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Towards circular economy – a wastewater treatment perspective, the Presa Guadalupe case

Cesar Casiano Flores
Department of Governance and Technology for Sustainability (CSTM), University of Twente, Enschede, The Netherlands

Hans Bressers
Department of Governance and Technology for Sustainability (CSTM), University of Twente, Enschede, The Netherlands

Carina Gutierrez
Universidad Politecnica del Valle de Mexico, Tultutlan, Mexico, and

Cheryl de Boer
University of Twente, Enschede, The Netherlands

Abstract

Purpose – In Mexico, only 19.3 per cent of industrial water is treated (Green-Peace, 2014, pp. 3-4), whereas municipal treatment levels are approximately 50 per cent (CONAGUA, 2014a). This paper aims to focus on how the wastewater treatment plant policy, from a circular economy perspective, is affected by the governance context at the Presa Guadalupe sub-basin. Circular economy can contribute to water innovations that help in improving water quality. However, such benefits are not easily achieved. This case provides an example of the complexity and challenges that the implementation of a circular economy model can face.

Design/methodology/approach – Data are collected via semi-structured in-depth interviews with the stakeholders that are members of the Presa Guadalupe Commission. The contextual interaction theory (CIT) is the theoretical basis for this analysis (Boer de and Bressers, 2011; Bressers, 2009).

Findings – The findings show that the wastewater treatment plant policy plays an important role in a circular economy model. Some incentives towards a circular economy model are already in place; however, the hurdles of a top-down implementation perspective, low availability of resources, prioritisation of short-term results, lack of enforcement of the "polluter pays" principle and a linear model of water systems need to be overcome. If Mexico wants to move towards a circular economy model and if the government wants to enforce sustainable development principles, wastewater treatment is a challenge that must be addressed.

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Originality/value – There are few studies in the circular economy literature that have analysed its implementation under a governance arrangement perspective.

Keywords Circular economy, Business ethics and sustainability, Mexico water management, Presa Guadalupe Mexico, Wastewater treatment policy, Water basin management, Water governance

Paper type Research paper

1. Circular economy model in wastewater treatment context

Interest in the circular economy model is increasing as more industries have shown some commitment to it. The main objective of the circular economic model is to eliminate waste "systematically, throughout the life cycles and uses of products and their components" (Zils, 2015). "It is perceived as a model that helps to generate more durable products, facilitate disassembly and refurbishment and, where appropriate, consider product/service shifts" (ELLEN MACARTHUR FOUNDATION, 2015a). "A circular economy will create value for local communities and municipalities, which must seize their opportunity to organize local closed loops for water, material and energy recovery" (VEOLIA, 2015, p. 2).

The principle of circular economy is a zero-waste imperative and it is based on three rules:

(1) All durables, which are products with a long or infinite life span, must retain their value and be reused but never discarded or down cycled (broken down into parts and repurposed into new products of lesser value).

(2) All consumables, which are products with a short life span, should be used as often as possible before safely returning to the biosphere.

(3) Natural resources may only be used to the extent that they can be regenerated (Stuchtey, 2015).

A circular economy perspective can bring water innovations that support water regeneration. Water has caught the attention of circular economy discussions as it is one of the most important resources for production. Sectors such as agriculture or aquaculture depend almost entirely on it. For this reason, various analyses about the role of water in a circular economy have been made.

"Water has been pushed into a linear model in which it becomes successively more polluted as it travels through the system, rendering future use impossible" (Stuchtey, 2015). The linear model is based on "take-make-dispose" (VEOLIA, 2015), which considers large quantities of cheap and easily accessible materials and energy (ELLEN MACARTHUR FOUNDATION, 2015b). The vision of water as part of circular economy can be described as follows:

> Water as part of a circular economy, [. . .] [must] retains full value after each use and eventually returns to the system. And rather than focus solely on purification, we should attempt to prevent contamination or create a system in which water circulates in closed loops, allowing repeated use. [When water is used for industrial purposes] the major goal is not to keep water free of contaminants but to manage the integrity of the closed-loop cycle. Situations that favour the durable view include those in which it would be too costly to dispose of the solvents and re-create them [. . .]. Whenever possible, energy and nutrients should be extracted from consumable water (Stuchtey, 2015).

The inclusion of water in a circular economy model can be approached in different ways to favour innovation; it involves:

- product–design partnership;
- wastewater treatment plants becoming energy positive;
- management for yield;

- basin management to reduce risk of flooding or freshwater pollution; and
- local organic nutrient cycles for agriculture (Stuchtey, 2015).

In addition, energy and nutrients can be extracted, and water can be reused. In this sense, wastewater treatment and wastewater reuse can have many benefits, such as aiding productivity in agriculture and increasing the production through "more crops per drop". It can also provide a new source of materials when undertaken in the mining industry or it can result in a new source of energy, for example through methane production (VEOLIA, 2015, p. 3). Thanks to technological development, there are promising results that even show the possibility of creating value-added biopolymers as a by-product of wastewater treatment (Arcos-Hernández *et al.*, 2015).

The industrial sector in a circular economy model can support water reuse too. For example, research in The Netherlands found that calcium carbonite, a by-product in the pellet softening process, can be used as a substitute of sand grain for drinking water treatment. The substitution in that case could reduce operational costs by 1 per cent (€38,000) and environmental impact by 5 per cent. The drinking water facility, Weesperkarspel of Waternet, who was the pilot project, wants to make a full transition from garnet sand to ground calcite (Schetters *et al.*, 2015).

Wastewater treatment is an essential part of water management in a circular economy model. Despite developments and efforts, wastewater treatment faces many challenges around the world, and its insufficiency is considered one of the main water-related problems (Ardakanian *et al.*, 2015). The average level of wastewater treatment approaches 70 per cent in high-income countries, whereas it is 38 per cent in upper-middle-income countries and 28 per cent in lower-middle-income countries (Allaoui *et al.*, 2015). Less than 5 per cent of water is reused around the world and unfortunately recycled water availability grows as use of water increases (VEOLIA, 2015).

Some important efforts are being made around the world to address the above challenges and to encourage a circular economy model from a wastewater perspective. The book *The Milestones in Water Reuse: The Best Success Stories* describes benefits of wastewater treatment reuse in countries such as Australia, Canada, Spain and Singapore. Among the main benefits is the increasing availability of water for both agriculture and industry (Lazarova *et al.*, 2013). One encouraging example of water management innovation, under an integrated circular vision of the water cycle, is the Milano-Nosedo municipal wastewater treatment plant where the "water–food–energy" concept is being applied while placing wastewater treatment at the core of the issue. Treated wastewater is reused for agricultural purposes with a production of 45 per cent corn, 15 per cent rice and 40 per cent grass and grains. Also, energy production is used for the heating and cooling system of the wastewater treatment plant facility (Dantin, 2016).

Technological developments and successful cases can be an inspiration in the pursuit of this circular economy model. However, many challenges need to be addressed to increase the possibilities to embed wastewater treatment in a circular economy model. This model and its inclusion of water reuse are part of the integrated water resources management (IWRM) concept. This concept requires an integrated management approach of the water subsectors such as sanitation and irrigation. Also its implementation requires great international efforts that include reforms of water management laws, regulatory systems and capacity building (CReW, 2012).Wastewater regulation and policy implementation are context specific (Allaoui *et al.*, 2015). Therefore, it is important to understand the context where a model like this is sought for implementation and this research provides a description and analysis of the context. The following section will provide a general description of the Mexican context as a first step to analyse the Presa Guadalupe sub-basin.

2. The Mexican context

In the first decades of the twentieth century, Mexico managed its water policy at the national level through regional agencies. The policy was mainly directed at the industrial, agricultural and forestry sectors and their development in the country (OECD, 2013). In 1940, the first river basin commissions were created and they were the first implementing agencies of the water policy, which focused on infrastructure building. The basin commissions were responsible for urban and rural development as well as communication, transportation, education and health services. The first National Water Program was created in 1975 and the management of water resources was kept at the regional level, driven by the federal government (OECD, 2013). Currently, the National Water Commission (CONAGUA) is the administrative, normative, technical and consultative institution in charge of water management in the country. It is a decentralised agency of the Ministry of the Environment and Natural Resources.

In November 1980, the Mexican President sent an agreement to transfer the water management responsibility to the state and municipal governments (Rodríguez, 2010, p. 21). The decentralisation process of water services started in the federal administration of 1982-1988, when reforms in Article 115 of the Constitution took place (Rodríguez, 2010). On February 5, 1983, the reform was approved, and stated that water-related services were to be an exclusive function of the municipalities. It also established the state government as transitional entities. In most of the cases, the state government transferred the new obligation to the municipalities immediately (Jardines Moreno, 2008, p. 84). However, Article 115 also mentioned that municipalities could coordinate and associate their efforts with other municipalities or at the state level to provide the water services (IMCO, 2014, p. 17).

The decentralisation process towards IWRM continued with the 1992 Water Law, and an important reform took place in 2004 to strengthen this process. The current National Water Law is considered a major turning point towards integrated water management. It established a process of decentralisation of some key functions to municipalities, river basin organisations and irrigation districts. It was supported by important investments to improve wastewater treatment plants, replacement of supply sources and modernisation of agricultural irrigation system technology (OECD, 2013). CONAGUA stated, "Mexico is fully committed to managing water in an integrated manner, so as to optimize the demand from different sources for the same water resources" (CONAGUA, 2012, p. 5):

> The National Water Law includes the obligation for CONAGUA to generate participation amongst water users in the administration of the system and services. This same regulation obliges CONAGUA to consult the different actors involved, through the MBCs [Management Basin Councils], in order to register their opinions and proposals in terms of planning, identifying problems and developing strategy for management, as well as evaluating the supply sources in terms of sustainable development. There are guidelines for public participation described in the Rules of Organization and Operation of the MBCs (Comisión Nacional del Agua, 2004) (Franco-Garcia *et al.*, 2013, p. 189).

Until now, 13 river basin organisations have been created along with 26 river basin councils that work with 35 river basin commissions, 47 river basin committees, 87 COTAS (Technical groundwater committee) and 39 local clean beach committees (CONAGUA, 2015b). The River Basin Commissions, such as the Guadalupe River Basin Commission, are auxiliary bodies of CONAGUA, and they "are expected to facilitate the implementation of river basin councils' strategy; inter-governmental co-ordination; and social participation at the sub-basin level" (OECD, 2013, p. 111). However, "decision-making power is still centralised within the hands of CONAGUA and its regional/local offices" (OECD, 2013, p. 17). The process of creation of Basin Organisations has been described as a mere offices' decentralisation instead of a decentralisation of the policy. The regional and local offices and their directors are directly subordinated to CONAGUA's director (Jardines Moreno, 2008, p. 91).

The decentralisation process did not have the intended outcomes. Water utilities have not shown improvements in the outcomes of their water management since 1980s (CONAGUA, 2015c). Lack of resources and law enforcement in the central Mexican context are common issues (Casiano and Boer de, 2015; Casiano Flores *et al.*, 2017, 2016) that can challenge the implementation of the IWRM concept and the circular economy model.

In Mexico, the past three federal administrations have made important efforts to increase wastewater treatment. The 2001-2006 National Water Plan had the goal of 65 per cent for municipal wastewater treatment; however, only 36.1 per cent was achieved (Peña de la *et al.*, 2013). The 2007-2012 federal water plan set a goal of 60 per cent, and the achievement was 47.5 per cent. None of those plans achieved their intended goals (Casiano and Bressers, 2015, p. 14). The current 2014-2018 National Water Plan has a wastewater treatment goal of 63 per cent (CONAGUA, 2014a, p. 137). CONAGUA reported a municipal wastewater treatment of 55 per cent in 2015 (CONAGUA, 2015a), whereas 19.3 per cent is the estimated percentage for industrial wastewater (Green-Peace, 2014, pp. 3-4). To implement wastewater treatment, the federal government works with the state and municipal level. The legal framework for water is composed by the National Water Law, the General Law on Environmental Protection, State Water Laws, River Classifications[1] and 26 norms (CONAGUA, 2015b, p. 173). Among these norms, there are four about wastewater treatment:

(1) NOM-001-SEMARNAT-1996 – establishes the pollution levels for wastewater discharges in national waters.

(2) NOM-002-SEMARNAT-1996 – establishes the pollution levels for wastewater discharges in municipal infrastructure.

(3) NOM-003-SEMARNAT-1997 – establishes the pollution levels for treated water and its reuse for public services.

(4) NOM-004-SEMARNAT-2002 – establishes the specifications and limits of the produced sludge and bio-solids as well as their final disposition.

In 1992, when the Water Law towards an IWRM took place, Mexico had 394 wastewater treatment plants. In 2013, the Mexican Government was aware of 2,287 municipal wastewater treatment plants and 2,651 wastewater treatment plants in the industry sector (CONAGUA, 2014b). The most common wastewater treatment process by the water utilities is the active sludge (CONAGUA, 2015b). In the case of the industry sector, the wastewater treatment plants are classified into primary, secondary and tertiary. Secondary treatment is the most used wastewater treatment by the industry sector and the least used is the tertiary type (CONAGUA, 2014b).

Until 2015, three programs formed the basis of the wastewater treatment plant policy in Mexico. The programs were supported by CONAGUA's Rules of Operation, which established the guidelines for the implementation of the programs. The most important programs were PROTAR (Wastewater Treatment Program) launched in 2009, APAZU (Urban Potable Water and Sewerage Program) 1990 and PROSSAPYS (Rural Waterworks Development Program) 1996. The programs required the creation of the Commission of Regulation and Follow up (CORESE). The CORESE is established between the federal government through CONAGUA and the state government. This allows the latter to present proposals for the programs and actions of the federation (CONAGUA, 2013b).

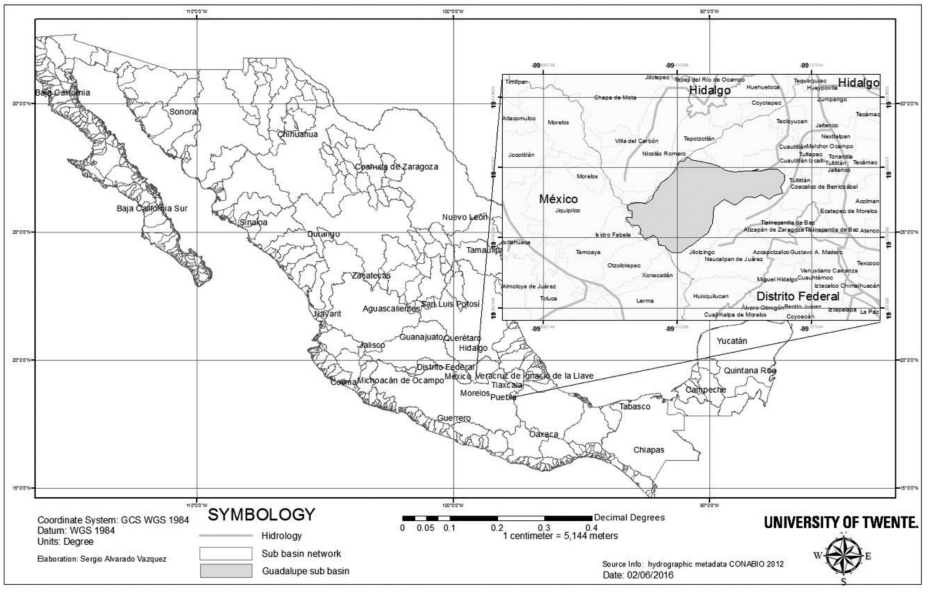
To complement the programs mentioned above and as part of a more integral water management approach, CONAGUA provides additional support to encourage reuse of treated wastewater. The water utilities can obtain a subsidy when they start reusing or exchanging at least 30 per cent of the treated water, and the economic support is doubled once they reach 60 per cent or higher. The support is doubled again if the water utility

replaces water consumption from primary water sources to treated wastewater from a wastewater treatment plant (CONAGUA, 2014b). Water reuse has increased from 20.1 m^3/s in 2007 to 77.5 m^3/s in 2013 and source replacement increased from 5.3 m^3/s to 8.7 m^3/s in the same period (CONAGUA, 2014b). In 2014, reuse reached 21.8 m^3/s (CONAGUA, 2015b). Also as part of the strategy to mitigate climate change, the Mexican Government, with the support of the CONAGUA's 2014-2018 National Water Plan, is encouraging the production and consumption of energy *in situ* as part of a wastewater treatment plant integral policy. One of the promoted technologies is biogas production, which can also help to decrease the energy operation costs of the plants (CONAGUA, 2014b).

3. Case description

The Presa Guadalupe river sub-basin belongs to the State of Mexico and it is located in the northern part of Mexico City. The municipalities that conform the river basin are Atizapán de Zaragoza, Cuautitlán Izcalli, Isidro Fabela, Jilotzingo and Nicolás Romero (Franco-Garcia *et al.*, 2013, p. 191). Figure 1 shows the location of the study.

Between 2004 and 2005, there were multiple occasions of fish death in the Guadalupe reservoir as a consequence of pollution problems. The main factors were lack of treatment of the wastewater, uncontrolled urban growth, land use change, deforestation and inadequate management of solid waste (Desarrollo y Sistemas S.A., 2008, p. 2). This tragedy showed the necessity of coordination across the different governmental levels, as the National Water Law and CONAGUA's programs emphasise the necessity of a multi-level coordination of the governmental actors to implement the wastewater treatment plant policy. Also, information from the municipalities proved that the high levels of pollution were the result of the wastewater discharges from different municipalities that form the sub-basin.



Source: Casiano Flores *et al.* (2017)

Figure 1.
Location of the Guadalupe river basin

In May 2005, one year after the first massive fish death event and with a diagnosis of the river basin problem, the main stakeholders under the leadership of Cuautitlán Izcalli representatives started the process to create the Guadalupe River Basin Commission (Comisión de Cuenca Presa Guadalupe, CCPG). The CCPG was officially created in January 2006 under the framework of the National Water Law (Franco-Garcia *et al.*, 2013, p. 192). This basin was initiated in a bottom-up fashion (Franco-Garcia *et al.*, 2013, p. 190), which is remarkable as most of the river basin commissions are created by CONAGUA in a "top-down" manner. One example of this is the Atoyac-Zahuapan Basin Commission (AZBC), which was created by CONAGUA with the support of the state government. Currently, the AZBC only exists on paper, as they never had a session and the stakeholders are unaware of its existence (Casiano Flores *et al.*, 2016).

The Guadalupe River Basin Commission is composed of several actors, which are presented in Figure 2.

The Commission's main goal is to coordinate the actions among the different actors at the sub-basin levels (Ixcahuicopa, 2009, p. 145) and it has the following objectives:

- promote wastewater treatment and monitor the water quality;
- improve the distribution and use of water;
- promote an efficient use of water;
- promote the environmental, social and economic value of water; and
- promote conservation and improvement of ecosystems (CCPG, 2015).

Nine years after the creation of the Commission, different stakeholders agreed that pollution problems have not been solved and little has changed in the sub-basin. A study published in 2013 confirmed that the main source of pollution is anthropogenic as well as the inadequate management of the reservoir. It contains high levels of nitrogen, phosphorus and carbon compounds and a high amount of bacterial pathogens (Sepulveda-Jauregui *et al.*, 2013):

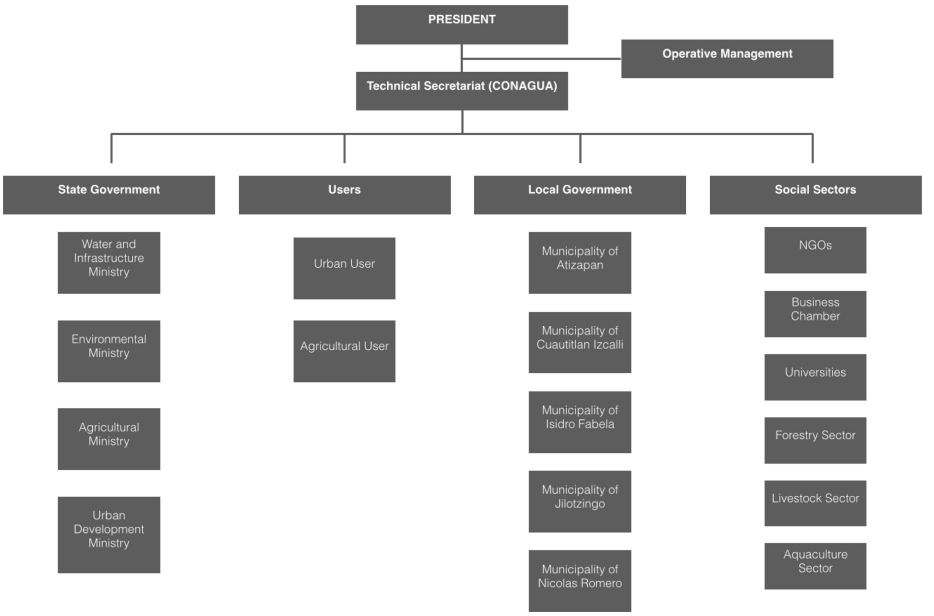


Figure 2.
Guadalupe river basin commission organigram

> It is estimated by CONAGUA that a volume of 14,924,455 m^3 per year of untreated wastewater is originated from Nicolás Romero (90.7 per cent), Atizapán de Zaragoza (6.6 per cent) and Cuautitlán Izcalli (2.7 per cent), through the rivers Cuautitlán, San Pedro, Xinté and Tecuane (Franco-Garcia *et al.*, 2013, p. 193).

The creation of a Commission, such as the CCPG seemed to be a promising approach to improve the water quality at the sub-basin, to promote wastewater treatment and to create integral management; however, important contextual limitations are present.

4. Methodology and theoretical framework

To understand the contextual factors that affect the implementation of wastewater treatment plant policy from a circular economy perspective, 20 in-depth interviews were carried out with the CCPG stakeholders. The questions asked are derived from the contextual interaction theory (CIT) framework and its elements of governance (Bressers and Kuks, 2003).

In this theory, the structural context is composed by the following five elements of governance:

(1) *Levels of governance:* governance assumes the general multi-level character of policy implementation.

(2) *Actors and their networks:* governance assumes the multi-actor character of policy implementation.

(3) *Perception of the problem and objectives:* governance assumes the multi-faceted character of the problems and objectives of policy implementation.

(4) *Strategies and instruments:* governance assumes the multi-instrumental character of policy strategies for policy implementation.

(5) *Responsibilities and resources for implementation:* governance assumes the complex multi-source basis for implementation of policy (Bressers and Kuks, 2003, p. 71).

Derived from these five elements, the governance model in the CIT "consists of questions that attempt to determine: Where? Who? What? How and With What? These questions respond to characteristics that feature modern governance systems" (Kuks, 2004, p. 30). These five elements (multi-level, multi-actor, multi-faceted, multi-instrumental and multi-resource based) of the governance context can be used to describe a certain policy field in a specified place and time (Bressers and Kuks, 2003, p. 71). Governance is used as a neutral concept as opposed to a normative concept or a hypothesis on developments in the government–society relationships as is done in much other governance literature. It is an enlarged understanding of the scope of the concept of "policy" (Boer de, 2012, p. 30). In this sense, the CIT will allow a systematic and structural understanding of the context where the wastewater treatment plant policy is being implemented to contribute to a circular economy.

This study has been preceded by two related studies in 2010 (Hendrawati-Tan, 2010) and 2012 (Franco-Garcia *et al.*, 2013). The information gathering technique for this study had two rounds of interviews. The first round consisted of three interviews (the president of the commission, one social actor and one governmental actor) in January 2015 and the rest of the interviews took place during the second round, between July and August 2015. Interviews lasted an average of 1 h per actor. The results were considered reliable, because the majority of the interviewed stakeholders consistently reported in similar ways. The interviews included few institutions, which are mentioned in Figure 3.

5. Results

The following section presents the findings organised by the five elements of governance as defined in the CIT.

5.1 Multi-level: The wastewater treatment plant policy implementation includes the three governmental levels and each level has a specific task

The wastewater treatment plant policy requires the involvement of the federal, state and municipal levels. If one of the governmental levels does not provide its share, the programs cannot be implemented, as they commonly require a co-investment system. It is between the state and federal levels where the planning and construction of the wastewater treatment infrastructure take place and it is the municipal level that operates the infrastructure. The lack of involvement of the municipal level in the planning and construction phases have resulted in the construction of wastewater treatment plants that are not being operated or are only partially in use. They are not adapted to the needs of the water utility as during the planning process, the municipal capacity to operate the plants was not considered and in many cases, they have become an economic burden. The CCPG and the strategy it developed were not taken into account when the wastewater treatment plant policy was implemented. The policy is implemented through CONAGUA's Rules of Operation, which emphasize the participation of the state and federal level. Some municipalities consider that as the state level does not understand and experience the problems, it should not be in charge of the tendering process. Sometimes the water utilities complain during the construction of the plants, but the answer from the constructor is that they are following instructions from the state government. Another problem they reported, is that at many occasions, the winner of the tender is the company with the lowest costs and the construction quality is very poor. In some cases, the material agreed during the project presentation is changed for another of lower quality during the construction. According to the municipal level perspective, CONAGUA and the state government seem to accept low-quality projects.

According to CONAGUA's inventory (2013), there are 18 wastewater treatment plants in the municipalities that make up the sub-basin (CONAGUA, 2013a):

- seven plants in Atizapan;
- eleven in Cuautitlán;
- one in Jilotzingo
- zero in Nicolas Romero; and
- zero in Isidro Fabela.

Most of the plants listed do not operate or if they do, it is with a very low capacity. A general estimation from a Commission staff establishes that around six plants are operating in the sub-basin and not all of them meet the parameters. The low level of wastewater treatment and the lack of the discharges meeting the norms limit the chances of the municipalities to sell treated wastewater. This situation increases their economic problems, because on the

Figure 3.
Institutions to which the interviewed stakeholders belong

one side, they are fined by CONAGUA due to polluted discharges and on the other side, they cannot have access to economic incentives for water reuse. Currently one wastewater treatment plant is being built in the sub-basin area, and there are negotiations about its operation. The new plant is located in the municipality of Cuautitlán Izcalli and it will receive wastewater from other municipalities, so the actors are negotiating to decide whether inter-municipal plant operation is possible.

5.2 Multi-actor: The wastewater treatment plant policy should be supported by two actors' networks. One network is created by the CCPG which allows the participation of the governmental, social and economic actors. The other is created by the CONAGUA programs and it is conformed by the federal and state governments

Participation from different stakeholders is found within the CCPC. Among them are the three governmental levels, users of water and NGOs. The user organisations still face limitations, as it was stated in a previous research in 2012: some economic sectors feel they are overlooked by the governmental actors and this has demotivated some of the CCPG stakeholders. The support given by the governance regime does not include productive sectors such as aquaculture that are important to improve the water quality status of the sub-basin (Franco-Garcia *et al.*, 2013, p. 200) and to encourage a circular economy model.

In the case of the aquaculture sector, CONAGUA has not granted them permits, therefore they are still operating and producing without them and they cannot apply to governmental programs to improve the water quality. There was a project between CONAGUA and the Ministry of Agriculture, Fishery and Rural Development (SAGARPA) that would allow them to improve the quality of their discharges. The aquaculture group was promised that they would receive settling tanks and water meters. However, differences among federal ministries provoked the cancellation of this project. The aquaculture group is aware that the water used in the aquaculture sector can be used as fertilizer in agriculture. However, no serious actions have been taken to implement a program in this regard. If a program of this type were implemented, an important step towards the circular economy model would have be taken.

Perceived acts of corruption diminish the interest of water users to participate alongside governmental actors. Water users mentioned that when they receive economic support from a governmental program, government employees require them to buy the products in specific stores or the materials are of a lower quality than the one agreed upon. The industrial sector has limited participation in the Commission and this diminishes the opportunity of dialogue to promote a circular economy model.

5.3 Multi-faceted: The wastewater treatment plant policy implementation is mainly based on the perspectives from the state and federal government

In general terms, there are two facets: one from the governmental actors, which is related to short-term actions and based on the governmental programs, and another from the social actors, which is a long-term perspective. This longer perspective is represented in the CCPG plan. The CCPG has helped in aligning perspectives about certain issues. The actors agree that the main challenges regarding water pollution are uncontrolled urban growth, deforestation and lack of wastewater treatment. The different stakeholders agree that brining some perspectives together is one of the main contributions of the CCPG. In this sense, meetings have been an important aspect. For example, the agricultural sector used to think that they did not pollute the water. Some trust has also been developed because the actors know each other. In the words of one interviewee, "The commission helps to keep communication, coordination, awareness; there is some follow up and the pollution problem

might be worse without it". However, lack of inclusion of upstream actors in the policy implementation has decreased their interest. Some of them argue that at the end, wastewater treatment in the upper region will not bring changes in the water quality status of the sub-basin because downstream water pollution is much higher.

One of the most common concerns, in institutional terms, is the impact of the short-term orientation of the municipal administration in the wastewater treatment plants policy. This situation causes processes and staff to be re-initiated every three years. Therefore the perspectives of these actors are also based on this time span so they prioritise actions that show immediate progress. These actions include construction and rehabilitation of the plants, instead of actions that can have a higher impact but are less perceived, such as industrial sector monitoring or wastewater treatment plants' proper operation. Some municipal representatives do not know about the existence of CONAGUA programs. The actions with higher impacts such as the planning, construction, operation and monitoring of wastewater treatment infrastructure are out of the CCPG hands. Thus the development of a joint strategy is a successful process, but the decoupling from investment decisions and operation makes the Commission's strategy extremely dependent on other powerful actors. Wastewater treatment programs are implemented only between the governmental levels. These programs are not developed from an integral perspective. Each one responds to a specific goal, such as building a wastewater collector, wastewater treatment plant construction or rehabilitation. The actors do not work together with a common vision, and no further actions have been made for wastewater treatment of the aquaculture production.

5.4 Multi-instrument: The instruments for the wastewater treatment plant policy are related to CONAGUA programs which have the objective of enforcing the water management legal framework

Due to the institutional arrangements, there are two Commissions from which actions concerning the wastewater treatment plants should be implemented at the sub-basin level. One is the CCPG and the other is the Commission of Regulation and Follow-up (CORESE). The current governance context for the Guadalupe Commission has not changed from the studies done in 2012:

> The commission depends on mid-level governments that view each project from the perspective of how it can address their own policies and are themselves only to some extent committed to the process (Franco-Garcia *et al.*, 2013, p. 202).

As mentioned before, until 2015, three federal programs included the most important actions towards wastewater treatment plants policy, namely, PROTAR, APAZU and PROSSAPYS. These programs require the creation of the CORESE to be implemented. In the CORESE, the implementation of the programs is discussed. These programs support wastewater treatment plants and collectors' construction or rehabilitation. The implementation of the programs faces many challenges. Some of the water utilities have not participated in any of the programs, therefore the water utilities do not have the resources granted through the CONAGUA programs. In one of the cases, the number of wastewater treatment plants operating has decreased through the years. The water utility is in charge of five plants and they are operating only one. The treated wastewater is used to water green areas that belong to the municipality, such as parks. An upstream municipality reported lack of interest from the federal and state government. They have been requesting support for wastewater collectors, but have not received it. The construction of a wastewater treatment plant from a circular economy perspective could be linked with the aquaculture and agriculture sectors in the upstream area of the sub-basin. Some municipal level representatives at the upstream

part of the sub-basin agree that if the CONAGUA programs were implemented, treated wastewater could really help the agricultural sector. They require the support of the upper levels and according to them, the state and federal governments do not take seriously the commitments they make and they prioritise the municipalities downstream where there are a higher number of inhabitants. The programs also face fragmentation; as they work in a separated manner without any integration, each program is related to a specific project.

5.5 Multi-resource based: The main resources for the wastewater treatment plant policy implementation come from the federal government and they are supported by the state and municipal levels. Generally, there is a lack of resources for the policy implementation

The governance context regarding the resources for implementation in the CCPG is still the same to what was found in the previous study:

> The context is only in principle supportive. It does not adequately equip organizations like the basin commission with sufficient support for its integrated ambitions for the basin nor does it give them the legal rights to collect those resources themselves (Franco-Garcia *et al.*, 2013, p. 202).

The wastewater treatment plant policy is multi-resources based, and the economic resources and legal capacities for the implementation come from different governmental actors. Normally CONAGUA contributes with 50 per cent of the project cost, the state government 25 per cent and the municipal government 25 per cent. The three governmental actors are involved in different degrees and with different responsibilities. The governmental level with the main responsibility to operate the wastewater treatment plants and to monitor wastewater discharges are the water utilities at the municipal level.

The upper governmental levels as well as some actors from the CCPG perceive that the municipalities are the governmental level with the lowest interest in the wastewater treatment policy at the sub-basin. The main challenges the actors perceive besides the short-term in office of the municipal administrations are their limited resources. The resources are so limited for the water utilities that they do not have the capacity to build infrastructure, to operate the wastewater treatment plants or to monitor industrial discharges on their own. CONAGUA is the biggest spender in the water sector; in 2015, the federal government provided 60 per cent of the economic resources, whereas the state accounted for 16.4 per cent and the municipalities for 9.5 per cent (CONAGUA, 2015b). There are also occasions when CONAGUA loses credibility because they agree to provide some economic support to the water utilities. However, they depend on the Ministry of Finance and sometimes the process takes longer than expected.

As the water utilities do not have the resources, the operation of the wastewater treatment plants is very low and the water utilities cannot obtain support for wastewater reuse actions. The lack of resources also affects law enforcement. The water utilities do not have the capacity to monitor the industry discharges. It is common that municipalities only monitor the industry sector with physical analysis and when there is social outcry. This situation results in an industry sector that prefers rather to pay the penalties than avoid them by building a wastewater treatment plant. On average, the improvement of wastewater treatment from the industry sector at the national level has been slower when compared to that of the municipalities (Peña de la *et al.*, 2013).

Sometimes the economic resources are so scarce that water utilities have to decide between operating the wastewater treatment plant or delivering the water service. This situation also occurs because they do not receive enough money from the services they provide, in part because the tariff does not represent the real cost of the water and because people do not pay for the service:

> The existing legal provisions do not allow the water utilities to set the water prices realistically. They only propose the tariff and depend on the approval of the State Congress, making the water utilities sensitive to political factors. Politicians are not willing to increase water prices due to political costs (Casiano Flores *et al.*, 2017).

The state and federal governments have a very low capacity for monitoring the projects. The CAEM and CONAGUA have assigned only one person per institution for approving projects and inspecting the wastewater treatment plants. This happens in a state with a population of more than 15 million people according to the last census (INEGI, 2015) with a land surface of 22,351 km^2. Most of the economic resources are used for building infrastructure. Such infrastructure construction is performed without a coherent plan. It ignores the plan that was developed by the CCPG and it generates a situation where the budget is poorly spent. Neither CONAGUA nor the municipalities have certified laboratories that provide legally valid analysis that can be used for sanctions. At the end, the monitoring actions are very weak at the three governmental levels. Water utilities' inspections normally take place only if there is a complaint from the citizens. In the case of CONAGUA and the CAEM, few inspections take place to monitor construction or operation of infrastructure. CONAGUA is financing more projects than it can monitor.

Acts of corruption reported by social actors decrease trust among the actors in the network. Examples of these are the experiences mentioned above about the behaviour of governmental employees, such as allowing overpricing of the materials used or changing quality of construction supplies from the planning to the building stage.

The inter-municipal wastewater treatment plant that the state and federal government are building to improve the water quality in the sub-basin presents an important challenge for its operation. One involved actor in the process commented that "when the state government wants to charge the municipalities for the operation process, it is legally and politically complicated". A common problem with the federal programs' economic support is their inflexibility to use the financial resources. One frequent complaint is that the state government cannot use the incentives they receive for one plant to improve another, even when this would make more sense for the goal of improving water quality from a more integrated vision.

6. Discussion and conclusions

When summarizing the five governance elements of the wastewater treatment plant policy, we can state that the multi-level arrangement is top-down, and the driver of the policy is CONAGUA through its programs and it is followed by the state and municipal government. Even though, all stakeholder should participate in the policy implementation due to the CCPG, the participation is limited to the actors of the CORESE. The CCPG has helped to align multiple perspectives, but the impact has not gone further because they have not been given sufficient legal and financial resources. The only considered perspectives for the wastewater treatment plant policy are the ones from the state and federal government. The instruments to support this policy emphasize infrastructure building over inspections and there is not an integrated perspective that can support water management innovations within a circular economy model. The resources are scarce and those are not well aligned with the responsibilities, for example, the tariffs are sensitive to political interests and politicians prefer short-term results due to their short term in office.

On the basis of these results, we can conclude that the path towards a circular economy model from the current wastewater treatment plant policy implementation is facing important contextual challenges. Even when Mexico has shown commitment towards IWRM with the reforms started in the 1980s and strengthened with the 1992 Water Law,

most of the legal objectives are only on paper. The existence of the CCPG should strengthen the wastewater treatment policy towards a circular economy model, as this body should promote wastewater treatment and water quality monitoring (CCPG, 2015). However, the CCPG faces many restrictions such as lack of resources and lack of legal and economic capacity to implement or support the wastewater treatment plant policy. The Commission "can only encourage others to take measures and their own capacity to act is very limited" (Franco-Garcia *et al.*, 2013, p. 197).

Thinking about wastewater treatment in a circular economy model perspective could help to decrease the water availability issues at the sub-basin and increase the water quality in the surface water bodies, such as the Guadalupe lake. Some instruments are already in place and the CONAGUA incentives to reuse treated wastewater within the CONAGUA programs are a clear example of this. However, the low level of treated wastewater diminishes these opportunities. The creation of the markets for treated wastewater will also be one of the biggest challenges. As the CCPG is highly involved in educational activities, they could carry out activities that inform society and water users about the benefits of treated wastewater use. The states where wastewater treatment plants are already operating have faced opposition from the agriculture sector, as they do not trust the quality or the benefits of using this water. This situation limits possibilities of innovation in the water sector too.

With the existing actors and the economic activities at the sub-basin level, important changes could take place towards a circular economy model. The water–food–energy concept is a good example in this regard. Within a circular economy model, the water from the aquaculture or the treated wastewater could be used for the agriculture or the industrial sector. Even the municipality of Romero Vargas could decrease its water scarcity problems. In the same line, new wastewater treatment plants could include energy production projects with methane.

If the federal government is really committed to a transition of the wastewater treatment plant policy towards IWRM, which nowadays embraces water reuse and therefore the circular economy model, it needs to be more open to take into account the municipalities and water user actors. There are many issues among the governmental actors that need to be prioritised. Long-term planning is required to promote a more integrated implementation of the wastewater treatment plants. The state and federal governments complain about the capacity of the municipal level as the staff change every three years. Actually, the policy of delegating water-related services to water utilities at the municipal level has been criticised during the past years as it is such a short-term government (Rodríguez Briceño, 2008). Long-term planning is complicated and it is very sensitive to political factors. One action that can be explored is the regionalisation of the wastewater treatment plant policy. Some Mexican states have already decided to manage water at the state level instead of strengthening the decentralisation process, for example in Baja California, Nuevo León, Tabasco, Oaxaca and Querétaro. While only few water utilities among hundreds operate at the state level, five of them are in the top-ten performance (IMCO, 2014). Also, the State of Tlaxcala has presented improvements in the wastewater treatment plant policy implementation by bringing the operation of the plants at the state level and securing the economic resources from the municipal government through state reforms. Nowadays, the state government even receives economic incentives for the wastewater treatment plants operation (Casiano Flores *et al.*, 2016) and they are trying to convince some farmers to use treated wastewater.

CONAGUA should strengthen its monitoring capacity. They define themselves as a normative responsibility oriented organisation and so they should act as such. Money should be spent more wisely, instead of financing new infrastructure without guaranteeing proper operation. They should increase the personnel for monitoring, to create a situation

where the built plants are meeting the standards required for correct operation. A higher level of monitoring could help to enforce the "polluter pays" principle against the water utilities and the productive sectors.

The federal government has already expressed its interest to develop plants that can produce and use their own energy. One of the promoted technologies is biogas production, which can also help to decrease the energy operation costs of the plants. However, the State of Mexico has not reported any improvement from 2012 to 2013 (CONAGUA, 2014b). If energy was produced by the wastewater treatment plants, the costs of electricity could be reduced. The high price of electricity is one of the main complaints from the water utilities and they consider that this high cost is one of the reasons not to operate their plants. Therefore, the promotion of green technologies should be part of the requirements for wastewater treatment plants construction or rehabilitation projects.

To move towards a circular economy model that allows innovation in the water sector, it is important that the government avoids reinforcing a linear model and end-of-pipe solutions. Wastewater treatment plant projects, such as the Atotonilco case, must be re-evaluated. One of the state level actors said, "The Atotonilco wastewater treatment plant will not change things in the state". The pollution in the state water bodies will remain the same as sanitation actions will not take place *in situ*. Water management in a circular economy model requires synergies between the government, industries and users with a high level of communication (VEOLIA, 2015, p. 4). The government requires negotiations and agreements with the industrial sector. Unfortunately, this sector has a low level of trust in the political sphere (Franco-García and Bressers, 2010). They also consider that the implementation of environmental policy is insufficient and the instrumentation is inapt (Franco-García and Bressers, 2010), thus they feel no need to negotiate seriously. The path towards circular economy from a wastewater treatment plant perspective implies the creation of synergy among the stakeholders. Some instruments are already in place. However, the mentioned issues need to be solved to overcome the current context, where a wastewater treatment policy from a circular economy perspective is still distant.

Note

1. According to Article 87 of the National Water Law, the River Classifications must specify the quality parameters for specific water bodies as well as the quality goals and the stages to achieve them (CONAGUA, 2015b, p. 150).

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Corresponding author
Cesar Casiano Flores can be contacted at: c.a.casianoflores@utwente.nl