (PCA) to reduce the set of environmental variables that influence the current state of the river. In respect to the algae community and benthic macroinvertebrates assemblage, we ran a one-way similarity analysis (ANOSIM) to determine both the influence of seasonality and different human activities. The statistical tests were recorded as significant when the global R was less than 5%, giving rise to a level of significance that would allow rejecting the null hypothesis of equality in these biological communities (Clarke and Gorley, 2006). BEST analysis (BIO-ENV algorithm) was used to establish the link between the environmental variables and the diversity and composition of biological communities. The biological data matrices were transformed using a square-root algorithm, the environmental data matrices were standardized and only those parameters that had a correlated distribution in the Draftsman plots were transformed using fourth-root algorithm. All tests were performed in the PRIMER V statistical program (Clarke and Gorley, 2006).

4. METHODS II: document analysis, qualitative interviews and focus groups

4.1. Historic events and perceptions

The topic of controversy surrounding the Magdalena River micro-basin has been demonstrated in newspaper articles written over multiple decades. The historical articles were provided by the Hemeroteca Nacional Digital de México (HNDM), an archive library that has digital and physical files of historic documents. Research of the social, political, and environmental relationships through the HNDM database has allowed for a glimpse into the past. The library has documents that are centuries old, but most of the documents used in this study are from the last 50 years. To navigate the endless string of data the HNDM provides, key words were searched in the archive's database (*i.e.* Rio Magdalena, Los Dinamos, Magdalena Contreras, *etc.*), articles were identified, and then located in physical and/or electronic copies of a historic newspaper. Once the article was located photos of the article were taken, with permission from the HNDM, and a timeline of key events was generated and used to create a summary of how discourse has changed/stayed constant over time (See Fig. 5). Other resources were also used to create a description of past events including doctoral dissertations and scientific articles. Key events and themes were identified and categorized, providing data to suggest how present discourse came to be.

4.2. Present day perceptions: interviews and focus group

We conducted nine interviews individually with inhabitants of informal settlements within the Magdalena River micro-basin. All settlements are located in the valley to the southwest of the City Hall *La Magdalena Contreras*[8] . Moreover, two focus groups were carried out. The first meeting consisted of 11 members from the Magdalena Atlitic community, formal landowners and key stakeholders within the micro-basin. The second group was composed of 21 inhabitants of informal settlements (mainly women). The interviews and focus groups were transcribed using Word software and analyzed using the MAXQDA software. The responses were categorized using analysis codes: socio-demographic characteristics, profession/ livelihoods, establishment of informal housing, use and perception of local natural resources, relationship with different stakeholders, the perceived pros and cons of living inside the conservation land, and interest in participating in conservation strategies.

[8] The City Halls are political administrative organs of each territorial demarcation of Mexico City. The City Halls are part of the public administration of Mexico City, and they are a level of government in terms of the Constitutional and legal rights and obligations.

5. Results

5.1. Evaluating hydrology: physical, chemical and ecological quality assessment

The physical and chemical variables showed high variability spatially and seasonally. For example, data sets ranged from: temperature (5.3−12. 8 °C), pH (6.4–7.9), specific conductivity (61–96 μS cm^{-1}), dissolved oxygen concentration (5.5–9.9 mg L^{-1}) and discharge (0.001−0.732 m^3 s^{-1}). During the dry season, there was an increase in the concentration of nutrients compared to the rainy season. Nitrite nitrogen concentration (0.013 mg L^{-1}) was recorded with the highest concentration at the second dynamo, an informal settlement site associated with the discharge of domestic wastewater. Nitrate nitrogen concentration (1.15 mg L^{-1}) had the highest values at the Third dynamo, an informal tourism site. Ammonium nitrogen had the highest concentration (0.135 mg L^{-1}) at the second dynamo-trout farms site. The values of nitrogenous compounds varied to a greater extent than orthophosphates, but our data suggests these influxes were not related to anthropogenic activity, but to varying environmental conditions (Table 1).

The Principal Components analysis explains 64 % of the variance in two axes (Fig. 2). Axis 1 represents the sampling sites in the rainy and warm dry season related to higher values of temperature (0.42) and pH (0.45), and lower concentrations of Nitrite nitrogen (−0.3), Nitrate nitrogen (-0.44), Ammonium nitrogen (−0.44) and Orthophosphate (−0.15). The second axis represents the sites with the highest discharge (0.5), dissolved oxygen (0.3) and better hydromorphological quality (0.5).

5.1.1. Analysis of bacterial content

The results of the bacteriological analysis show levels of degradation progressing from the highest sites (upperstream): the reference site (SR) and third dynamo (TD), to the lower sites (downstream) with the greater human activities and interventions (SD-TC, SD-AU, SD-PR y T) (Fig. 3). In these sites, potential sources of fecal contamination were identified related to dry toilets for tourism and trout farming systems.

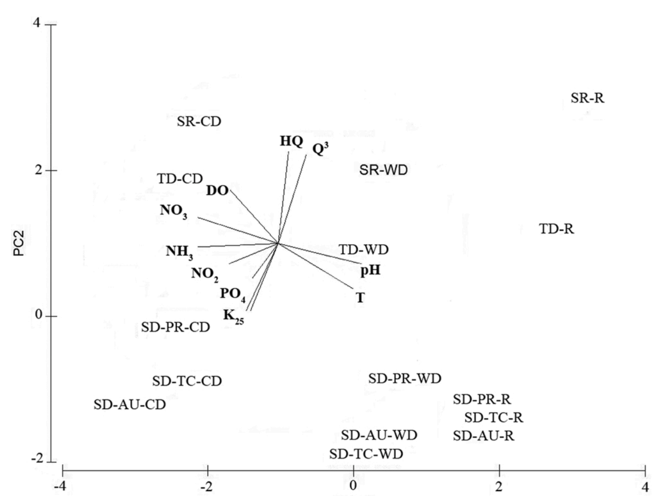

Fig. 2. Organized by two principal axes of the sites studied in the micro-basin of the Magdalena River that represent the environmental parameters measured, according to (PCA).

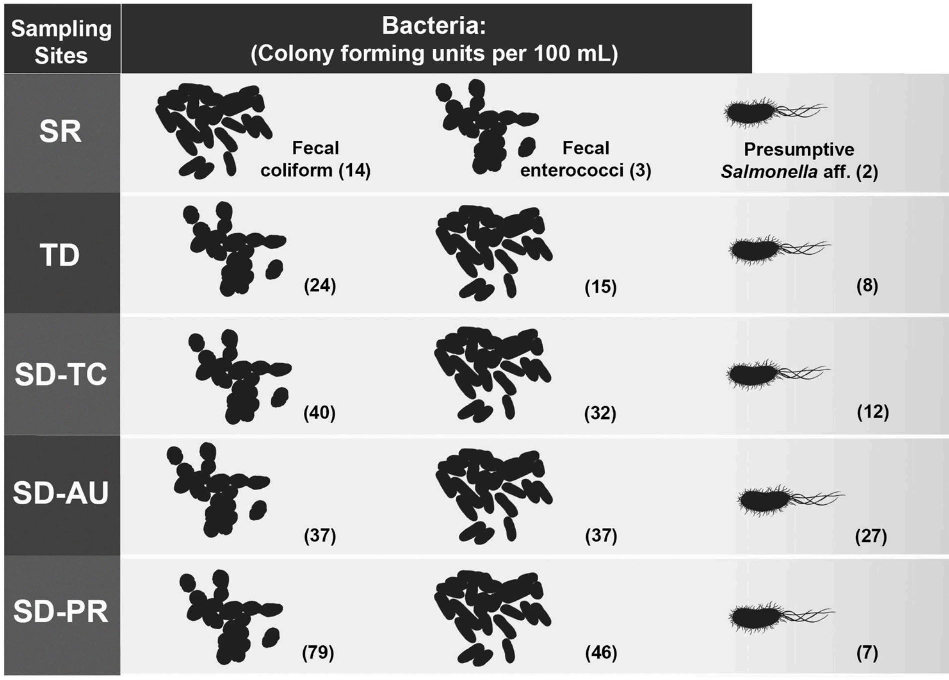

Fig. 3. Presence of fecal coliforms, fecal enterococci and presumptive *Salmonella* sp. in the sites analyzed in the natural area of the Magdalena River. The name of the sites and climatic season is as shown in Table 1.

5.1.2. Ecological quality: hydromorphology and bioindicators

The quantitative/qualitative assessment of the hydromorphologic quality of the riparian ecosystem showed that there were no sites without any kind of anthropogenic intervention. However, there was little impact caused by gabion dams at the reference site whereas the other sample sites were greatly affected by the infrastructure of old hydroelectrical dam. For example, remaining water diversion canals and gate structures of old dams negatively impact the river continuity and biological connections. The sites were also found to be altered by the presence of gabion dams, restaurants, agriculture, and trout farms near to the river-channel. The installation of this infrastructure affected the native cover and composition of the riparian vegetation and in some cases modified it completely by the removal of all vegetation. There was no evidence of seasonal variability affecting hydromorphological

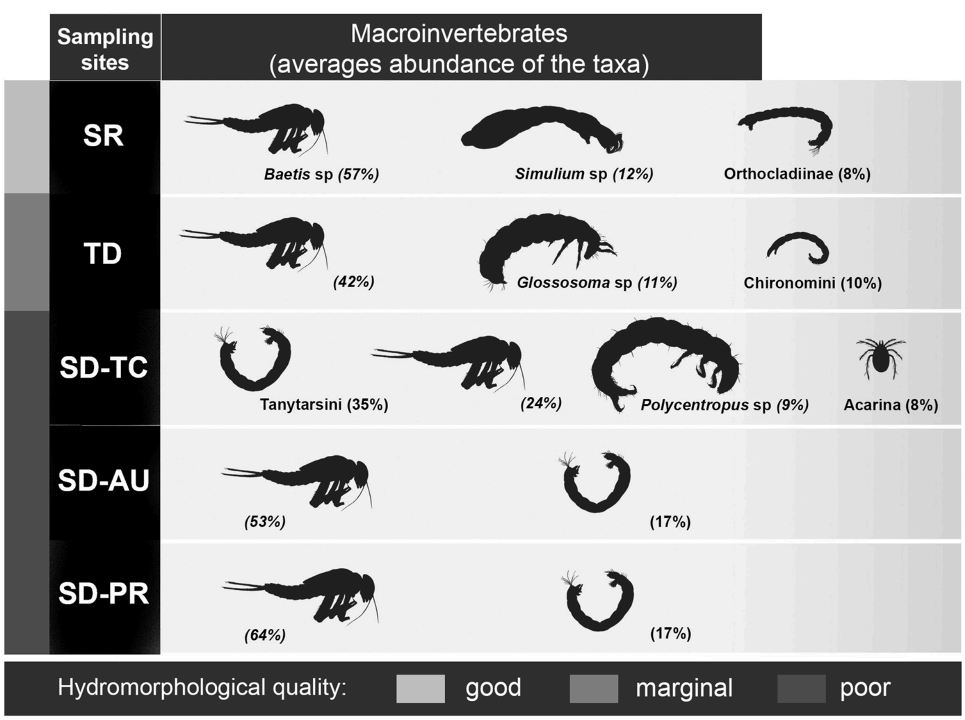

Fig. 4. The ecological quality per site according to the assemblies of registered MIBs in each of one sampling sites. Mayflies: *Baetis* (blue winged-olive); no-biting midge: Orthocladiinae (midge), Chironomini (blood-worm), Tanytarsini (green midge); Caddisflies: *Glossosoma* (saddle-case caddies), *Polycentropus (tramper net caddisflies)*; Acarina (water mites).

factors.

5.1.3. Biological indicators: benthic macroinvertebrates

We collected and identified a total of 1922 individuals. Most of them belong to the family of mayflies and the no-biting midge. The mayfly larvae commonly named blue winged-olive (*Baetis* genus) were dominant in most of the sampled sites and their presence was consistent through the climatic seasons, representing 47 % of the total sample. The next most common invertebrate was midge larvae, commonly named green midge (Tanytarsini, Chironomidae sub-family) (16 %) (Fig. 4). We founded significant differences between sites assemblages through the climatic seasons (ANOSIM test; $R = 0.393$; $p = 0.006$) but found no significance between the varying human impacts at the sampled sites ($R = -0.095$; $p = 0.73$). Finally, the relationship between environmental variables and macroinvertebrate assemblage's abundance and diversity (BEST) was influenced by variables such as temperature, specific conductivity, discharge, and nitrate nitrogen concentration as a proxy for trophic level of the Magdalena River ($R=0.34$, $p = 0.005$).

5.1.4. Biological indicators: macroscopic algae

Over three collection periods cover percentage of seven species and functional groups belonging to the following taxonomic groups were identified (Fig. 5): The green algae (Chlorophyta) *Cladophora glomerata* filamentous (1 %), *Prasiola mexicana* laminar (28 %) and *Ulothrix* sp. filamentous, (2.3 %). The blue-green algae (Cyanoprocaryota) *Nostoc aff.parmelioides* mucilaginous (6.3 %), *Placoma* aff. *regulare* mucilaginous (15 %) and *Phormidium autumnale* filamentous (1%), and the yellow-brown algae (Ochrophyta) *Vaucheria bursata* filamentous (2%). We found significant differences between sites with different human activities/infrastructure (ANOSIM, $R = 0.234$; $p = 0.02$), but found no significance between sites throughout the climatic seasons (ANOSIM, $R = 0.121$; $p = 0.9$). Finally, the relationship between environmental variables and algae abundance/diversity (BEST) showed influence of variables; such as, oxygen saturation, specific conductivity and ammonium nitrogen concentration as a proxy of the trophic level (0.32, $p = 0.005$).

5.2. Evaluating document analysis, qualitative interviews and focus groups

5.2.1. Historic events and perceptions

In 1910 Mexican Revolution began, social groups opposed sought to reclaiming labor rights and redistribute public land (see Fig. 6, a timeline of complied historic research). Post-Revolutionary Agrarian Reform resulted in nearly 60 % of the territory was converted into collective land tenure in the form of: *ejidos* (land granted to rural population) and agrarian communities (land restitutions to indigenous communities) (Caro-Borrero et al., 2020). Additionally, many Spanish *haciendas*[9] were transformed into public property and became part of the agrarian distribution (Zamora, 2013). Though much of the land was redistributed, local water rights were not reallocated, and they greatly favored factories built along the Magdalena River (Zamora, 2013). During this time the Magdalena Atlitic people, or *comuneros*, were given what is modern day Los Dinamos, a recreational park protected under the Conservation Land doctrine in Mexico (Zamora, 2013). In 1944 urban development began to expand, and the river was piped in Santa Fe, a sector of Mexico City, as it was perceived as an "unattractive element" to the growing upper-class neighborhood due to the high levels of pollution. "La Junta de Agua" (A Water Collective composed of local authorities and local volunteers) was the first governmental management group assembled with intention to manage the Magdalena River (Zamora, 2013). The principle goal of the Water Collective was to keep the river clean of solid pollution. They also worked to create fair distribution of water among and between the different local actors that made use of the river. The main use of the river had shifted from industrial to domestic by the year 1970, and despite local efforts water quality continued to deteriorate (Zamora, 2013). In 1979 President López-Portillo designed a water drainage/sanitation plan to be implemented in the Los Dinamos park, but not much effort was made into making the action plan, resulting in little change (Avance, 1979). Also, as one of the first initiatives to better water quality, the governmental officials failed to collaborate with locals or update them on changes being made. The project was unsuccessful, and the human health issues corresponding to the poor ecological condition of the river were left unchanged (Avance, 1979). Over the next decade several events made the necessity of productive management of the Magdalena River more widely. For example, severe floods resulted from poor construction of canals and lead to the death of a local boy (Alcauter, 1984). There was an instance of local volunteers who cleared four truckloads of trash once a week for three months because people were using the Los Dinamos forest as a local dumping ground (El Nacional, 1987). Also, non-governmental organizations and the government began to reforest areas with forest loss as a result of illegal logging and the land use change for informal settlements (El Nacional, 1986). In addition to ecological degradation, there was the social issue of indigenous people losing their land to urban expansion and people using their resources to unlawfully develop housing. This led to an indigenous and agrarian ecological rights movement throughout central and southern Mexico to recover and validate land rights in 1992 (Valle de México, 1992). Through the rapid urban development in the 20th century a lot of public land and natural habitat was lost. Much of the land was a part of ejidos and the misuse resulted from lack of management and inter-governmental communication (Valle de México, 1992). The areas designated as *ejidos* were too large and the sectors of people with property rights on the land had different goals, for example, some of them were indigenous people while others were low-income agrarian residents. Essentially the actors were too diverse, making it difficult to manage land in a way that benefits everyone. The land had been lost due to different interests before the majority of locals knew it was gone. The impacts of urbanization were felt all over Mexico, including in the micro-basin where many Magdalena Atlitic natives still live (Valle de México, 1992). In 2002 a huge logging scandal was revealed, and locals were displeased (Cesarman, 2002). The evident mismanagement of the resources leads locals of the micro-basin to grow more and more skeptical of local, regional, and national government. In 2006 the want for better water management was at the forefront of locals' desires because of local water availability is becoming scarcer. In response to local concern, the government was willing to try to find a solution to improve the water quality of river and make it potable. The Federal Secretary of Environment, the Universidad Nacional Autónoma de México and the Universidad Autónoma Metropolitana created a "Master Plan of Recovery" (SMA, 2012). The recovery plan's main goals were to install a better drainage system within the micro-basin and the *Los Dinamos* park to prevent primary contamination. Also, to develop water treatment plants to make water potable and accessible. The Master Plan of Recovery has been one of the most ambitious environmental projects regarding the Magdalena River. But ultimately it was not as successful due to two main factors: 1) Construction was carried out by companies without taking into account the previous ecological studies from Master Plan. Lack of planning seriously alters hydrological patterns of the river, changing water flow. 2) There was little to know local involvement/participation by the local people in decision making process over the land/natural resources (Sosa, 2009). These short comings has led to skepticism local people, and their hesitance must be addressed to create a viable sustainable solution for recovering the Magdalena river. Recent discourse shows weekend tourism, corruption by government entities and landowners, lack of local ecological knowledge, pollution, and

[9] Hacienda is a common word in Spanish-speaking countries which refers to plantations, large land extensions with agricultural manufacturing, mining, or raising of animals and typically with large central living quarters for the Spaniards.

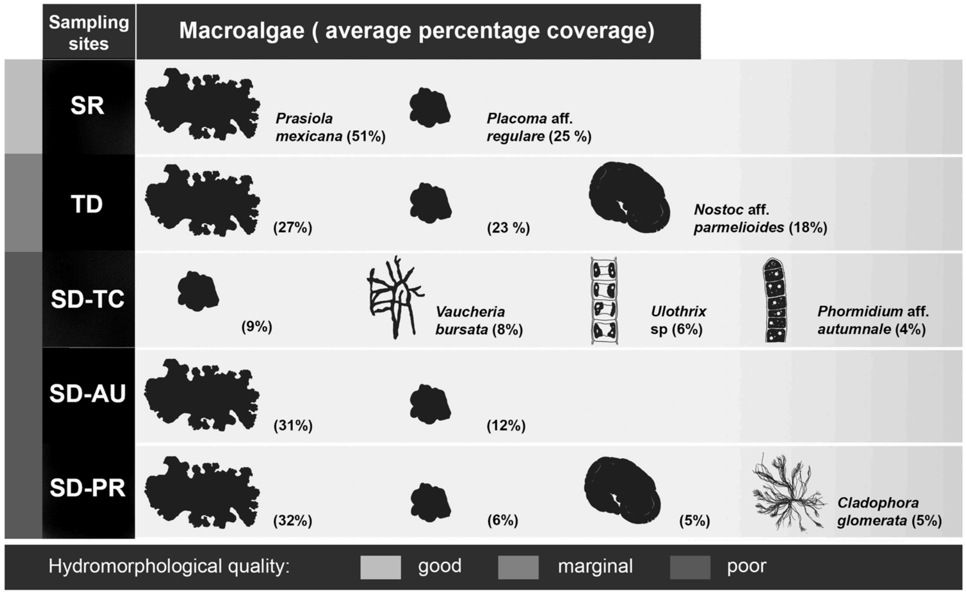

Fig. 5. The ecological quality per site according to the assemblies of registered algal in each of the sampling sites.

continued urban expansion. Continue to inhibit ecological productivity and resource provision of the Magdalena River.

5.2.2. Present day perceptions

Regarding the establishment of informal built homes on the Conservation Land, three main methods for land transformation were identified from interviews and the focus group: 1) unlawful sale of plots by landowner communities (*comuneros* and *ejidatarios*), backed only by a purchase intention paper; 2) change of land use from rural to urban facilitated by the same landowners; and 3) land appropriation illegally, without any payment or agreement with the landowners. The first finding was the most common way of obtaining the land, even though the Agrarian Law says that urbanization is not allowed in areas with any kind protection category, both in ejidos and agrarian communities[10]. Therefore, respondents point to local landowners as the main vector responsible for growth of informal settlements. In addition, interviewees showed verbal evidence of corruption of local government withing the Magdalena Contreras city sector, including the Mayor. They recounted the past Mayor promise to find a solution for the housing shortage and issue of informal establishments with the promise to regularize/legalize it and to provide it with basic services but failed to even attempt to solve the issue once in office.

5.2.3. Use of water resources and sanitation services

Three main points of water source were identified: 1) governmental public drinking water network; 2) piping water into local homes and private companies with governmental support; and 3) direct surface water extraction from the Magdalena River and springs that feed it. The first two methods of water source are lawful. Regarding direct surface water extraction, our research detected the existence of an informal network of spring water abstraction. There is system of local governance to obtain water through buy/sell deals. Water consumption is motivated by the collective understanding that river water is not safe to drink, but spring water is pure. Informal settlements have insufficient sewage systems and many deposit waste into the Magdalena River. Some inhabitants have connections to septic tanks that are self-managed. As result the river is a public health hazard while the springs and tributaries remain safe for local use.

5.2.4. Perception of living in the area: pros and cons

Focus groups conducted to communicate with locals identified a neighborhood collective run by local volunteers to better living conditions has been an important factor to the betterment of the informal community within Los Dinamos. However, despite neighborhood efforts to improve the quality of housing and access to basic services (water, electricity, and waste management), this continue to be the main difficulty that residents detected when living in informal settlements. For example, solid waste management is an issue, since there is no collection service provided by the government. The neighborhood collective has contributed monetarily and through voluntary labor to provide themselves and their community with benefits such as paving and lighting the streets. The local government sometimes provides support to these groups, by supplying construction materials.

Other inconveniences derived from their irregular situation were the insecurity, lack of economic opportunities and connectivity, for example public transportation and internet access, were recognized in the interviews and focus group discussion as well.

A contradictory issue recognized by informal inhabitants through individual response and focus groups was the population growth in the informal settlements. They exposed the construction of communication and access roads as a vector of urban growth. However, the progress of urbanization is seen as beneficial by locals. They believe a large informal population could encourage the government to legalize or simply overlook the settlements and mitigate the risk of being evicted.

Respect to the ecological aspects, natural disasters like floods were identified as another problem. The precarious conditions of the houses in high-risk areas often result in loss of homes and/or domestic assets during floods. Despite the evident cons, most of the interviewees expressed that living in a quiet wooded area with clean air and access to water are advantages that generates well-being compared to people who live in the city with polluted air and scarce access to water.

5.2.5. Local management: focus group feedback from comuneros and ejidatarios

Focus group participants who lawfully owned their land found the decrease in the quantity and quality of water in the Magdalena River to be a major issue. Decrease in water quantity was associated with canaling and piping lower reaches of the river to transport it to other

[10] Article 88.- The urbanization of *ejido* lands located in protected natural areas, including ecological preservation zones is prohibited […].

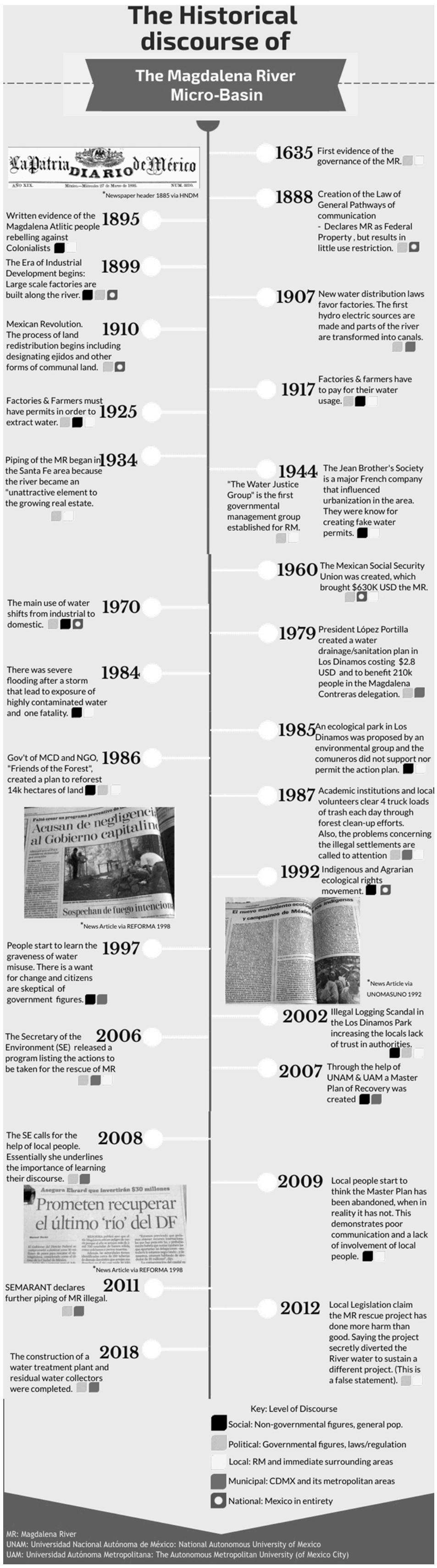

Fig. 6. Timeline about the historic managements and interventions over the Magdalena River micro-basin. See Header: Timeline Resources.

areas of the city. Decrease in water quality was associated with informal settlements, tourists, and restaurants. Other factors detected by the group was a loss of forest cover, this change was attributed to illegal logging and population increase in Conservation Land. Other sources of negative change to the Magdalena River were the trout farms, and the construction of restrooms and restaurants, which are generators of biowaste often drained into the river.

The establishment of informal settlements in the upper part of the micro-basin was an issue identified as critical to the landowners, as they feared the loss of their land. The problem has forced many of landowners to establish their homes and live within Conservation Land acting as patrol on their lands. Despite this situation, *comuneros* and *ejidatarios* are willing to collaborate with people from informal settlements who are interested in participating in conservation activities. Ideally, they would be integrated into a conservation activity programs aiding forest and Magdalena River management. However, participation in conservation activities is limited due to the availability of monetary resources. Most funding comes from programs run by the local government and, to a lesser extent, the federal government. Petition for government funding can is difficult and unreliable. Overall, the main issue is that the use and management of water is not regulated by authorized landowners or local authorities, permitting overconsumption of water and distribution to other areas of the city.

6. Discussion

6.1. Hydrology and ecological evaluation: effect of human activities

Through the ecological surveying and social perception evaluation, it is evident the Magdalena river has experienced land use change that compromises the functioning of the riparian ecosystem. These changes depend on intensity and frequency of human activities *in situ*. Our study showed that with a low level of human perturbation an increase in nutrients occurs (oligo-mesotrophic water levels), favoring the diversity of communities such as those of the macroinvertebrates (Caro-Borrero and Carmona-Jimenez, 2019). However, we do not know the threshold of tolerance of biological communities to contamination. Nonetheless, our results we suggest the joint presence of the Chironomidae, Baetidae and Simuliidae families as an indicator of early changes to the physical and chemical structure in the river. The most important changes in the macroinvertebrate's assemblies were triggered by the instability of the aquatic habitat, including; changes to substrate and removal of riparian vegetation. These disturbances on a physical scale at basin-level are reflected in local physical habitat simplification, water pollution, and degraded aquatic assemblage condition (Macedo et al., 2016). For example, the *Baetis*-mayfly typically abundant in mountain rivers, showed low population concentrations in the Magdalena River. Perhaps low availability of substrate limited ephemeral establishment (Doeg and Lake, 1981). In contrast, a dominance of mosquitoes (Tanytarsini green midges) was observed and favored by the increase in matter organic particulates from the trout farms. These examples demonstrate the need to maintain the natural forest and riparian cover of the basins as a determining factor in the conservation of aquatic environments.

In this study, the algae communities were more sensitive than benthic macroinvertebrates assembly to local changes derived from anthropogenic activities. The decrease in the percentage coverage of cyanobacteria *Placoma aff. regulare*, *Nostoc aff.parmelioides,* and green-alga *Prasiola mexicana* indicates changes in the conditions of the trophic water state. Specifically, the algae respond to changes in the concentration of phosphorus (maybe from household soaps) (Carmona-Jiménez et al., 2016). Which makes us think that they are a perennial community that responds to small changes in nutrient concentration.

The biotic scenario described in this study, for both macroinvertebrates and algae, shift when the alterations in the structure of the riverbed (*i.e.* gabion dams) and water diversions are identified to satisfy tourist activities (González et al., 2010; Caro-Borrero et al., 2015). These activities clearly favor the local economy but are detrimental to the ecological productivity of the river (Affek and Kowalska, 2017; Walsh et al., 2005). Sites influenced by urbanization resulted in hydromorphological quality deterioration and presented the most severe effects in relation to habitat quality. Low diversity of both macroinvertebrates and algae reflected habitat degradation (Walsh et al., 2005). These habitat-scale modifications constitute a key element impacting growth rates, abundance, and structure of the macroinvertebrates assembly (Fremier, 2004; Vannote et al., 1980).

Even when in mountain rivers such as Magdalena, the slope and the current velocity are factors that favored the transport and the self-purification of contaminants produced by the human activities, this capacity can be exceeded. For example, we registered in all sampled sites the presence of fecal bacteria and presumptive *Salmonella* as a product of diffuse contamination. Which is affecting the water quality consistently, being an ecological and social well-being element of risk. Despite, pollution and non-regulated activities within the Magdalena River micro-basin was permitted by both the landowners and local authorities. For example, trout farms and restaurants were not obliged to follow any legal regulations and most discharged waste into the river without treatment. Our research registered a response of the river-ecosystem through the assemblage of macroinvertebrates, macroalgae and bacteriological indicators. The bioindicators responded in a directly proportional way related to the intensity and frequency of human activities, negatively affecting their populations (Farley and Voinov, 2016; Gunderson et al., 2016).

The results show a non-existence of legal regulations/strategies to effectively stop urbanization as the main driver of land use change within Conservation Land. These findings were consistent with previous studies within the area (Aguilar and Santos, 2011a, b; Varley, 2019) and examples of processes of ecological degradation in other cities of Latin America (CEPAL, 2016; Hardoy et al., 2013). Thus, there is a systematic failure in the management of conservation areas when political and social pressures are stronger than environmental ones. However, some possibilities are at stake: first, the regularization of informal settlements could favor the intervention of construction companies and the conservation land could disappear definitively with a massive urbanization process. Second, these processes can gradually end social property in Mexico and involve a process of displacement for rural communities[11] (Varley, 2019).

6.2. Document analysis, qualitative interviews and focus groups

After analysis of interviewees discourse and the historic news articles, several key themes have been identified. First, local people living within the micro-basin have a severe mistrust of outsiders, especially governmental officials and people illegally building homes within Conservation Land boundaries. This factor of mistrust is transgressional discourse that has transmitted from generation to generation and has become an obstacle to the governance of natural resources. The severe lack of mistrust is built on a long history of conflict deeply embedded in Mexican culture, and false claims from the government, and environmental scandals within the micro-basin add to locals' distrust. In the case of the Magdalena River these 'outsiders' are the government at the municipal and federal level, logging companies, and members of academia undergoing research. An example of corruption was represented by the logging scandal exposed during 2002, reporting the illegal removal of trees (20 tons) and false claims presented to the public (Cesarman, 2002). Locals were told that the loggers were purging trees that had diseases and mitigating fuel to prevent forest fires. However, the trees that were removed did not have any sort of illness (Cesarman, 2002). The loggers were reported to be cutting healthy mature trees, and clear cutting an entire area. The article also claimed that some of the local communities were bribed through the "donation" of food by the local Secretary of Environmental Protection (Cesarman, 2002). Essentially the government allowed loggers to cut trees for profit on Conservation Land.

A second theme; the people that live within the communities surrounded by Conservation Land are extremely marginalized, and the natural resources that were once part of their livelihood are now off limits due to the conservation protection. The resources they are allowed to take are limited, yet the government is making profit illegally and while simultaneously telling locals they must abide by protection laws (Caro-Borrero et al., 2015). When looking at this example, it is clear why locals do not have trust in authorities and this is not the only case where authorities have lost trust of locals (Almeida et al., 2017; Aguilar and Santos, 2011a; Aguilar, 2008). Examples of corruption and mismanagement of natural resources throughout history have generated the current panorama of social dysfunction, causing divided opinions and a lack of commitment to the conservation activities proposed by the government. There have been two big pushes to restore the Magdalena River throughout history, first in the late 1970s through the orders of President López-Portillo, and secondly in 2007 the Master Plan of Recovery from orders of the Environmental Secretary (Secretaría del Medio Ambiente, by Spanish acronym) (Avance, 1979; SMA, 2012). There was a lot of effort put into developing these plans of restoration, but they fell apart for several reasons. First, there were no hard timelines in either of the plans. There were only general yearly goals, but they were vague and not mapped out well enough to have a real agenda of progress. Secondly, they both failed to talk with locals (landowner and informal residents) about their ideas and plans. Also, they failed to learn the local knowledge of the area or gain the approval of the locals (Caro-Borrero et al., 2017). Academic studies about the masterplan have shown that the majority of local people were never informed about any part of the plan, and they were never asked their opinions nor were they consulted about the project (Sosa, 2009). When a new community is not confronted about a 2-million-dollar project to take place in their community, they are subject to be untrusting of the construction. A third project of planning and restoration should take place and address local discourse that our study has be begun to collect. Ideally understanding of diverse discourse would mitigate conflict and increase the likelihood of success.

Future projects need to address the issue of the lack of trust between locals and the government (Figueroa et al., 2016). Locals should be able to participate in the planning of the project and should be informed of a timeline. Also, the plan should make clear that locals would benefit from changes, and the needs of new infrastructure (Almeida et al., 2017; Gunderson et al., 2016; Knüppe and Knieper, 2016). There should be a monitoring system put in place, a sort of checks and balances that the plan is being executed as it should (Almeida et al., 2017). UNAM, the local university, could work well as a "middle man" per say. The University could be the most active within the Magdalena Contreras Community, they then could report their findings to the government to gain funding and permission. Overall, the development of a new plan must evaluate the different discourses of local people, the government, the university, and any other stakeholders that will be impacted (Knüppe and Knieper, 2016). The panorama of contradictory discourse concerning conservation is evident in three main social groups: one of them corresponds to the landowners (*comuneros* and *ejidatarios*), which declared their concern about irregular activities within the micro-basin that deteriorate the quality of forest and water. But on the other hand, some informal residents have acted as accomplices and participants in the selling of Conservation Land and land degradation (Aguilar and Santos, 2011a, b; Varley, 2019). A second group corresponds to informal settlements, people fighting for their right to housing (Hardoy et al., 2013). They argued the advantages living within a forest with clean air, spring water and surrounded by nature and expressed their need for

[11] When regularizing the land where the irregular settlements are located, it is necessary to expropriate the land from the ejidos and/or agrarian communities in order to legalize the new homes with their owners.

more housing, pressing the government to provide them with basic services and legal recognition (Aguilar and Santos, 2011a, b). In a third group there are local and regional authorities who have devised conservation and rescue plans for the river. Adversely, these same actors are responsible for illegal logging and the regularization of land bribes, a driving force of informal settlements. In many cases; public policies, government economic incentives, and outside interests of conservation areas may end up undermining cultural relations and conservation practices that favor the ecosystems conservation (Méndez-López et al., 2014; Aguilar and Santos, 2011a; Bennett et al., 2015; Comberti et al., 2015). This reciprocal relationship of human-nature benefits is broken and avoids their co-evolutionary role that can contribute to the ecosystems functioning (Comberti et al., 2015). It is here, where there is the opportunity to generate dialogues that can direct a reallocation of values in the conservation land from the relationships between cultural identity and local heritage (Affek and Kowalska, 2017).

The example of the Magdalena river micro-basin is not an isolated case in Mexico or in Latin America, where the lack of confidence in the government's actions is a barrier that hinders communication and the governance of natural resources. Historically, indigenous/rural communities have been excluded from decision-making and thus resulting in the failure of many conservation programs that involve local people (Figueroa and Caro-Borrero, 2019; Figueroa et al., 2016). Finally, we highlight the importance of framing any socio-ecological action within the basin in context to their socio-historical background. As the present ecosystem conditions are connected to historical decisions made and the/relationships (or lack thereof) between locals and the government concerning natural resource management.

7. Conclusions

The Conservation Land of Mexico City shows a dynamic of informal urban growth and ecosystem deterioration, consistent with other large cities where the price of housing exceeds the possibilities of the low-income population. This study proves that the impact of low to moderate urbanization is gradual and is presenting early warning signs at the ecological level (*e.g.* changes in the characteristic assemblages of macroinvertebrates and algae, and the presence of pathogenic bacteria), which could be reversible with adequate management interventions. However, the socio-historical evaluation puts this perspective at risk, as it shows that urbanization will continue not only because of the need for, but also because of the historical complicity of the relationships between landowners and local authorities.

Past ecological recovery programs within the micro-basin do not seem to have had a positive effect on the quality of the ecosystem. Therefore, these recovery programs were insufficient. Past interventions did not consider these complex social dynamics between formal landowners and informal settlements, and this played into their failure. The proposal for a micro-basin recovery plan must involve a change in local social welfare, which will be reflected by a change in conservation attitudes and strategies. This means that both informal settlements, restaurants, and trout farms must adopt mitigation and conservation measures. Though past recovery plans have failed, it is crucial that new approaches are being taken to protect the Magdalena river micro-basin for the future equity and stability of local people and freshwater environments.

The process of the encroachment and ecological deterioration will continue unless a new approach is taken. From the interviews and focus groups an alternative emerges, consisting of generating a program of local participation in conservation efforts for informal inhabitants who will likely not be forced to move from the Conservation Land. For example, the informal inhabitants could be participants of zero growth program, a local government project that seeks to limit the growth of irregular human settlements.

In a broader context, the lessons learned from this case study reveal important facts of three contexts: 1) the ecological context, urbanization simplifies the aquatic habitat and biological diversity is lost significantly, affecting the provision of ecosystem services that maintain human well-being locally and regionally, and, 2) in the social context, misunderstanding or overlooking historical relationships makes it difficult to understand governance over natural resources in the present. Lack of trust in the government is the key factor undermining conservation efforts. And 3) in the socio-ecological context, the need to connect the current state of the ecosystem, the perspectives and socio-environmental history around the river of the local inhabitants and the policies of both conservation and social support within the Conservation Land to create successful management plans looking at all factors.

Authorship contributions

Caro-Borrero, A.: Conception and design of study; acquisition of data; analysis and interpretation of data; revising the manuscript critically for important intellectual content.

Carmona-Jiménez, J.: Drafting the manuscript; acquisition of data; analysis and interpretation of data; revising the manuscript critically for important intellectual content and version of the manuscript to be published

Ribera, K.: Acquisition of data; analysis and interpretation of data.

Bieber, K.: Acquisition of data; analysis and interpretation of data.

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