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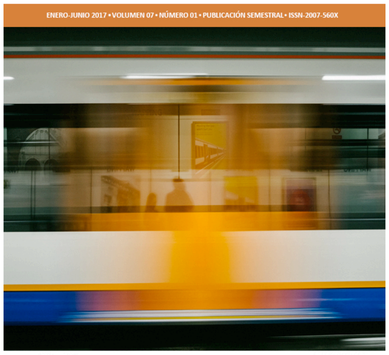

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Espacialidades, Revista de temas contemporáneos sobre lugares, política y cultura tiene como propósito constituirse en un foro de discusión académica que aborde la compleja, contradictoria y multicausal relación entre el espacio y la vida social. *Espacialidades* se inscribe en el debate académico internacional sobre el giro espacial en las ciencias sociales e invita al análisis de diversas prácticas sociales y formas de organización y acción política desde una perspectiva multidisciplinaria que ponga énfasis en las diferentes escalas territoriales. Los textos publicados incorporan métodos y problemas tratados desde la sociología, la ciencia política, la economía, los estudios urbanos, la geografía, los estudios culturales, la antropología, la literatura, el psicoanálisis y el feminismo, entre otros.

The Economic Benefits of The Atoyac Basin's Restoration in Puebla, Mexico

Los beneficios económicos de la restauración de la cuenca de Atoyac en Puebla, México

Gloria Soto Montes de Oca *
Alfredo Ramírez- Fuentes**

Abstract

Unesco reports that more than 80% of sewage in developing countries is discharged untreated; polluting rivers, lakes and coastal areas. This contamination reduces water availability and creates a public health risk. Restoring water resources is far from a priority in developing countries; however, recently emerging countries, such as Mexico, have shown greater concern about the importance of reducing water resource pollution. The Mexican government established the ambitious objective of treating 60% of wastewater for 2012. In this context, the federal and local authorities are assessing a large-scale project for cleanup of the River Atoyac and Dam Valsequillo, which crosses the city of Puebla. This paper presents the results of a large scale Contingent Valuation survey to estimate households' willingness to pay (WTP) as an input for a cost-benefit analysis. Results confirm that people are concerned and are familiar with the water pollution problem in the area and its consequences. WTP is determined by variables suggested by economic theory; particularly the distance decay effect which provides a validity criterion. Households are willing to pay on average up to 3.3% of their income, while, in fiscal terms, aggregate WTP figures show that authorities could collect the resources necessary to fund this project.
Keywords: Water quality, river restoration, contingent valuation, distance decay, Puebla in Mexico.

Resumen

La Unesco reporta que el 80 por ciento de las aguas residuales en los países en desarrollo se libera sin ningún tratamiento, contamina los ríos y lagos de las zonas costeras. La contaminación reduce la disponibilidad del agua, degrada los ecosistemas y crea riesgos de salud pública. La restauración del agua está muy lejos de ser una prioridad en los países en desarrollo; sin embargo, países emergentes como México muestran una preocupación mayor en la importancia para de reducir la contaminación en los recursos acuíferos. El gobierno mexicano estableció un proyecto ambicioso para tratar el 60 por ciento de las aguas residuales para 2012. En este contexto, las autoridades federales y locales planean un proyecto a gran escala para limpiar el Río Atoyac y la Laguna de Valsequillo, que cruzan la ciudad de Puebla. Este artículo muestra los resultados de una encuesta de valoración para estimar la licitación de la Iniciativa para Pagar (Willingness to Pay, WTP) por hogar como base para el Análisis Costo-Beneficio (Cost Benefit Analysis, CBA). El resultado fue que los residentes están familiarizados con el problema de contaminación y están preocupados por las consecuencias. El WTP está determinado por variables sugeridas en la teoría económica,

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particularmente en el efecto de decaimiento por distancia, que da un criterio de valor. Los hogares podrían pagar un promedio de hasta 3.3% de su ingreso, mientras que, en términos fiscales, figuras del agregado WTP muestran que las autoridades pueden juntar los recursos necesarios para pagar el proyecto.
PALABRAS CLAVE: calidad del agua, restauración de ríos, valoración, decaimiento por distancia, Puebla en México.

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Introduction

Despite the value of natural water bodies, such as rivers and lakes, they have undergone increasing exploitation and degradation, which has reduced their capacity to provide key environmental services. Although certain practices of resource exploitation and pollution may have been for society's best interests, in many cases, the resource is lost through activities with limited benefits for society, and sometimes it entails high costs (Turner *et al.*, 2004). River services are considered a quasi-public good because, on one side, everyone benefits from its existence —such as, recreational and aesthetic uses—, while in some cases water is used for private purposes, such as water for irrigation or domestic consumption (Turner *et al.*, 2004; Palaniappan *et al.*, 2010). Moreover, the lack of market values for certain river services limit the incentives to maintain or invest in restoration actions.

Most rivers around urban areas in developing countries are used as open sewers (Seregeldin, 1994). The United Nations (WWAP, 2012) reports that over 90% of sewage in developing countries is untreated and discharged into water bodies, polluting rivers, lakes, and coastal areas. Poor water quality not only affects the quantity and availability of the resource, but pollution also potentially poses a risk to public health and recreational uses, and subsequently, affects economic and social development, in addition to damaging the ecosystem. The World Bank estimates that in the Middle East and North Africa, the cost of poor quality water ranges from 0.5% to 2.5% of GDP annually (WB, 2007 in Palaniappan *et al.*, 2010). In Mexico, estimated damage due to water degradation is approximately 0.5% of GDP (INEGI, 2013). Overall, there is a general consensus that the poorest communities are the most severely affected.

In response to the growing problem of water pollution in Mexico, the government set an ambitious goal of treating 60% of wastewater by 2012 (Conagua, 2010), which unfortunately was not achieved. Nevertheless, within this context, federal and local authorities assessed a large-scale project for the restoration of one of the most polluted surface water courses: the Alto Atoyac Basin, composed of the Atoyac River, its streams and the Valsequillo Dam; which crosses the city of Puebla, the fourth largest metropolitan area in the country. The challenge was to justify the high cost of the cleanup of surface water bodies, given that market prices for several benefits did not exist, such as improving aesthetics in urban and rural areas, restoring a number of ecological services that have a positive impact on human health. Although the National Water Commission (Comisión Nacional del Agua, Spanish acronym Conagua) has experience using Cost Benefit Analysis (CBA), this was the first time that the contingent valuation method had been regarded as the most feasible option for estimating project benefits.

This paper is organized as follows, in section 2 we present a literature review of non-market valuation studies of the restoration of surface water bodies. Section 3 describes the case study, reviewing the water pollution problem and the project for restoring the rivers and dam in the region. Section 4 presents the research design, detailing the scenario and questionnaire characteristics, the WTP elicitation, and the sample design. In section 5 we present and discuss the survey results, particularly the estimated household WTP and aggregate benefit as an input for the CBA. Lastly, we discuss our main results and provide some policy considerations.

Literature Review

Non-market values of water and other environmental resources have been broadly estimated using stated preference methods, particularly with the contingent valuation method (CVM). This method involves the use of a contingent market, or hypothetical scenario, that introduces respondents to a series of proposed changes in the characteristics of the environmental good or service, and then asks whether they are willing to pay for it (Mitchell and Carson, 1989; Arrow *et al.*, 1993, Bateman *et al.*, 2002).

In particular, CV studies have been prolific not only in terms of theoretical and methodological issues, but also of empirical studies, which have multiplied across developed and developing countries during the past decades (Carson, 1995, 2011). The practical application of the method has been dominated by studies in developed countries, whereas its application in developing countries has been limited and, sometimes, received criticism (Whittington *et al.*, 1992; Brookshire and Whittington, 1993, Whittington y Pagiola, 2011).

Developed countries have evaluated and funded ecosystem restoration activities for a long time (see Holmes *et al.*, 2004; Brouwer and Pearce, 2005). Studies to assess the restoration of instreams flows have been conducted as part of investment strategies and policy evaluation by various international organizations such as the European Commission (Bateman *et al.*, 2009; Biliem *et al.*, 2009; Barton *et al.*, 2009; Hasler *et al.*, 2009; Raggi *et al.*, 2009a; Raggi *et al.*, 2009b; Ščeponavičiūtė *et al.*, 2009) and the Inter-American Development Bank (Ardila *et al.*, 1998). For instance, 11 case studies were conducted in various European countries, which assessed the improvement of water quality from moderate, to good or very good in the context of the European Water Framework Directive. Results indicate that WTP varies from $20 per household per year in Lithuania to more than $300 a year in Norway and Spain (Barton *et al.*, 2009; Ščeponavičiūtė *et al.*, 2009).

In Latin America, the Inter-American Development Bank supported 15 projects, where benefits were estimated using CVM (Ardila *et al.*, 1998). The Average WTP for these studies was $69.3 a year for various improvements, including reducing bad odor and improving water quality for swimming. The lowest WTP was found in Uruguay with $8.8 per year and the highest in Peru with $160.5 per year. Vaughan *et al.* (1999) estimated the benefits of water quality improvement in Liet River in Sao Paulo, Brazil, which included sanitary sewer extension and the installation of treatment plants. In this case, WTP near the river reached $116.6 per year and furthest from the river totaled $ 50 per year. As noted, there is a substantial difference in WTP between sites, which can be explained by the specific improvements offered by the scenario and the local socio-economic conditions, but it is remarkable that WTP is not necessarily determined by the level of development of a given country. The literature emphasizes that WTP is context-specific, i.e., the population may show different levels of interest in the environmental improvements offered depending on local issues (Whittington *et al.*, 2008).

A number of studies highlight the accuracy of the estimates regarding the water quality change valued and how WTP varies between households living in close proximity to water bodies, compared to those across the region (Pate and Loomis, 1997; Loomis *et al.*, 2000; Bateman *et al.*, 2006; Tait *et al.*, 2012). As Bateman *et al.* (2006) argue, this would reflect the lower interest of present nonusers while those nearer to the site in question may switch from being non-users to users as quality increases. In a broader perspective, Pate and Loomis (1997) also state that "by not including a distance factor, and if the sample was too limited geographically, there could have been positive values outside the sample frame" (p. 200). Therefore, the design of studies should consider the distance decay effect because WTP would decline as the distance between the household and the river increases.

In Mexico, stated preference methods have been applied to assess water resource services. Pérez Verdin *et al.* (2012) analyzed 13 cases where non-market valuation techniques were undertaken for various types of watershed services in Mexico (including Sanjurjo, 2004 and Lara-Dominguez *et al.*, 1998). The WTP obtained through non-market approach ranged from US$ 0.45 to 15.8 monthly per household, being Mexico City the case with the highest WTP. The main types of services provided by the watersheds were wildlife habitat, human consumption, and soil retention. Soto and Bateman (2006) used contingent valuation surveys to investigate WTP for two scenarios, one for maintenance and the other for the improvement of water supply provision levels in Mexico City. Results showed that for the maintenance scenario households' WTP ranged from 57 pesos bimonthly for low income households to 629 pesos for high income ones, while for the improvement scenario WTP ranged from 212 for low income to 424 pesos bimonthly for high income homes. Aviles-Polanco *et al.* (2010) used the CV method to estimate their WTP to maintain the water supply service in La Paz, Baja California. Here, results showed that households are willing to pay in average 132.7 pesos monthly to maintain or improve their service conditions.

Ojeda *et al.* (2008) studied overexploitation in a water-scarce region of the Yaqui River Delta in Sonora and found that households' WTP in Ciudad Obregon was 73 pesos monthly ($5.6 USD) to preserve riparian vegetation, wetlands, and estuaries; the habitat of birds and other fauna; to keep local fisheries; diluting pollutants; recreation; and other services associated with non-use values. Donoso (2009) analyzed the Apatlaco River area in Morelos, Mexico. He estimated 101 pesos monthly per household (7.78 USD) for a program offering wastewater treatment, improved solid waste management, the expansion and strengthening of municipal services, and strategic basin management. Ayala-Ortiz and Abarca-Guzman (2014) used the CV method to analyze the WTP to improve water quality in a section of the Lerma River, located in the metropolitan area of La Piedad in Michoacan and Santa Ana Pacueco in Guanajuato. They estimated that households' WTP in La Piedad is 50.4 pesos monthly, while in Santa Ana Pacueco is 43.7 pesos.

In the Alto Atoyac Basin, almost the same study area of this research, an analysis was undertaken to estimate the cost of water pollution based on market methods. Considering the effects on population (health, income, recreation, migration, and industry externalities) and economic activities (agriculture, tourism, and fishing), the total estimated cost reaches 483.3 million pesos for 2005; 65% of this cost is due to direct effects on population welfare, while the remaining 35 % is due to loses in economic activities (Rodríguez-Tapia *et al.*, 2012). These studies show positive results for the use of the contingent valuation method in the Mexican context and there is also evidence of economic costs for the Atoyac basin region.

Case study: The Alto Atoyac hydrological basin and project description

The majority of surface water bodies in Mexico receive untreated wastewater discharges from domestic, industrial, agricultural, and livestock sources. These have caused varying degrees of pollution and have limited the direct use of water resources. The National Water Commission (Conagua, Spanish acronym) monitors the quality of water resources through the National Network for Monitoring Water Quality (RNMCA, Spanish acronym). Conagua published the Water Quality Index (WQI) up to year 2000, with values on a scale from 0% to 100% (with greater WQI value indicating better water conditions), which was obtained from a weighted average of 18 individual quality parameters, including pH, BOD and suspended solids. According to Conagua, for the period from 1974 to 2000, the highest levels of pollution of surface water were in the Basins of Lerma, Alto Balsas, Bajo Bravo, and Alto Panuco. These are heavily polluted, making it difficult to use this resource directly for almost any activity. Recent publications confirm heavy pollution levels in these basins (Conagua, 2001).

Our case study focuses on the Alto Atoyac Basin, which belongs to the Balsas region, one of the four most polluted in the country. The Atoyac River and its streams cross the Metropolitan Area of Puebla-Tlaxcala, the fourth most important urban area in Mexico, with a population of 2.5 million inhabitants in 2005, most of whom (88%) live in the state of Puebla, the remaining population residing in the state of Tlaxcala (INEGI, 2005b) (Figure 1). The Alto Atoyac Basin comprises four sub-basins: Zahuapan, Atoyac, Alseseca, and the Valsequillo Dam. It covers an area of 4 011km^2 and the Atoyac River has a length of 113.7 km, of which 20 km belong to the neighboring State of Tlaxcala (Conagua *et al.*, 2007).

In most of this basin, infrastructure for treating wastewater is non-existent, and in some areas the water quality treatment level is below the acceptable standard set by the NOM-001-Semarnat-1996 (Semarnat, 1996). It is estimated that 70% of the total wastewater produced in the region is discharged by municipal sources and 30% by industry, the latter being regarded as being highly polluted (GEP, 2011). The consequences of failing to treat sewage include biodiversity loss, bad odor, reduction in agricultural yields, pollution through solid waste, and health problems among the population that live near the banks. Some local media highlight the health hazards linked to river pollution which includes cancer, leukemia, congenital hand and feet problems, cleft lip and the presence of high levels of lead in human blood (Rivas, 2009). Aquino-Moreno (2012) estimated the costs of gastrointestinal diseases caused by bacteria coliform contamination of rivers Atoyac and Zahuapan in the six municipalities of the region. Results show that when ill people are treated by the Seguro Popular (the national security system), the average cost of treatment per person is 463.3 pesos, but estimated through market prices the average cost of treatment per person is 958.8 pesos.

Although wastewater has been used for irrigation in the Valsequillo District, this water is not suitable for agricultural use due to the high concentration of dissolved heavy metals and other ions (Domínguez *et al.*, 2004; Rodríguez *et al.*, 2011). In various periods throughout the year, the amount of waterlilies in the Valsequillo Dam is a serious problem, contributing to the proliferation of mosquitoes and almost halving the dam's storage capacity (Conagua *et al.*, 2007). A broad study of the impact of river pollution was undertaken in 2005 by a group of researchers (Rodríguez and Morales, 2014). Rodrígez *et al.* (2014) estimated that river pollution generated an annual reduction in agriculture production of 2 464 tons; in fishing of 10.6 tons, in livestock of 8535 tons, while visits declined in 43 290 tourists. Regarding the direct effects on the population, 174 811 events of gastrointestinal diseases were estimated and a reduction of 2 612 066 leisure activities for inhabitants, also income reduction in 435 990 families in the region, as well as migration of 226 people.

Research Design

This study used the contingent valuation method, the goal being to obtain an estimate of the benefits of improvements in water flows in the Alto Atoyac Basin in Puebla, by eliciting willingness to pay (WTP) from the rural and urban residents for a project that included upgrading and installing a number of treatment plants and maintaining them, as well as other complementary activities, so that this estimate could then be used in a CBA.

Scenario and elicitation format

Economic valuation assumes that households' welfare will change as a result of specific changes on environmental quality, which is reflected through their WTP. Therefore, respondents should not only clearly understand what the changes will involve but also how large they will be (Bateman *et al.*, 2002). Based on this assumption, great care was taken by the group involved in this project to define and clearly explain the current situation and likely changes in river conditions on the project's completion. The prospect of improvements in water quality conditions were derived from the planned standard required by the Declaration of Classification of National Water Bodies (DOF, 2012).

The scenario referred to the improvement offered between an intermediate level of water quality as result of wastewater treatment by industries, to a higher level that can be obtained by installing treatment plants for municipal wastewater. Respondents were therefore informed that industries would be required to construct and manage their own wastewater facilities. The specific WTP scenario and question read to respondents was as follows:

> During the second stage of the project, the government of Puebla and Conagua will install treatment plants to clean households' wastewater. These actions would further improve Atoyac and Valsequillo Dam water quality as shown in these photographs (images were shown): the natural color of water would be restored; unpleasant odors would disappear; the quality of the vegetation would increase, which would attract birds and other life, such as wild ducks and quail; over time it would be possible to see other species of fish, such as carp, tilapia or chub. In addition, lilies would disappear from the dam, which would reduce the number of mosquitoes. Water quality of the river and dam would improve recreation. Water quality would be suitable for irrigation of all crops without posing a health risk and, the diseases caused by poor water quality would gradually decrease.
>
> To install and maintain treatment plants at this stage of the project, each family in Puebla State shall pay an amount that would be permanently charged on their water bill, which will be used exclusively for this project. Those families not receiving water bills would be invoiced through the electricity bill.
>
> Given that the industries had already been cleaning their waters, and considering the income and expenses of your family, if the installation and maintenance plants to treat households' drainage cost your family X pesos every two months, would you

vote in favor of this project that offers to improve the water quality of the rivers and dam?

As observed, the information provided indicated the positive impacts of all the changes. Examples were given of the benefits that would be obtained from the various stages of the project, while color pictures were used to help with visualization and to contrast the different situations. Given the nature of the water bodies involved, no attempt was made to separate total economic value into use and non-use values categories (e.g. recreation vs legacy, or existence values), because current pollution conditions require a broader picture of the expected situation (Berrens *et al.*, 1998). However, it was expected that there would be a significant component of non-use values.

In keeping with the best practice guidelines, this scenario and a draft questionnaire was presented in focus groups with local residents from rural and urban areas to determine whether the information was clear and comprehensive, given the differences among the population living in the region. Three focus groups were conducted, the first with participants from towns in the rural area upstream of the Atoyac River; the second with participants from the city of Puebla, and the third with participants living around the Valsequillo Dam area. We noticed concern among most of the participants, but residents near the Valsequillo showed more distress due to bad odor problems, excess mosquitoes, and fear about the pollution of water sources for human consumption and health-related problems among children and people living in the vicinity.

The WTP elicitation format selected was a single bound dichotomous choice (DC) bid, where respondents are asked whether or not they would be willing to pay a set price; followed by one follow-up question (half of the first price offered) for respondents who rejected the first price proposed (DeShazo, 2002) and an open-ended question eliciting maximum WTP (Arrow *et al.*, 1993). The range of prices was first defined with the information obtained from the focus groups and subsequently confirmed using the results of the pilot survey. Bid amounts ranged from 30 to 500 pesos bimonthly and were randomly offered among the sample of surveyed households. These five bid levels used a roughly logarithmic distribution, with each respondent being randomly allocated to a single bid amount (Bateman *et al.*,1995).

Sample Design and Selection

The population for the study included all homes in the 138 towns located within the Alto Atoyac Basin, who would directly benefit from the treatment plants. According to the data collected by the National Population and Housing Census, 2.1 million inhabitants lived in the area, in 495 627 households (INEGI, 2005a). To select a sample from the population, a probabilistic stratified random sampling strategy was developed with a three-stage selection process. The 138 villages were organized into five strata according to population size. Table 1 summarizes the demographic structure, 80% of households are concentrated in seven large localities (5% of the total localities), while only 1% of households are located in 77 small towns.

In the first stage, a number of towns were selected to obtain a statistical sample in proportion to the number of households within the strata based on population size. In the second selection stage, a number of units known as Basic Geo-statistical Areas (Áreas Geográfico Estadísticas Básicas AGEB, Spanish Acronym) were selected from towns with a population of more than 2 500 inhabitants. The third stage was a simple random sampling of those households pertaining to the chosen AGEBs. Table 2 shows the number of interviews defined based on this procedure, with a total sample of 1 220 households, with a confidence level of 95% (see figure 2).

To assess the impact of the distance effect, this variable was calculated in meters/ kilometers from the nearest point of the riverside for each specific town selected. In the city of Puebla, by far the largest town in the Basin, the distance from the selected area (AGEB) to the river bank was calculated (see figure 3). The distance from AGEBs and towns to the river ranged from 0 to 18.89 kilometers.

The level of pollution across the river was also considered, because water quality changes from upstream to downstream might affect people's perception of the environmental benefit. The course of the Atoyac River was divided into four sections, taking into account pollution criteria. Thus, a variable was created linking each selected town, or AGEB, to one of these four sections of the river pollution levels.

Questionnaire Structure and Fieldwork

The questionnaire was divided into four sections. The first was used to introduce the issue by assessing the perception of environmental problems in Puebla and water pollution problem in the rivers. The second section assessed respondents' contact with the area; as well as perceptions regarding the causes of river contamination and its possible consequences. The third provided information on the pollution problem in the water flows, followed by the valuation scenario, the WTP elicitation question, and the follow-up questions. Lastly, questions were included to elicit information on household demographics, respondents' employment, and their income profiles. Table 3 presents the main survey question topics.

In line with best practice guidelines, face-to-face interviews were selected as the interview method (Arrow *et al.*, 1993). The head of the house was selected as the respondent or, when he/she was not at home after several visits, his/her spouse. This criterion was selected because when they hypothetically pledge to pay, they might possess a broader sensitivity and knowledge of the economic capacity of their homes, and can better analyze their response when evaluating the proposal based on their income and expenditure (Whittington, 1998).

Payment method was another concern, given that a significant proportion of the population lives in rural or semi-urban areas, where water bills are not necessarily received, as we confirmed in the focus group interviews. In order to increase the credibility of the scenario it was decided to frame the charged amount as an invoice via either water or electricity bill, since the latter is invoiced virtually to all households.

The interviewers were full-time professionals with extensive experience in conducting surveys. A training session was undertaken to explain the objective of the study, the characteristics of the questionnaire, the mobility and distribution in the field, and the selection criteria for households and respondents, among other logistic aspects. A guide explaining all the relevant aspects of the fieldwork was given to each interviewer.

After this training session, a pilot test was conducted, with 60 questionnaires. Findings suggested that the range of bid levels should obtain virtually unanimous acceptance or rejection at either end of the bid spectrum, while remaining within the constraints of credibility (Herriges and Shogren, 1996). The final survey was conducted in September 2009. During the fieldwork, state government officials were particularly helpful with the process of obtaining access to those areas where some form of resistance to the survey application was initially encountered, mainly in high- income areas. The information obtained from the survey was analyzed through statistical and econometric methods, using the SPSS program.

CV survey results

There were 1 220 complete responses from a total of 2 832 households visited. Data were processed with the expansion factors for the number of households projected for 2010 for the study area.

Survey responses confirmed that respondents are aware of and concerned about the river and dam pollution problem. First, the water supply and sewage services were mentioned in the survey as the third most important problem at the state level, just after public security and unemployment. These services are indirectly related to the research topic since they refer to water availability and quality. Pollution in the Atoyac River, its effluent, and the Valsequillo dam were consistently mentioned as the second most important environmental concern, preceded only by inappropriate solid waste management.

Regarding perceptions, most respondents readily indentified the water courses but said that they lived far away from them or did not go through the area where they are located. A total of 62% mentioned that their place of residence was far from the rivers and dam, while the remaining 38% reported that they lived near the Atoyac, another river or the Valsequillo dam. The perception corresponded with the estimated distance from the households to the Atoyac River, since more people responded that they lived near the river when the estimated distance in kilometers was in fact shorter (significant correlation at the 99% confidence).

Consistent with the rise of pollution during the last decade, respondents' perceptions of being users of the river for specific activities has changed since 1990. Thus, activities such as using water for domestic use fell from 11.6% before 1990 to 5.7% at the present. For recreational use, it fell from 7.9% before 1990 to 1.3%, while for discharging wastewater it increased from 8.7% to 11%. Overall, the number of respondents who reported being users fell from 26.8% before 1990 to 18.9% in the present, while an increase was registered for wastewater discharge (see figure 4).

Regarding the perception of the pollution level of these water bodies, most of the respondents (over 90%) considered that water quality was either poor or very poor. When asked about the main causes of water pollution, the most frequently mentioned sources were wastewater discharge and rubbish disposal by industries and households. Respondents were worried about the impact of water pollution, particularly regarding health problems (27%), unpleasant smells (22%), and the creation of invasive fauna (17%) (see figure 5).

As noted earlier, respondents mentioned the discharge of industrial wastewater as the main source of water body pollution. Thus, an important issue was the interviewees' belief in to the government's ability to oblige industries to treat their wastewater as the preliminary phase for achieving the ecological restoration project. This is a real concern because the government has turned a blind eye towards the pollution of rivers and other resources as a means of promoting local investment across the country. In this case, 82% of the respondents declared that it was fully possible, possible or partly possible for the government to be able to force industry to treat its wastewater. This relatively high credibility is a good sign because it shows that people in Puebla trust the government to solve the problem. It would be interesting to contrast this level of credibility with other regions in the country. Socio-economic and demographic information on the population sample is also given in table 4.

Data Analysis

Theoretical validation of the WTP responses was undertaken through the estimation of a probit model, relating positive responses to bid amounts and a spectrum of variables derived from economic theory and empirical regularities observed in the literature. The yes/no answer to the DC format question was used as the dependent variable. Table 5 presents the number and percentage of "yes" responses for each bid amount. As expected, WTP diminishes as the suggested price rises, and there is a significant relationship between the suggested price and the decision to pay it (chi-square sig. 0.0001). Considering the two follow-up questions, 73.2% mentioned that they would be willing to pay something for the program, 21% declared they would not pay anything, and 4.4% said they did not know whether they would pay.

WTP results and the probit regression model

Due to the binary nature of our response data, we adopted a probit modeling approach using maximum likelihood techniques, which, as can be seen from the literature review, is a common method for estimating households' WTP (Barrens, *et al.*, 1998; Holmes, *et al.*, 2004). The probit coefficients were transformed into WTP coefficients using Cameron's method (1988). Cameron shows how the variation in bid amounts allows researchers to rescale the probit equation by dividing the constant term and all the coefficients in the model (other than the bid amount) by the absolute value of the coefficient in the bid amount variable. This makes it possible to interpret coefficients with ordinary least squares and estimate the WTP for each observation (Pate and Loomis, 1997).

Table 6 presents the descriptive statistics for the variables analyzed. The dependent variable was the DC WTP variable and the explanatory variables explored included bid amount, household income, distance from the Atoyac river or the Valsequillo Dam, section of the river defined by pollution level, size of town, contact with the river; and various socioeconomic characteristics including education, gender, age, presence of children, legal status of the property, and town of residence. The distance variable was introduced through an inverse exponential function (*fdx*= 1/1+ exp {*d*-3/0.5}), which more effectively showed how distance has a much greater effect in the area closer to the river but decreases rapidly after a certain distance (see table 6). Negative and "don't know" responses were combined to yield conservative estimates of measures of welfare.

Every independent variable was subjected to analysis and retained when the significance level was 0.05 or lower. To save space, only the model with significant independent variables is presented in table 7 with the estimated coefficients and t-statistics. The model shows the expected relationships with explanatory variables, including consistent signs on coefficients throughout, and the particular effects of certain towns. The significant variables are suggested price (p<0.001), household income (p<0.001), the inverse exponential function of distance to the river (p= 0.018), having contact with water bodies during the present year (p= 0.018), age of respondent (p= 0.012), living in San Pedro Cholula (p= 0.002), and living in Amozoc (p= 0.001). The model has a level of adjustment (Pearson goodness-of-fit chi-square) of 0.365 and the regression included 1 061 out of a total of 1 220 cases.

As expected, the probability of an affirmative response declines as the suggested price rises. WTP also increases with household income. Distance from the river reduces the probability —yet given the inverse exponential function of this variable— a positive sign means that distance has a much greater effect on the area closer to the river. As expected, the 'closeness with the river' variable increases the probability of an affirmative response, meaning that people in direct contact are willing to pay more than those who are not. Increasing age has a negative effect, which is consistent with other studies on water conservation programs (Pate and Loomis, 1997; Soto and Bateman, 2006). Although we did not have prior expectations regarding the preferences of towns included in the sample, living in San Pedro Cholula town diminished the probability of paying, whereas living in Amozoc increased the probability of an affirmative response. San Pedro Cholula is located about 6.7 km from the Atoyac River, by the river area with high water pollution and very near to the city of Puebla. According to the WTP responses, people oppose paying to solve river water problems because they consider that the government or industries should be responsible for full payment of the restoration program. Conversely, respondents in Amozoc, located at 18.8 km, often expressed interest in solving the water pollution problem in the region despite not living close to the area.

One of our hypotheses was linked to the possible effect of the water quality variable on the probability of an affirmative response. However, none of the dummy water quality variables was significant. The distance variable rather than water quality has a greater impact on WTP.

The probit coefficients in table 8 were transformed into WTP coefficients using the Cameron (1988) approach, by dividing the constant term and all the coefficients in the model, except the bid amount, by the absolute value of the coefficient on the bid amount variable. The resulting expression for the WTP function was:

Yes WTP = ((-353.47) + (73.38*logarithm_Income) + (71.61*distance (inv_exp) + (70.66*contact with river or dam) - (2.08*age) - (134.62*San Pedro Cholula) + (188.52* Amozoc))

The mean value was calculated using the distribution of the simulated WTP estimates of the previous function. Table 8 presents a summary of the findings. The estimated mean WTP per household was 186.8 pesos bimonthly, with a 95% confidence interval of between 186.6 and 186.2 pesos. The median is 188.6 pesos bimonthly, almost equal to the mean. This amount represents an average of 3.3% of household income.

Once WTP was estimated for every observation with the Cameron method (1998), data were disaggregated to obtain further information from the sampled population. Considering the distance variable, a key theoretical variable, households living less than 4 km from the river or dam have a mean WTP of 248 pesos bimonthly, while those living farther away have a mean WTP of 168 pesos bimonthly, 32% lower than the former. This demonstrates a clear distance decay effect and confirms that residents living in close proximity perceive greater benefits from the proposed project than those living further away.

The mean WTP in our study, equivalent to 93.3 pesos monthly per household (186.6 pesos bimonthly) is between the estimates of the other two studies for restoring river ecosystems in Mexico, the 73 pesos per month for ecosystem services in the Yaqui River reported by Ojeda *et al.* (2008) and the 101 pesos per month reported by Donoso (2009) for a restoration program in the Apatlaco River, but higher than 43-50 pesos per month to restore a section of the Lerma River (Ayala-Ortiz and Abarca-Guzman, 2014). However, the estimated values of the Lerma study might be influenced by the elicitation format which initiated with an initial price of 5 pesos, followed by an open-ended question and which might have induced strategic bias (Bateman *et al.* 1995).

We should remember that in the 15 studies carried out in various Latin American countries, average WTP was $69 dollars annually for various improvements, the highest being in Peru with $160.5. In the Atoyac River, annual payment of 1 242 pesos, equivalent to $107 dollars, is within this range. However, as described above, these studies evaluated different improvements, some associated with domestic and industrial pollution, others with agricultural activities and environmental services improvements, meaning that they are not really comparable.

Households' WTP Aggregation and CBA

As discussed earlier, there is some concern with aggregation of studies assessing water quality improvements of surface water bodies using mean WTP since this might lead to miscalculating total benefits. WTP values are expected to decline with increasing distance from the site, but when the sample does not represent the entire population, and mean values are used from a subset area, the direct aggregation could be inaccurate. However, since we designed a random sample from the entire population that would benefit in this study, the estimated mean WTP considers the decline in benefits associated with distance.

Mean WTP per household was multiplied by the number of households in the population (544 019), yielding an aggregated WTP of 609.7 million pesos annually (see table 10). These aggregated benefits were used for the CBA, in addition to other benefits for agricultural production, estimated by another group of specialists. Although we do not give the figures of the CBA here because information other than the estimated WTP was considered by a different team, aggregate benefits would exceed the cost by a sufficient margin to undertake the proposed project. Thus, from an economic perspective, the proposal to restore this hydrological basin is justified because public benefits would exceed the cost of installing and maintaining the required treatment infrastructure.

As mentioned before, Rodríguez-Tapia *et al.* (2012) estimated a total cost of 483.3 million pesos for 2005 due to the effects of the Atoyac River pollution derived from health impacts, household income reduction, lost of recreation, migration, industry externalities; and economic activities in agriculture, tourism, and fishing. The estimated costs did not included environmental costs, such as biodiversity loss, aesthetic or bad odor. Comparing the 483.3 million pesos —estimated by Rodríguez *et al.* (2012)— with the 609.7 million pesos estimated in this study, we confirm that restoration has a great value to the affected population, and that when environmental benefits are included, the amount increases substantially.

Discussion and conclusions

Mexico, like other developing countries, has extensive water pollution in many of its water resources. In this study, we analyzed the case of the Alto Atoyac Basin, one of the most heavily polluted basins in the country, which the government has expressed an interest in restoring. To estimate the benefits, a Contingent Valuation Survey was undertaken to determine households' WTP for a project to install and update a number of treatment plants to improve water quality. Survey results confirmed that people are both concerned and familiarized with the water pollution problem in the area, including its consequences. Households' estimated mean WTP is 186 pesos bimonthly, totaling to 1 120.8 pesos annually (equivalent to $87 US dollars) and accounts for 3.3% of household income. This figure is within the range of WTP estimated in other countries with similar conditions.

WTP was found to be determined by the following variables: bid amount, income, distance, age, contact with rivers, and the contrasts between San Pedro Cholula and Amozoc towns. In particular, distance plays an important role in the determination of WTP and it was confirmed that households living near the rivers and the dam are willing to pay up to 32% more than others living further away. Overall, significant variables such as bid amount, income, closeness with the river and distance provide a validity criterion consistent with theoretical debates.

As mentioned above, the project was the first to use contingent valuation methodology to justify public investment and some concern was expressed by federal authorities regarding the feasibility of obtaining a consistent, positive result for a CBA. The benefits far exceeded the cost of the project. Thus, from an economic efficiency perspective, the project to restore this basin is justified because the public benefits would offset the cost of installing the required treatment infrastructure.

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Tables

Table 1. Population and number of households considered in the Alto Atoyac project, classified by size of locality

	Strata by population size	*Population 2005*	*Number of households 2005*	*% of households*	*Number of localities*	*% of localities*
1	More than 50 000	1 594 177	395 954	79.9%	7	5
2	From 10 001 to 50 000	272 793	59 080	11.9%	14	10
3	From 5 001 to 10 000	122 037	24 087	4.9%	17	12
4	From 1 001 to 5 000	61 265	12 794	2.6%	23	17
5	Up to 1 000	17 461	3 713	0.7%	77	56
	Total	*2 067 733*	*495 628*	*100%*	*138*	*100*

SOURCE: Composed with information of National Population and Housing Census (INEGI, 2005a).

Table 2. Final sample localities, number of AGEBs, and number of interviews

Strata	*Range of population by locality strata size*	*Number of locali-ties in sample*	*AGEBS Number by locality*	*Interviews by AGEB*	*Interviews by locality*	*Total interviews by strata*	*% of interviews by strata*
1	More than 50 000	7	10	10	100	700	57.4%
2	From 10 001 to 50 000	6	3	10	30	180	14.8%
3	From 5 001 to 10 000	6	3	10	30	180	14.8%
4	From 1 001 to 5 000	4	2	10	20	80	6.5%
5	Up to 1 000	4	*	*	20	80	6.5%
Total		*27*	*112**			*1,220*	*100.0%*

SOURCE: Produced with data from INEGI (2005a).

Table 3. Survey question topics to assess households' WTP for restoration of the Alto Atoyac Basin

Question topic	**Possible Answer**
Section I. Perception of environmental problems in Puebla	
The three most serious problems in Puebla	1) Water supply service; 2) Sewerage service; 3) Environmental problems ; 4) Public lighting; 5) Public Security; 6) Unemployment; 7) Education; 8) Health services; 9) Other
The three most serious environmental problems in Puebla	1) Air pollution; 2) Rubbish collection; 3) River pollution; 4) Deforestation; 5) Loss of green areas; 6) Excess mosquitoes; 7) Other
Section II. Perception about contact with the river area, causes, and consequences of river contamination	
Perception of place of residence	1) Near the Atoyac River; 2) Near the Valsequillo Dam; 3) Near another river; 4) Not close to the area
Passing by a river or a dam to perform daily activities or get to work	1) On the way to work; 2) On the way to daily activities; 3) Does not go through the area
Perception of the place of residence before 1990	1) Near the Atoyac River; 2) Near the Valsequillo Dam; 3) Near another river; 4) Not close to the area; 5) Does not know
Activities using the rivers or dam (open question)	1) Use of water for domestic activities; 2) Use of water for cattle; 3) Irrigation; 4) Fishing; 5) Commercial purposes; 6) Recreation; 7) Drainage disposal, 8) Rubbish disposal; 9) Other Recoded as: 1= direct contact due to any activity 0= there is no direct contact
Activities using the rivers or dam before 1990 (open question)	1) For domestic activities; 2) For cattle; 3) Irrigation; 4) Fishing; 5) Commercial purposes; 6) Recreation; 7) Drainage disposal, 8) Rubbish disposal; 9) Other
Level of concern from 0 to 4 on current water quality of the rivers or dam	1) Not worried to 5) very worried
The three most important factors that contribute to the rivers and dam pollution	1) Household drainage disposal; 2) Industrial wastewater disposal; 3) Rubbish disposal; 4)Laundry; 5) Agriculture; 6) Washing animals; 7) Other
The three most serious effects of water pollution of the rivers and dam	1) Health problems; 2) Bad odor; 3) Creation of invasive fauna; 4) Harms fauna and vegetation; 5) Decrease of aquatic life; 6) Harms recreational activities; 7) Harms businesses; 8) Harms tourism; 9) Harms agriculture; 10) Pollution of wells and aquifers; 11) Creation of invasive flora

Knowledge of water pollution problems	1) Yes; 2) No
Section III. WTP *section*	
Is the household willing to pay X pesos every two months for a program to clean household drainage and improve the water quality of the rivers and dam?	1)Yes; 2) No
Is the household willing to pay X/2 pesos every two months for the program?	1)Yes; 2) No
Maximum amount willing to pay for the program	
Reasons why the respondent is willing to pay (open question)	1) Improve people's health; 2) Better conditions for children; 3) Quality of life; 4) Improve water quality; 5) Collaborate with the project; 6) Elimination of bad odor; 7) Because everyone would pay; 8) Price is reasonable; 9) Everybody is responsible; 10) Future generations; 11) Improve economic activity; 12) Improve the water supply service; 12) Other
Reasons why the respondent would not pay (open question)	1) Cannot afford to pay; 2) Already pays taxes; 3) Pollution does not affect them; 4) Industry should be fully responsible; 5) Distrust of authorities; 6) Does not believe that the government will make industry clean their wastewater; 7) Needs more information; 8) Other
Level of confidence on a scale of 0 to 4 of the government's ability to make the industrial sector clean its wastewater	1) Not confidence at all; 5) Very confident
Section IV. Socio-economic and demographic information	
Gender	1) Male; 2) Female
Marital Status	1) Single; 2) Married; 3) Divorced 4) Widowed
Education	1) None; 2) Elementary; 3) Middle School; 4) High School; 5) Undergraduate; 6) Postgraduate
Occupation	1) Employee; 2) Self-employed; 3) Homemaker; 4) Student; 5) Retired; 6) Unemployed; 7) Permanently disabled; 8) Other
Sector of employment	1) Agriculture; 2) Livestock; 3) Mining; 4) Industry; 5) Construction; 6) Trade; 7) Services; 8) Education
Income (pesos)	1) Up to $ 1 500; 2) $1 501 - $3 000; 3) $3 001 - $6 000; 4) $6 001 - $9 000; 5) $9 001 - $15 000; 6) $15 001 - $30 000; 7) More than $30 000; 8) Does not know; 9) No answer
Is the respondent the head of the household?	1) Yes; 2) No
Age of head of household	

Gender of head of household	1) Male 2) Female
Number of children under 12.	
Length of residence	
Legal status of property	1) Home owner; 2) Rents; 3) Borrowed or other situation
Receives water bill	1) Yes; 2) No
Receives electricity bill	1) Yes; 2) No
Suggested price (pesos)	30, 70, 180, 330, 500
Income (income logarithm /pesos)	\$1 500, \$2 250, \$4 500, \$7 500, \$12 000, \$22 500, \$30 000
Imputed variables	
Distance function	0 km up to 18.9 km Function: *fdx*) 1/1+ *exp* {*d*-3/0.5}
Section of river by pollution criteria	1) 0-17km, 0) other 1) 17.1 - 37 km, 0) other 1) 37.1 - 65 km, 0) other 1) 65.1 - 85 km, 0) other
Size of town	1) above 50 000 inhabitants; 1) 10 000 to 50 000 inhabitants; 1) 5 000 to 10 000 inhabitants; 1) 1 000 to 5 000 inhabitants; 1) Below 1 000.
Municipality	1) for every municipality in the sample

Table 4. Socioeconomic and demographic information of the sampled population

Mean Age (years)	*45*
Gender	Female= 59%
Marital Status	Married= 78% Single= 12% Divorced= 10%
Education	None= 8% Elementary= 38% Middle School= 24% High School= 16% Graduate and Postgraduate= 14%
Occupation*	Employee= 26% Self-employed= 25% Homemaker= 40% Retired= 6% Other= 4%
Sector of employment*	Trade= 37% Services= 30% Construction= 11% Industry= 10% Agriculture & Livestock= 8% Education= 4%

Income	Up to $ 1,500= 25% $1 501 - $3 000= 37% $3 001 - $6 000= 27% $6 001 - $9 000= 8% More than $9 000= 4%
Is the respondent the head of the household?	Yes= 63%
Households with children under the age of 12.	57%
Average time of residence (years)	19
Legal status of property	Home owner= 81%
Receives water bill	Yes= 68%
Receives electricity bill	Yes= 97%

* Due to rounding, percentages may not appear to add up to 100%.

Table 5. Responses to each bid amount

Bid (pesos bimonthly)	*30*	*70*	*180*	*330*	*500*	*Total*
Yes	184	141	110	62	46	543
No	56	99	125	172	189	641
Does not know	4	4	9	10	9	36
% Yes	34	26	20	12	8	1220

Table 6. Descriptive statistics for selected variables

Variable	*Description*	*Mean*	*S.E.*
Dependent variable			
WTP	Willing to pay X pesos every two months for a program to clean household drainage and improve the water quality of rivers and dam (1= YES, 0= NO)	0.46	0.49
Independent variables			
Price	Bid amount for DC valuation question (30, 70, 180, 330, 500)	222	173.59
dis_rio	Calculated distance to the river	5.65	5.80
Distance function	0 km up to 18.9 km Function: *fdx*= 1/1+ *exp* {*d*-3/0.5}	0.42	0.45
P8_river use	Any activity using the rivers or dam (domestic activities, for cattle, irrigation, fishing, commercial purposes, recreation, drainage disposal, rubbish disposal)= 1	0.18	0.38
Lningres	Mid points of the household income categories $1 500, $2 250, $4 500, $7 500, $12 000, $22 500, $30 000 (logarithm /pesos)	7.98	0.61
sd1_age	Age in years	45.38	14.71
Gender	Female=1	0.59	0.49
sd14_education	Education level. 1) None; 2) Elementary; 3) Middle	3.33	1.52

	School; 4) High School; 5) Undergraduate; 6) Post-graduate		
Niñoschild	Children under 12	0.57	0.49
Property	Home owner	0.74	0.43
Estrata1	More than 50 000 inhabitants	0.79	0.40
Estrata2	Between 10 000 and 50 000 inhab.	0.12	0.33
Estrata3	From 5 000 to 10 000 inhab.	0.04	0.21
Estrata4	From 1 000 to 5 000 inhab.	0.02	0.15
Section1	Km 0.0-17.0 Km - medium-high level of pollution=1	0.26	0.43
Section3	Km 37.1 - 65.0 Km - maximum level of pollution= 1	0.09	0.28
Section4	Km 65.1 - 85.0 Km - lowest level of pollution= 1	0.14	0.34
MUN015	Amozoc	0.11	0.31
MUN034	Coronango	0.03	0.16
MUN041	Cucutlancingo	0.02	0.15
MUN060	Domingo Arenas	0.01	0.09
MUN074	Huejotzingo	0.03	0.16
MUN114	Puebla	0.50	0.50
MUN119	San Andrés Cholula	0.02	0.14
MUN122	San Felipe Teotlalcingo	0.00	0.04
MUN132	San Martín Texmelucan	0.12	0.32
MUN134	San Matías Tlalancaleca	0.01	0.09
MUN136	San Mihuel Xoxtla	0.02	0.14
MUN140	San Pedro Cholula	0.12	0.32
MUN180	Tlahuapan	0.01	0.09

Table 7. Probit regression model of WTP for restoration project of the Alto Atoyac Basin

Variable	*Co-efficient*	*Z*	*Sig.*
Price	-0.003	-13.523	.001***
Logarithm_INCOME	0.255	3.545	.001***
Contact with rivers or dam	0.245	2.372	.018**
Age	-0.007	-2.505	.012**
Distance (inv_exp)	0.249	2.360	.018**

San Pedro Cholula town	-0.468	-3.113	0.002**
Amozoc town	0.655	3.987	0.001***
Constant Chi square sig 0.161	-1.227	-2.077	.038**

** Significant at the 0.05 level.
*** Significant at the 0.01 level.

Table 8. Estimated measures for households' WTP

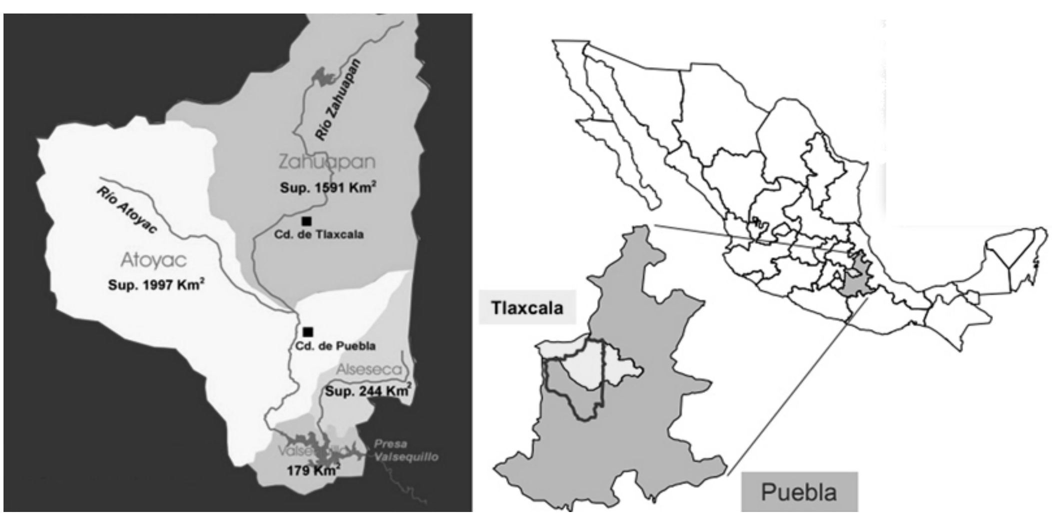
	Results
Estimated mean WTP (pesos/bimonthly)	186.8
Median WTP (pesos/bimonthly)	188.6
Standard deviation WTP (pesos/bimonthly)	107.3
Percentage of income households is willing to pay (%)	3.3%

Table 9. Annual benefits per household and aggregated benefits

Annual WTP per household (pesos)	1,120.8
Number of households in the basin	544,019
Aggregated annual WTP (million pesos)	609.7

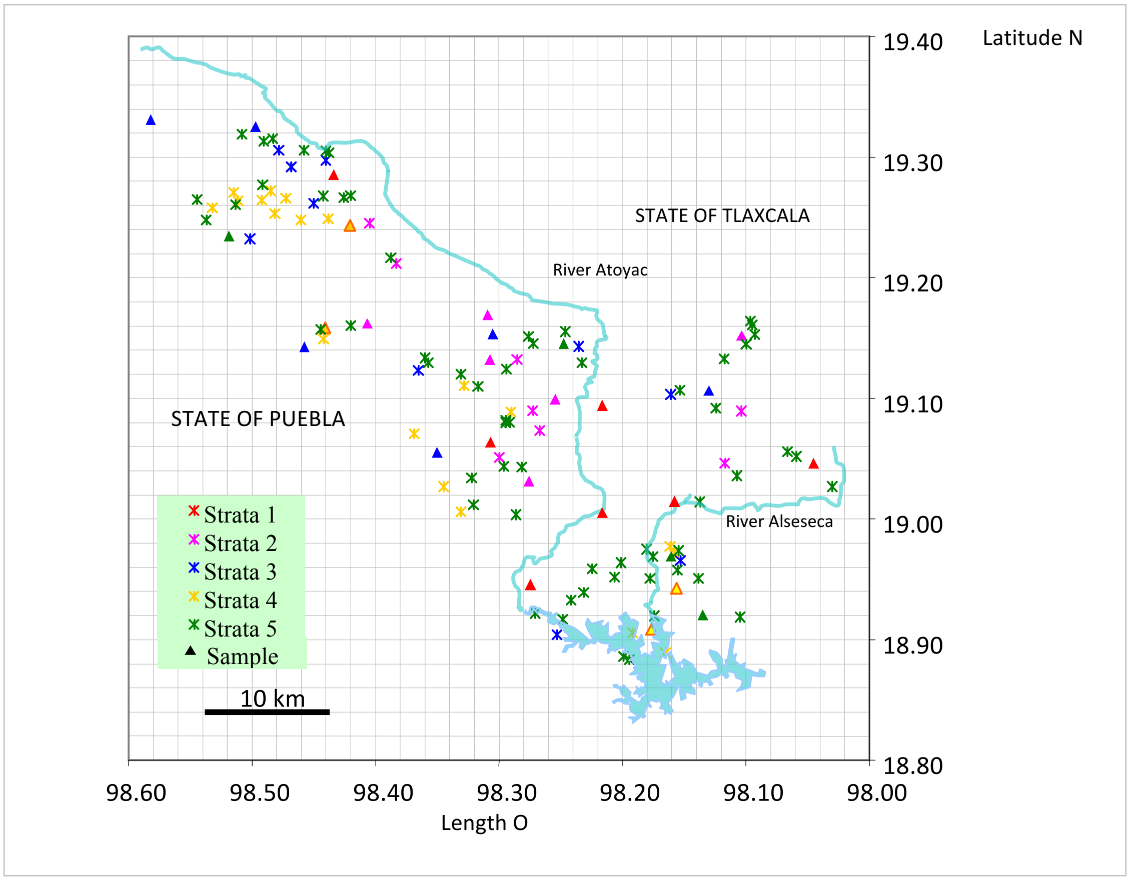
Figures

Figure 1. Location of the Alto Atoyac Basin



SOURCE: Conagua (2011).

Figure 2. Total number of localities by strata and those included in the sample



SOURCE: Produced with data from table 2.

Figure 3. Example of estimation of distance from selected town to the river

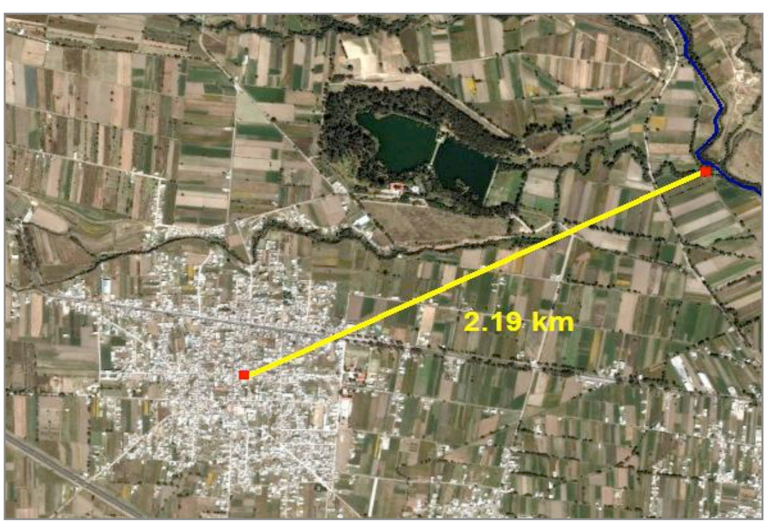


Figure 4. Activities using the rivers or Valsequillo Dam

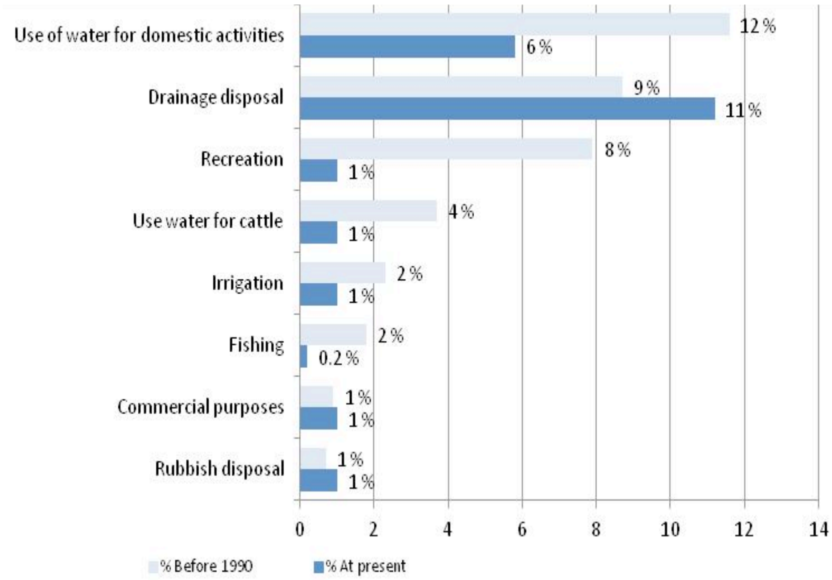


Figure 5. The most serious effects of the water pollution of the rivers and dam