

2021 Social Cost of Water Pollution Workshop

Water quality and property prices

Argentina, Brasil y Mexico

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QUALITY UNKNOWN

THE INVISIBLE WATER CRISIS

The aim of this project was to investigate the effects of poor water quality on health, the environment and the economy, and to take advantage of world experience to suggest policy solutions that were effective, efficient and appropriate to improve water quality

QUALITY UNKNOWN: The invisible water crisis

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Capturing Environmental Amenity Values

*Is there a willingness to pay for
good quality water?*

*Is the quality water in the
surroundings capitalized on the
price?*

Water quality and property prices

Lack of a directly observable market for quality water.

Valuation alternatives:

1. Contingent valuation
2. Revealed preferences

A derivation of the revealed preferences approach is used: the hedonic pricing model.

Water quality and property prices

The hedonic model suggests that the benefits derived from a change in water quality will be reflected in the price that individuals pay for the property they choose.

Buyers and sellers have perfect information.

Model estimated

$$\text{Log}(P) = W\tau + X\beta + S\gamma + L\tau + D\tau + \mu ,$$

Where: W is a matrix of attributes related to water quality, X is a matrix of dwelling characteristics, S is a matrix of neighborhood attributes and socioeconomic characteristics at census track, and L is a matrix of fixed effect by municipality, D is a set of dummies of distances to the monitoring station (0=less than 0.5Km, 1=0.5 to 1Km, 2=1 to 1.5km, 3=1.5 to 2Km and 4=2 to 2.5km) and μ is the error term.

In Mexico we keep the cities with more than 500 properties.

Controls at census track level (Locality in Mexico).

Regression clustered at monitoring station level

Literature review

Lancaster (1966), Rosen (1974) and Roback (1982)

- *Few studies address water quality in the environmental economics literature. **Why?***

Leggett and Bockstael (2000); Bockstael and McConnell (2007); Phaneuf et al. (2008) and (Artell, 2015)

1. *Difficulty finding a water quality indicator that is observable to the public*
2. *Lack of variation in water quality in the chosen area.*

- *Some works for the USA (e.g. Michael et al., 1996, 2000, Poor et al., 2001, Gibbs et al., 2002, Leggett and Bockstael, 2000, Poor et al., 2007)*
- *Absence of papers for Latin America*

Literature review

- **Stream water quality** (*Epp and Al-Ani, 1979; Streiner and Loomis, 1995*),
- **Lakes** (*Boyle et al., 1998, 1999; Gibbs et al., 2002; Michael et al., 1996; Hsu, 2000; Poor et al., 2001; Steinnes, 1992*),
- **Coastal waters** (*Parsons, 1992; Leggett and Bockstael, 2000*),
- **Proximity to hazardous waste sites** (*Lewis and Acharya, 2003; Hite et al., 2001; Ihlanfeldt and Taylor, 2001; Faber, 1998; Palmquist et al., 1997; Kiel, 1995; Kiel and McClain, 1995; Zeiss and Atwater, 1990; Michaels and Smith, 1990*), and
- **Perception:** *Poor et al. (2001)*, respondents consistently underestimated the official measure of water clarity.

DATA

	Argentina	Brasil	México
Area	Matanza - Riachuelo Basin	Sao Paulo	Main cities
Water quality parameters	Source: Acumar; Monthly data from 2008 to 2017 on COD, DQO, SST, Escherichia coli, Oxygen Dissolved, N-NH4+, PT, Cr, Pb, HCT, CE and Ph.	Source: CETESB - Environmental Company of the State of São Paulo; Monthly data from 1978 to 2018 on COD, DQO, SST, Escherichia coli, Total and Thermotolerant Coliforms, Nitrate, Nitrite, Turbidity and Colour	Source: The National Water Information System (SINA). Data on COD, DQO, SST and Fecal Coliforms for 2015-2017
Property prices	Asking prices from webpages for 2016-2018.		
Standard dwellings' characteristics	Indoor living space, lot size, living space, number of rooms and bathrooms and parking availability.		
Socioeconomic characteristics based on census tract level data:	Data at census tract level: access to sewerage, gas and current water, people with unsatisfied basic needs, unemployment rate and the share of homeowners.	Data at census tract level: Total population, per capita household income, access to water network, sewage, wooded areas, driveway, property title, lighting, pavement, proportion of non-white and literate.	Data at locality level: % Homes without electric light, piped water, toilet, drainage and any durable goods

DATA

Variables	Argentina	Brasil	México
Area	Cuenca Matanza - Riachuelo	Sao Paulo	Main cities
Price (USD) in thousands	219,208	238,495	187,596
<i>Water Quality</i>			
BOD	26.0	72.6	63.2
COD	69.2	144.3	171.1
SST	46.8	172.0	87.6
E. Coli	486,912	5.5	157,634
CE	1,585.8	8.7	
Monitoring stations	15	149	642
<i>Structural</i>			
Lot size (m2)	193.0	292.9	296.9
Interior space (m2)	127.9	172.1	211.0
Rooms (Quantity)	3.3	2.2	3.0
Bathrooms (quantity)	1.1	1.1	1.2
Park (= 1 Yes)	36.1%	11.1%	37.9%
Garage (= 1 Yes)	36.0%	3.2%	24.1%
Home (= 1 Yes)	47.2%	46.9%	81.5%
Observations	3,869	37,392	74,692

Cuenca
Matanza
Riachuelo
(Argentina)



Water quality and property prices

Results

Country	BOD	COD	SST	E.Coli / Fecal o thermotolerant Coliforms
Matanza - Riachuelo	-0,137***	-0,088***	-0,049	-0,050**
Sao Paulo	-0,075**	-0,096**	0,012	-0,035**
Mexico	-0,069**	-0,081***	-0,062**	-0,034***

Demanda biológica de oxígeno (BOD), demanda química de oxígeno (COD), Total de sólidos en suspensión (TTS).

***p < 0.05, ***p < 0.01.*

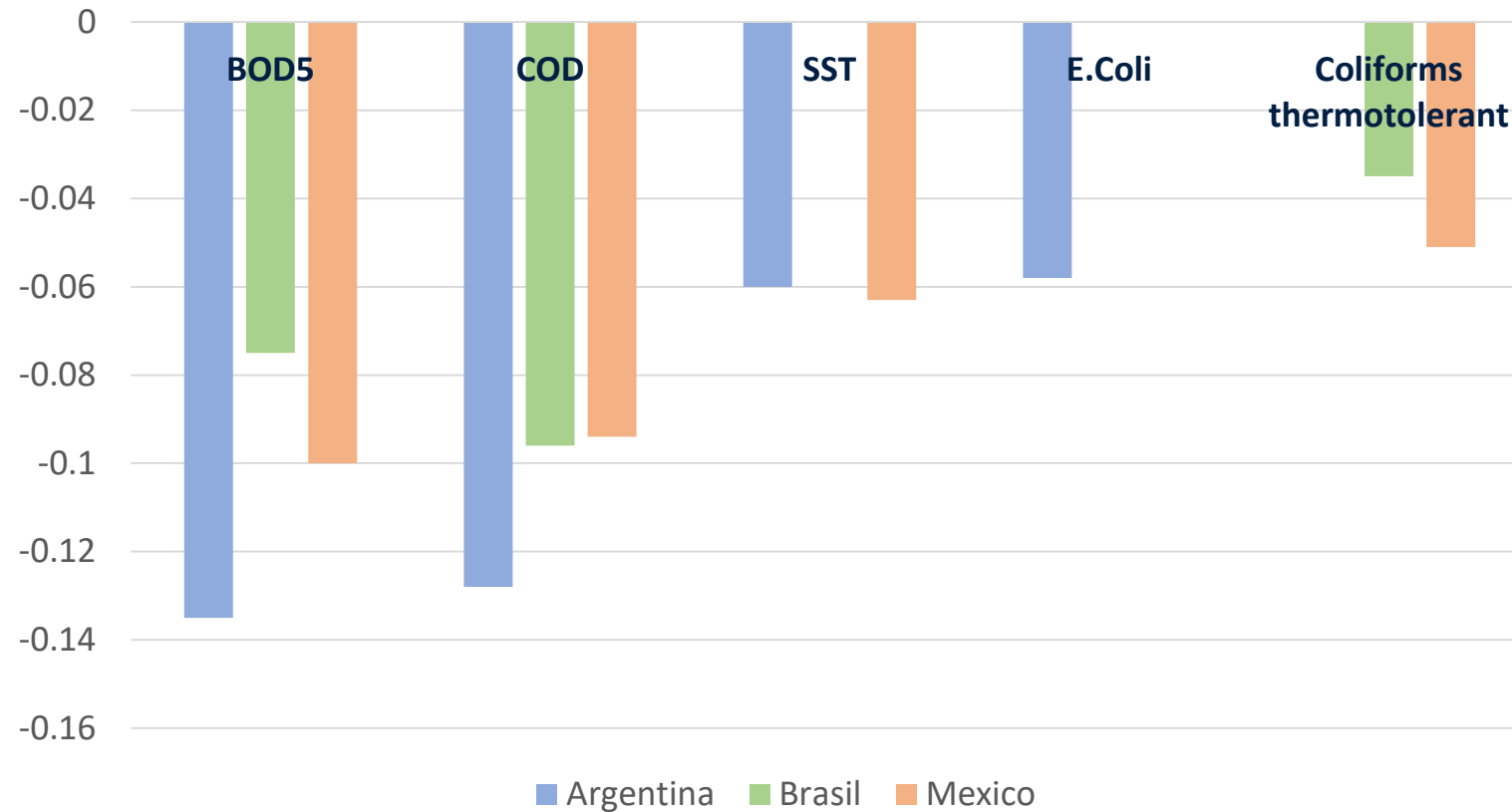
Water quality and property prices

Resultados

- *In all three cases the results consistently show that declining water quality leads to diminishing property prices.*
- *The differences between countries is not highly significant suggesting that those affected by water respond in similar ways to the perceived impacts.*

Water quality and property prices

Estimated coefficients



Caveats

- Many harmful water pollutants are colorless, odorless and impossible to detect without specialized monitoring equipment
- The water quality parameters came from the monitoring station near each property not the quality of the water inside the house.
- The analysis is cross section.
- We do not analyze causality.
- Possible criticisms for endogeneity.



Comments are welcome at
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Thank you

Water quality thresholds

Parameter	Acceptable	Good quality	Excellent
BOD (mg/l)	30	6	3
COD (mg/l)	40	20	10
TSS (mg/l)	150	75	25
E. Coli (millions)	0.001	0.0002	0.0001

BOD = biological oxygen demand; COD = chemical oxygen demand; TSS = total suspended solids.

Benefits of water quality improvement

$$\pi_{Cod} = \beta_{Cod} * (l_{Cod}^{Acceptable} - l_{Cod}^{current}) * \bar{P} * N_c$$

- Where π_{Cod} is the Benefits capitalized in the property of improving water quality from current to acceptable level.
- β_{Cod} is the regression coefficient, $l_{Cod}^{Acceptable}$ is the acceptable level of COD (30 mg/l) and $l_{Cod}^{current}$ is average value of COD in houses with values higher than the acceptable limit, \bar{P} is the average price of those houses and N_c is the number of houses with values higher than the acceptable limit.
- Results:
 - Benefits of water quality improvement vary between parameters and countries.

Benefits of improving water quality to acceptable standards

		Increase in property price (%)	Average profit per household	Households Benefited
BOD	Argentina	6,0	13.265	283.227
	Brasil	5,6	13.361	1.126.224
	México	5,3	10.158	2.087.352
COD	Argentina	3,2	7.020	655.389
	Brasil	6,3	15.036	1.685.381
	México	6,0	11.441	3.440.306
E. Coli	Argentina	4,2	9.263	731.910
	Brasil	3,4	8.245	1.717.004
	México	3,1	5.870	4.423.683

BOD = biological oxygen demand; COD = chemical oxygen demand.

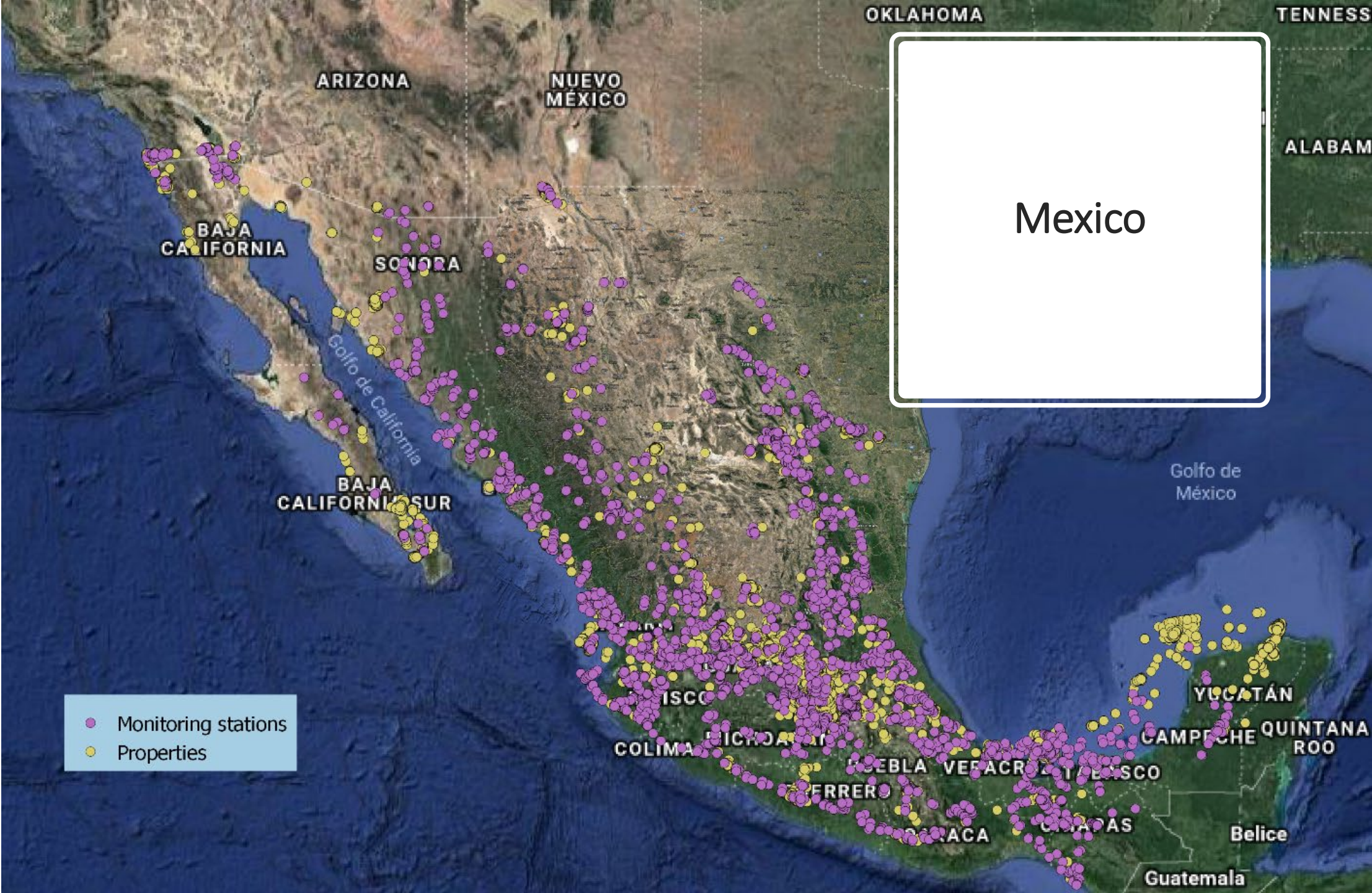
Appendix

A satellite-style map of the Sao Paulo region in Brazil. The map shows a mix of green vegetation and brownish-grey urban areas. A prominent black line, likely a major road or railway, runs from the top left towards the center. Numerous red and blue dots are scattered across the map, with a high concentration in the central and eastern parts, particularly near the coast. The dots are semi-transparent, allowing the underlying terrain to be seen. The coastline is visible at the bottom right, with the dark blue ocean. A white box with a black border is located in the bottom left corner, containing the text 'Sao Paulo (Brazil)'.

Sao Paulo
(Brazil)

Mexico

- Monitoring stations
- Properties



Results Argentina

Variables	BOD	COD	TTS	E. Coli	CE
Water quality					
Parameter	-0.137***	-0.088***	-0.049	-0.050**	-0.136 ^x
Structural					
Lot size(m2)	0.000	0.000	0.000	0.000	0.000
Indoor size (m2)	0.004***	0.004***	0.004***	0.004***	0.004***
Bedrooms (number)	0.115***	0.114***	0.112***	0.114***	0.113***
Bathrooms (number)	0.084	0.084	0.082	0.085	0.086
Courtyard (=1 yes)	-0.011	-0.018	-0.018	-0.01	-0.013
Garage (=1 yes)	0.214***	0.214***	0.216***	0.218***	0.218***
House (=1 yes)	0.118	0.123	0.124	0.121	0.121
Locational					
Dist. CBD (km)	-0.026***	-0.021**	-0.022**	-0.025***	-0.021***
Dist. Slum (km)	0.023	0.023	0.023	0.02	0.018
Slum size (Hectares)	0.000	0.000	-0.001	-0.001	-0.001
Socioeconomic					
Share of access to water	0.001	0.001	0.001	0.001	0.001
Share of access to sewage	0.001***	0.002***	0.001***	0.002***	0.002***
Share of access to gas	0.006**	0.006**	0.006**	0.006**	0.006**
Share of people with unsatisfied basic needs.	-0.058***	-0.060***	-0.062***	-0.058***	-0.059***
Unemployment rate	-0.006***	-0.005***	-0.005**	-0.006**	-0.006**
Share of homeowners	0.010**	0.010**	0.010**	0.010**	0.010**
Constant	11.577***	11.467***	11.364***	11.804***	12.212***
Observations	3,523	3,523	3,523	3,523	3,523
R-squared	0.588	0.583	0.583	0.585	0.583

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, fixed effects by municipality and distance bins to the monitoring station, clustered errors at district level.

Results Brazil

Variables	BOD	COD	TTS	Coliforms Therm.	E.Coli
Water quality					
	-0.075**	-0.096**	0.012	-0.035**	-0.021
Structural					
Lot size(m2)	0.000***	0.000***	0.001***	0.000***	0.000***
Indoor size (m2)	0.003***	0.003***	0.003***	0.003***	0.003***
Bedrooms (number)	0.090***	0.091***	0.060***	0.089***	0.091***
Bathrooms (number)	0.02	0.019	0.031	0.019	0.019
Courtyard (=1 yes)	0.029**	0.030***	0.027	0.027**	0.028**
Garage (=1 yes)	0.009	0.01	0.033	0.012	0.013
House (=1 yes)	0.081	0.087	0.137*	0.089	0.081
Socioeconomic and Locational					
Dist. CBD (km)	-0.012	-0.011	0.004	-0.012*	-0.012
Share of access to water	-0.158	-0.177	-0.342***	-0.3	-0.26
Share of access to sewage	0.404***	0.338***	0.122	0.336***	0.373***
Share of access to drain	0.048	0.051	0.080**	0.044	0.045
Share of access to pavement	0.034	0.003	-0.302	0.124	0.079
Share of homeowners	0.04	0.092	0.045	0.11	0.082
Share of access to sidewalk	-0.074	-0.04	0.207	0.022	-0.016
Share of access to ramp	-0.021	0.026	0.108	0.002	-0.016
Share of garbage accumulated	-0.213*	-0.241**	-0.124	-0.223*	-0.232**
Share of access to trees	0.055	0.087	0.143**	0.077	0.07
Share of access to sewage	-0.132	-0.106	-0.096	-0.167	-0.165
Average per capita income	0.000***	0.000***	0.000**	0.000***	0.000***
Share of literate	-0.351	-0.431	-0.203	-0.687	-0.504
Share of Nonwhites	-0.939***	-0.746***	-0	-0.866***	-0.907***
Total population	0	0	-0.000***	0	0
Constant	16.532***	16.183***	11.204***	16.542***	13.253***
Observations	34328	34328	14906	34328	34328
R-squared	0.668	0.669	0.647	0.669	0.667

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, fixed effects by municipality and distance bins to the monitoring station, clustered errors at district level.

Results Mexico

Variables	BOD	COD	TTS	Fecal coliforms
Water quality				
	-0.069***	-0.081***	-0.062**	-0.034***
Structural				
Lot size (m2)	0.000***	0.000***	0.000***	0.000***
Indoor size (m2)	0.004***	0.004***	0.004***	0.004***
Bedrooms (number)	0.154**	0.143**	0.147**	0.145**
Bathrooms (number)	-0.026	-0.031	-0.035	-0.031
Courtyard (=1 yes)	0.115***	0.107***	0.110***	0.103***
House (=1 yes)	0.019	0.032	0.032	0.025
Locational				
Dist. CBD (km)	0.000	0.000	0.000	0.000
% with electricity	0.015*	0.018**	0.016*	0.015
% with running water	0.002	0.001	0.002	0.001
% with sewage	0.02	0.024*	0.024*	0.023*
% Housing with drainage	-0.014	-0.015	-0.015	-0.014
% homes with any good	-0.054**	-0.059**	-0.060**	-0.057*
Total population	-0.000***	-0.000***	-0.000***	-0.000***
Constant	9.681***	9.900***	9.732***	9.845***
Observations	34,438	34,438	34,438	34,438
R-squared	0.628	0.625	0.622	0.623

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$, fixed effects by municipality and distance bins to the monitoring station, clustered errors at district level.