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Water reuse for irrigation as part of the wastewater management for the sanitation of the Atoyac River Basin, Mexico: an alternative from a hydraulic point of view

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Introduction

Despite efforts to recover quality in rivers and other water bodies, the situation today is that sanitation and wastewater management are issues that are not addressed completely due to the lack of political prioritisation that can be translated into poor governance and inadequate operation and maintenance (O&M). But also there are cultural barriers that impact at different levels: local, regional and tras-basins.

Stream Restoration means *improve hydrologic, geomorphic, and ecological processes in a degraded watershed system and replacing lost, damaged, or compromised elements of the natural system*" (Wohl et al. 2005; Kauffman 1997; Palmer 2005; Roni et al. 2002).

Aim

This paper presents an option to mitigate pollution as result of untreated wastewater disposal into water bodies as rivers or streams associated to the localities where they come from. The study case considered four communities with more than 1000 but less than 10,000 inhabitants, within the Atoyac River Basin, looking at the wastewater as a commodity

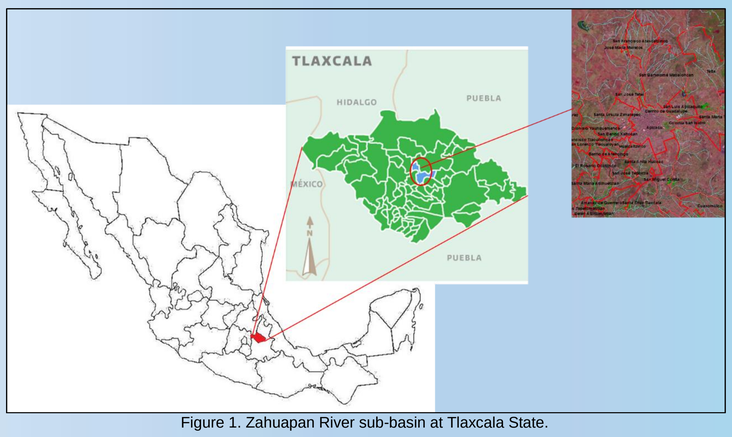

Figure 1. Zahuapan River sub-basin at Tlaxcala State.

Study area

CONAGUA declared that the Atoyac River belongs to the Nation, thus, they need to be recovered (protected, improved, conserved or restored). Moreover, that it has suffered a quality deterioration as result of the final wastewater disposal coming several point and nonpoint contamination sources (DOF, 2011).

The localities analysed are allocated at the micro-basin of the Atenco River that belongs to the Zahuapan River sub-basin at the Upper Atoyac River Basin in the state of Tlaxcala (Figure 1). The Zahuapan River sub-basin has been subject to an important increment of the population as result of the demographic dynamics associated to the growth rate of birth, but also to the industrialisation.

Water uses at the sub-basin are mainly for agriculture, then for urban, rural and livestock and finally for the industry. The main source of wastewater are linking to textile industry and urban and rural settlements.

Figure 2. localities studied: SB matlalohcan, San Luis Apizaquito, Cerrito de Guadalupe and Colonia San Isidro. Neighbourhood density, brown circles are sewage discharge (to the river and ravines), and DEM (contour lines)

Tlaxcala had 57 treatment plants functioning being Tlaxcala and Apizaco cities those with a major treatment capacity installed.

Only 0.25% of these facilities correspond to a proper wastewater secondary treatment, since not all of them operate according to their designed capacity and quality.

The rest of the facilities have a primary treatment corresponding mainly to septic tanks.

Important improvements need to be done in order to treat a major wastewater quantity and produce a desire quality for human direct and indirect use or for water bodies

Table 1. Water quality parameters to be regulated to cope with legislation (NOM-001-SEMARNAT-1996, Right Federal law) on 2020

Physic and Chemical	Toxic and mycrobiology and toxicity	
Temperature**	Arsenic*	Faecal Coliforms**
pH**	Cadmium*	Helminth eggs**
Floating matter**	Cupper*	Acute toxicity
Sediment solids**	Chromium**	Chloroform
Total suspended solids**	Mercury*	Vinyl Chloride
Biochemical Oxygen Demand (5 days)**	Nickel*	1,2 Dichlorobenzene
Total Nitrogen**	Lead**	1,3-Dichlorobenzene
Total Phosphorus**	Zinc*	1,4-Dichlorobenzene
Fats and oils**	Cyanides*	1,2 Dichloroethane
Substances Active to Methylene Blue	Ammoniacal Nitrogen*	Tetrachlorethylene
Sulphates*	Phenols	Bis 2 (ethyl hexyl) phthalate
Total dissolved solids**	Iron*	Diethylphthalate
Electric Conductivity	Benzene	Nitrobenzene
Chlorides*	Toluene	
Colour	Ethylbenzene	
Chemical Oxygen Demand*	Xylenes	
	Sulphide*	
	Aluminium	
	Methyl Chloride	
	Methyl Chloride	

** to be removed in a first step; * to be removed in second step, the rest to be removed in a third step. Source: DOF, 2011

Methodology

The proposal considers

- *the improvement or change of the sewage network system, and*
- *to implement a hydraulic sanitisation system focused in the reuse of the treated wastewater*.

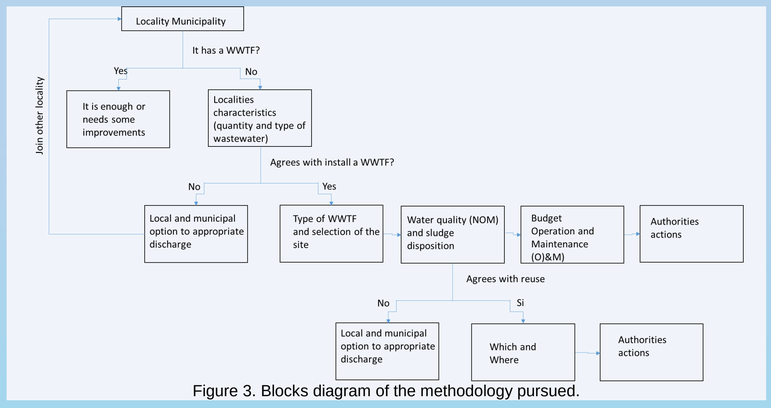

Figure 3. Blocks diagram of the methodology pursued.

The ***hydraulic analysis*** considered a susceptibility to be inundated these parts of the Atenco River.

The ***hydrologist analysis*** considered the conversion of rainfall into runoff in order to obtain the maximum flows expected for different return periods.

Data used involves satellite imagery and information such as national digital maps, thematic aspects (vegetation, soils) (INEGI, 1999b and c) and population and its growing rate (INEGI, 2005), drainage network maps (this information was not available) and wastewater quality. The growing rate it is important in order to project number of inhabitants expected in 25 and 50 years (INEGI, 2011).

Results

At the moment of this paper, the coverage of the sewage drainage at the four localities is 99%, and although there is not a confirmation that the drainage is divided between pluvial and municipal, one considered a combined drainage.

The possible solution for each locality as function of the population and urban density, topography and micro-basin hydrology is:

SB Matlalohcan

Two main collectors will be built from North to South, one at each side of the highway, and conveyed the wastewater to a WWTF (Wastewater Treatment Facilities) that could be allocated down to the 10 de Mayo town, where is the discharge (circle brown) 01-D1, at the right side of the highway (Fig 4).

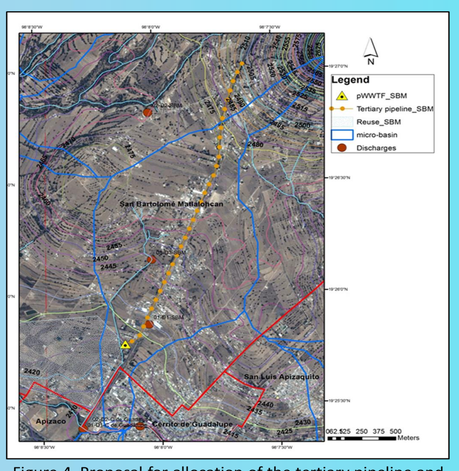

Figure 4. Proposal for allocation of the tertiary pipeline and WWTF and site for reuse in order to mitigate river pollution coming from SB Matlalohcan.

A secondary treatment with disinfection could be appropriated. Sludges treatment and disposal in a landfill close to the WWTF.

Water treated is ready to be conveyed to the irrigation area and also, there is the possibility that the exceeding flow could be discharged into the Atenco River.

Cerrito de Guadalupe (CG)

Drains (outfall points) could be connected, if they did not, to a primary pipeline and transport sewage to a WWTF. It is highly recommendable to continue the main collector downstream, in order to join with the wastewater of SL Apizaquito.

San Luis Apizaquito

To install a primary pipeline to collect the secondary drains along the Atenco River, if it does not exist, and other tertiary pipeline that collect all the sewage coming to 02-D2 Apizaquito (Centre-Easth). In particular, this second collector could end into a WWTF within S L Apizaquito and the wastewater treated could be used to irrigate the left bank of the Texcalac stream.

Colonia San Isidro (CSI)

Presumably, as well as the other localities, the locality has a main collector that it suggested be continued until the WWTF Apizaco A, which is allocated in San Miguel Contla that is part of the Metropolitan Zone of Apizaco at the East side.

Final proposal

The four localities were analysed as function of the topography, urban density, municipality belonging (social, economic and environmental aspects), landscape, wastewater quality, existing drainage system, among other conditions and information available. Thus, the proposal is to construct:

1 main collector, at each side of the highway, whether it does not exist, and a WWTF in the same locality of San Bartolome Matlalohcan . In the case that the main collector exist, it is recommendable to review its capacity and conditions and if it is necessary to improve them.

1 main collector, whether it does not exist, to convey wastewater from Cerrito de Guadalupe, San Luis Apizaquito and Colonia San Isidro and its disposition in to the Apizaco A WWTF allocated in the town of San Miguel Contla at the municipality of Santa Cruz Tlaxcala (Fig 5). This WWFT will need to be reviewed in capacity and quality goals (mainly for agricultural purposes).

Table 2 summarise the main characteristics of the main collectors computed with base on the component method using cost information from actual works.

Locality	Average Flow Q, LPS	Terrain level, m		longitud m	N° Wells	Cost
		Initial	Final			pesos MX
SB Matlalohcan	11.87	2510	2430	3125	27	$2,622,015.4
C Guadalupe, SL Apizaquito, C San Isidro	19.19	2409	2387	5190	44	$4,335,681.4

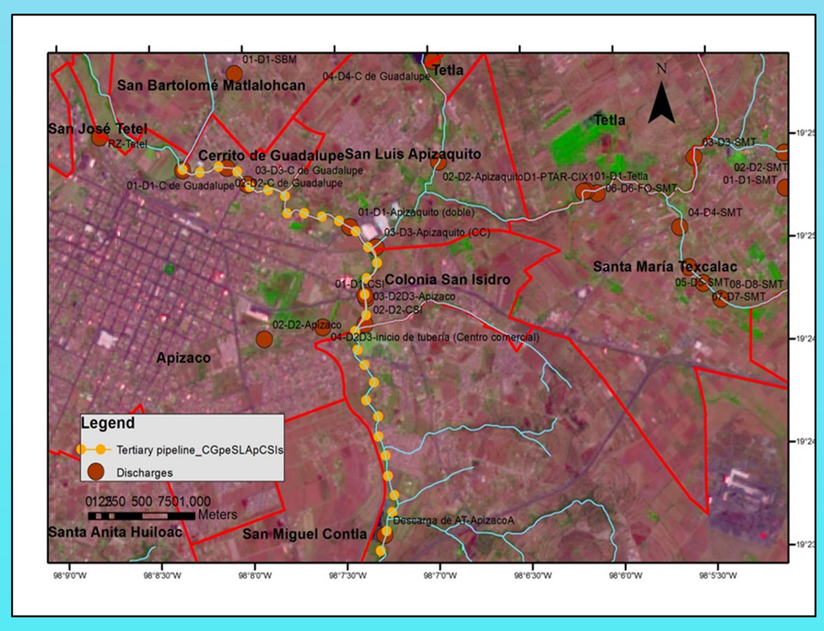

Figure 5. Proposal for allocation of the tertiary pipeline and WWTF in order to mitigate river pollution coming from Cerrito de Guadalupe, San Luis Apizaquito and Colonia San ISidro.

Conclusions

River restoration could be achieved in this case to avoid the continue pollution of the river and protect human health as well as to provide some recreational activities that could have had the river before its pollution.

Policymakers need to consider an integrated operation of the WWTF in the river basin, and one key issue is the role associated to the building of the pipeline and the final benefits expected.

Some questions need to be answered,

- Who is going to pay the construction of the pipeline?
- Who are the direct or indirect beneficiaries of the collection, convey and treatment of wastewater?

However, the interaction of all the mentioned processes in an unstable region with social, municipal and regional conflicts, and also environmental crisis that reduce water availability (treated or not) or may a non-uniform distribution of the economic benefits could increase social instability. Thus, who is going to solve conflicts and how?

The proposal shows that it is possible to guarantee a zero discharge into the Atenco River, and although during the rainy season it could be expected some discharge of wastewater treated into the river, an integrate river management can be achieved.