Impact Assessment of Water Translocation from the Tucutunemo River to Camatagua Reservoir (Aragua State, Venezuela)

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Abstract

In order to control the increase of water level of Lake of Valencia, during 2009 began the translocation of water from the Taiguaiguay reservoir, through the Tucutunemo and Guárico rivers, to Camatagua reservoir, which is used as the main source of drinking water for the city of Caracas; this water translocation stopped in January 2015. Considering that water of Taiguaiguay reservoir is fed with treated wastewater from Taiguaiguay treatment plant, which is rich in nutrients, mainly P and N, the objective of this study was to evaluate the impact of water transfer from Taiguaiguay reservoir on water quality and quantity of Camatagua reservoir. We analyzed the data from 37 samples made from 2012 to 2016, near the water intake, in which *in situ* measurements and samples were taken for physicochemical and biological analysis (Secchi disk transparency, turbidity, ammonia, phosphates, total dissolved phosphorus, total phosphorus and phytoplankton abundance). Decrease in translocation flow from 2013, until its final elimination in 2015, caused a marked decrease in the water level of Camatagua reservoir. Water transparency and turbidity were affected by the entry of water from the Taiguaiguay reservoir. Also, ammonia and total phosphorus

concentrations showed an increase from 2012 to 2016, as a consequence of the high content of nutrients reaching to Camatagua reservoir from Taiguaiguay reservoir, as well as the decomposition of the organic matter. Nutrient input stimulated the increase of phytoplankton density with dominance of the species *Cylindrospermopsis raciborskii*, *Oscillatoria planctonica*, *Leptolyngbya limnetica*, *Microcystis aeruginosa* and *Synechocystis aquatilis* for the whole study period.

Keywords: water translocation, camatagua reservoir, water quality, eutrophication.

Introduction

In order to control the water level increase in Lake Valencia, during 2009 the excess of water of Taiguaiguay reservoir was traslocated to the Tucutunemo River, which joins downstream to the Guárico River, the main affluent of the Camatagua reservoir (GONZÁLEZ et al., 2015). The water from Tucutunemo River is rich in nutrients (mostly N and P), which come from the Taiguaiguay treated wastewater treatment plant.

Camatagua is the main drinking water reservoir for the City of Caracas and other adjacent populations (ca. 6 million of inhabitants). The impact of this translocation affected the water quality supplied for human consume, increased the eutrophication process of reservoir

and, by this reason, it finished in January 2015.

Camatagua reservoir was classified as eutrophic, according to the criteria of Salas and Martinó (1991) for warm tropical lakes, based on the concentration of total phosphorus (GONZÁLEZ, 2017).

Objective

Evaluate the impact of water translocation from Taiguaiguay reservoir on the water quality and quantity of Camatagua reservoir.

Study Area

Camatagua reservoir is located in the Central region of Venezuela (Figure 1).

Figure 1 – Relative location of Camatagua reservoir and the sampling site () near the uptake tower.

Main morphometric characteristics of the Camatagua reservoir

The main morphometric characteristics of Camatagua reservoir are (CASTILLO et al., 1973):

- Geographic location: 9°50' N – 67°00' W
- Surface: 59,000,000 m²
- Volume: 1,250,000,000 m³
- Altitude: 302 m.a.s.l.
- Mean depth: 21 m
- Discharge: 19 m³/s

Methods

Data were analyzed from a total of 37 quarterly samples from 2012 to 2016, near the uptake tower in Camatagua reservoir. Samples were taken at the three levels: surface, intermediate and bottom, using a van Dorn bottle for physicochemical analysis and for phytoplankton in the euphotic layer. In the field, water transparency was measured (Secchi disk 20 cm in diameter).

Once in the laboratory, the following variables were analyzed:

- Turbidity: Nephelometer HACH.
- Ammonia, phosphates, total dissolved phosphorus and total phosphorus: Standard Methods (APHA, 1992).

- Biological variables: Phytoplankton

Samples were fixed with lugol solution. Phytoplankton species were identified after sedimentation in Uthermöhl chambers, observation under an inverted microscope and the help of taxonomical keys for the elaboration of the species inventory. Algal density was determined by counting of cells in Sedgewick-Rafter and Uthermöhl chambers, with the help of an optical microscope (APHA, 1992).

Results of all determined variables are shown based on the annual average values of the water column. Flow of water transferred from the Taiguaiguay reservoir to the Tucutunemo River corresponds to the annual average value.

Results and discussion

- **Translocation diagram from Taiguaiguay reservoir to Camatagua reservoir:** During 2009, water translocation from the Taiguaiguay reservoir to the Tucutunemo River and after to the Camatagua reservoir was made, with an initial flow of 3000 l/s. Figures 2 and 3 show the diagram of water translocation from Taiguaiguay reservoir to Camatagua reservoir. Figure 2 clearly shows clearly the high input of N and P to the Guárico River from the Tucutunemo River.

Figure 2 – Diagram of water translocation from Taiguaiguay reservoir to Camatagua reservoir and values of P, N and CE in 2009.

Figure 3 – Flow of translocation from the Taiguaiguay reservoir to the Tucutunemo River. It can be noted the development of a thick layer of phytoplankton in the pit of the pumping station.

- **Translocation and water level in Camatagua reservoir:** Water translocation made to control water level of Lake of Valencia, contributed to maintain the normal level of water in Camatagua reservoir. The decrease in translocation flow from 2013, until its final elimination in 2015, caused a marked decrease in the water level in Camatagua reservoir (Figure 4).
- **Transparency and turbidity:** Transparency and turbidity (Figure 5) were affected by the entry of water from the Taiguaiguay reservoir. The impact on water quality was still present, even after the stop of translocation. As in 2013, a decrease in water transparency was observed, probably due to the increase in turbidity and the high abundance of phytoplankton, which give the water a turbid greenish color, limiting penetration of light only to a few centimeters from the surface (euphotic layer with no more than 2 m of extension).
- **Ammonia concentration:** Ammonia concentration (Figure 6) also showed an increase from 2012 to 2016, as a consequence of the high content of nutrients reaching the Camatagua reservoir from the Taiguaiguay reservoir, as well as from the increased organic matter decomposition.

Figure 4 – Relationship between water translocation (Q) and water level in Camatagua reservoir.

Figure 5 – Relationship between water translocation (Q), transparency and turbidity in Camatagua reservoir.

Figure 6 – Relationship between water translocation (Q) and ammonia in Camatagua reservoir.

- Orthophosphate, total dissolved phosphorus and total phosphorus concentrations:** Orthophosphate, total dissolved phosphorus and total phosphorus concentration (Figure 7) also showed the same trend of ammonia. According to Salas, Martínó (1991) criteria, this water body was classified as eutrophic. The total-P increased from 40 µg/L in 1992, to more than 80 µg/L in the euphotic layer (GONZÁLEZ, 2017).
- Phytoplankton:** Nutrient input stimulated the increase of phytoplankton density (Figure 8) and this community had a change in its composition. Cyanobacteria now accounted up to 90% of the relative proportion. *Cylindrospermopsis raciborskii*, *Oscillatoria planctonica*, *Leptolyngbya limnetica*, *Microcystis aeruginosa* and *Synechocystis aquatilis* were the dominant species during the whole study period.

Figure 7 – Relationship between water translocation (Q) and orthophosphate (a), total dissolved phosphorus (b) and total phosphorus (c) in Camatagua reservoir.

Figure 8 – Relationship between water translocation (Q) and phytoplankton abundance in Camatagua reservoir.

Conclusions

Water translocation from Taiguaiguay reservoir brought a relative benefit of maintaining the water volume in Camatagua reservoir at normal levels, but affecting its water quality.

Despite the reduction of the translocation since 2013 until its total elimination in January 2015, ammonia, orthophosphate, total dissolved phosphorus and total phosphorus concentrations, continue to increase in Camatagua reservoir, probably due to the decrease of water volume in Camatagua reservoir that also contributed to the increase of nutrient concentration.

An increase in phytoplankton abundance was also noted, mainly Cyanobacteria

species, as a result of the nutrient input from the Taguaiguay reservoir.

Trophic state of Camatagua reservoir changed from oligo-mesotrophic in 1992, to eutrophic after the water translocation.

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References

APHA, 1992. *Standard methods for the examination of water and wastewater*. 18th. edition. APHA, AWWA, WEF. Washington.

CASTILLO, C.E., GÓMEZ, J. and MONTES, C., 1973. El Agua. *Serie Embalses de Venezuela*, vol.1, no. especial. Caracas.

GONZÁLEZ, E.J., 2017. *Evaluación limnológica del embalse Camatagua* (Edos. Aragua y Guárico). Informe Final del Proyecto PEII 20110001391. FONACIT. Caracas, 37 p.

GONZÁLEZ, E.J., MATOS, M.L., BUROZ, E., OCHOA-ITURBE, J., MACHADO-ALLISON, A., MARTÍNEZ, R. and MONTERO, R., 2015. Urban Water. Venezuela. In: ROLDÁN, G., TORREGROSA, M.L., VAMMEN, K., GONZÁLEZ, E.J., CAMPUZANO, C. and DE LA CRUZ, A. (Eds.). *Urban Water Challenges in the Americas. Perspectives from the Academies of Sciences*. Inter-American Network of Academies of Sciences (IANAS) – Programa de Aguas, con apoyo de IHP-UNESCO. ISBN 978-607-8379-12-5. México: 556-601.

SALAS, H. and MARTINÓ, P., 1991. A simplified phosphorus trophic model state for warm-water tropical lakes. *Wat. Res.*, vol. 25, pp. 341-350.