XVI World Water Congress
International Water Resources Association (IWRA)
Cancun, Quintana Roo. Mexico. 29 May- 3 June, 2017

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Water Quality Index of Lake Chapala in Mexico and its potential risk to public health

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Introduction

- Lake Chapala is located 1,500 m above the sea level in western Mexico (CONAGUA 2015).
- Lake Chapala provides the 62% of the water consumed in the Metropolitan Zone of Guadalajara and is the largest body of water in Mexico.
- Lake Chapala is a discharge of the Lerma River, which carries many and different type of contaminants, industrial and domestic sewage without treatment.
- About 300,000 people live in communities and with economic activities as fishery one, around Lake Chapala, which also discharged wastewater without treatment (CEAS 2017).

Objective: To assess the water quality of Lake Chapala, in order to prevent a potential risk for public health.

Methodology

Selection of sampling sites

Seventeen sampling sites in Lake Chapala were selected by using GIS (see Fig. 1). Sampling sites were chosen based on mean municipalities settled on Lake Chapala. Samples were taken approximately 400 to 600 m to the shore of the Lake (Batimetry 1981) between 1 and 1.5 m to analyze the physicochemical parameters. Three additional points were included in order to establish a comparison of this study with the water quality reported by local Drinking Water Treatment Plants (DWTP) (Table 1).

Water sampling campaign

- Two sampling campaigns were established: dry season (from April to early June), and rainy season (July to August), according to CONAGUA.
- Water sampling was performed by triplicate to determine physicochemical parameters and metals. Samples were collected in amber glass and stored at 4 °C before processing the next day.

Physicochemical analyzes

Physicochemical parameters including pH, temperature, Oxidation Reduction Potential (ORP), Dissolved Oxygen (DO), Conductivity, Resistivity, Total Dissolved Solids (TDS), Salinity and Atmospheric Pressure were determined on site by multiparameter probes (HANNA). Parameters as: fecal coliforms, biochemical oxygen demand (BOD), total phosphate (Total PO_4), nitrate, and total solids (TS) were determined on laboratory using the Standard Methods (Eaton 2005). Metals as Aluminum (Al), Barium (Ba), Cadmium (Cd), Copper (Cu), Chromium (Cr), Iron (Fe), Manganese (Mn), Mercury (Hg), Lead (Pb), Sodium (Na) and Zinc (Zn) were determined using the Method 6010B (USEPA 1996).

Water Quality Index (WQI)

The WQI was calculated using the online software of the United States Water Research Center (WRC) (WRC 2016), this program is established according to the parameters specified by the NSF.

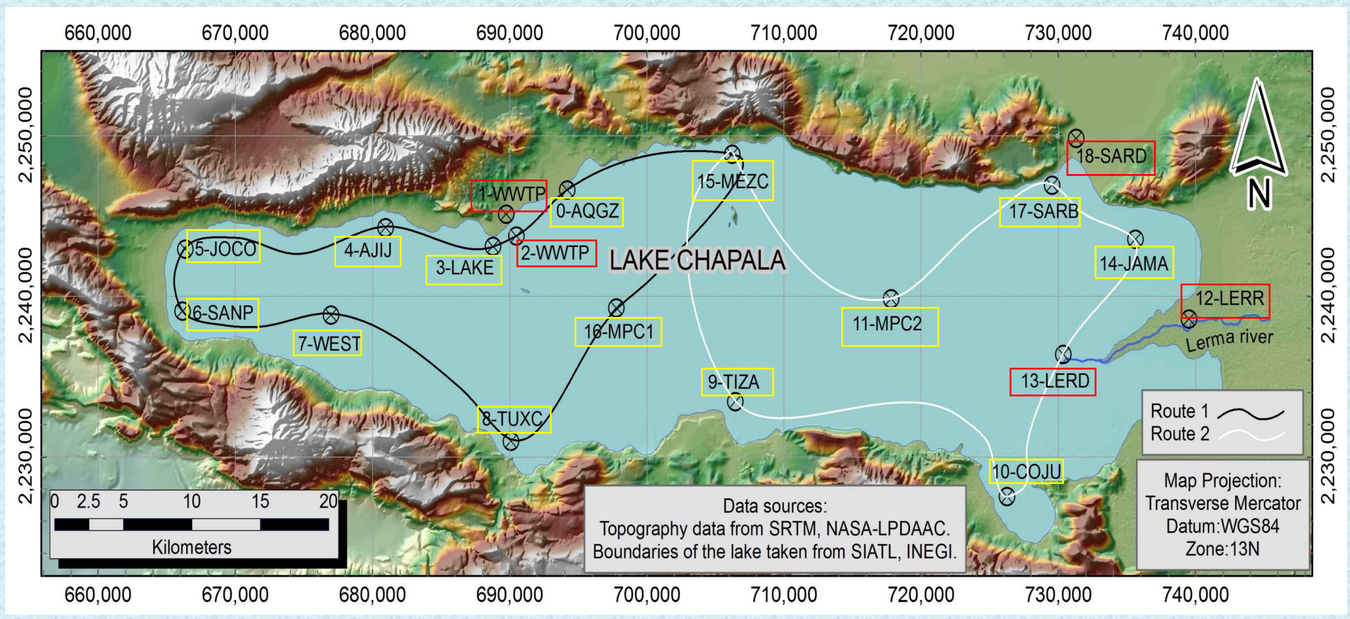

Figure 1. Sampling sites (including two routes) in Lake Chapala, color of label indicates the WQI in Table 1.

Results

Field parameters

- **Average temperature** was around 25 °C for dry and 23 °C for rainy seasons.
- **pH values**, regardless of season and site, are over 7.5 in all sites of Lake (Fig. 2a and 3a).
- **DO (O_2)** exceeded 5 mg/L, except for 1-WWTP and 18-SARD (nearly zero mg/L), in both seasons (Fig. 2b and 3b).
- **Resistivity** ranged from 800 to 1,100 ohm/cm during the dry season.
- **Salinity** ranged from 0.4 to 0.6 units of salinity (PSU) in the dry season (Fig. 2b and 3b), The highest values may be due the anthropogenic activities generate a great amount of salts or also the drags of sands through the Lerma River, which are deposited in the Lake.

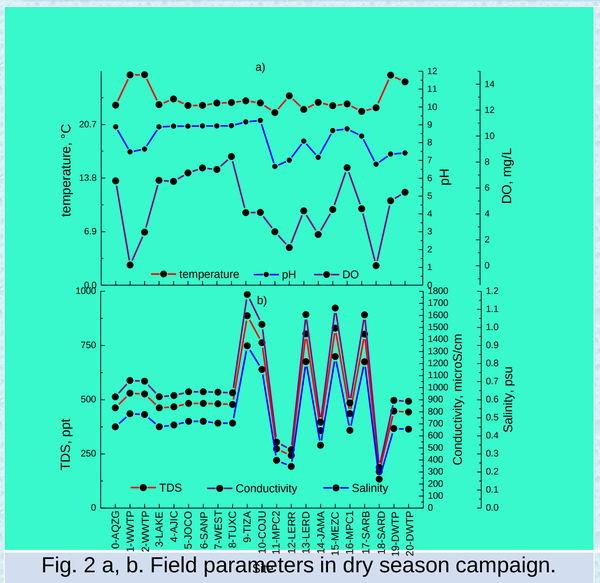

Fig. 2 a, b. Field parameters in dry season campaign.

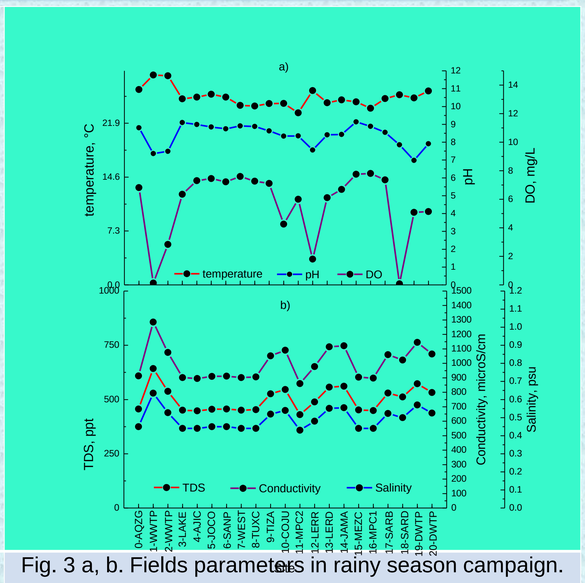

Fig. 3 a, b. Fields parameters in rainy season campaign.

Metals

Concentrations of metals are lower than the limit established by NOM-127-SSA1-1994, including heavy metals as Cr, Hg or Pb, during the two campaigns.

Water Quality Index

Figures 4 a-i show the values of parameters for WQI calculation. Approximately 66% of the sampling sites have a medium level of WQI, 23% for good and 10% for bad (Table 1). The lowest WQI was found for the site 18-SARD (41 points), indicating a bad water quality (red label). Water is currently used for crop irrigation in this region and would be a potential risk for population that consumes the products. The only site that barely achieves the medium level (yellow label) of WQI was site 15-MEZC, whose WWTP has a low degree of efficiency. Sites 19-DWTP and 20-DWTP have 80 and 73 points (green label), respectively, which may indicate that the DWTP operates adequately.

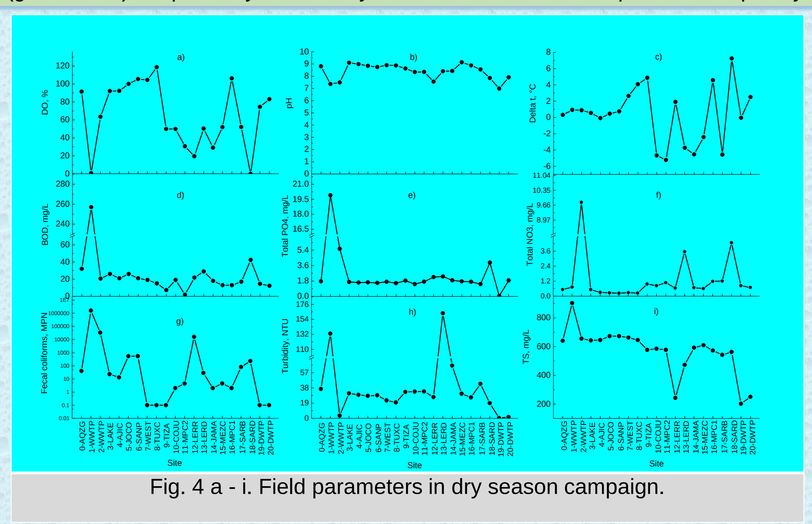

Fig. 4 a - i. Field parameters in dry season campaign.

Table 1 Sampling sites of Lake Chapala, location and keyword

Site number	Location	Label	WQI	Diagnostic (level)
0	Aqueduct to transport water to DWTP of MZG	0-AQZG	59.00	Medium
1	Influent of WWTP of Chapala City	1-WWTP	32.00	Bad
2	Effluent of WWTP of Chapala City	2-WWTP	47.00	Bad
3	100 meter inside of Lake Chapala to WWTP	3-LAKE	59.00	Medium
4	Ajijic	4-AJIJ	62.00	Medium
5	Jocotepec	5-JOCO	56.00	Medium
6	San Pedro Tesistán	6-SANP	56.00	Medium
7	Middle point, near to San Luis Soyatlán	7-WEST	67.00	Medium
8	Tuxcueca	8-TUXC	66.00	Medium
9	Tizapán el Alto	9-TIZA	60.00	Medium
10	Cojumatlan	10-COJU	57.00	Medium
11	Middle point, near to Las Palmas	11-MPC2	59.00	Medium
12	Three km before to Rio Lerma discharge	12-LERR	45.00	Bad
13	Delta of Lerma River	13-LERD	46.00	Bad
14	Jamay	14-AMA	51.00	Medium
15	Mezcala	15-MEZC	55.00	Medium
16	Middle point, near to San Nicolás Ibarra	16-MPC1	63.00	Medium
17	Beginning of Santiago River	17-SARB	53.00	Medium
18	Santiago River,1500 m dowstream	18-SARD	41.00	Bad
19	Effluent of DWTP-1	19-DWTP	80.00	Good
20	Effluent of DWTP-2	20-DWTP	73.00	Good

Sites 19DWTP and 20DWTP are not shown in Figure 1.

Conclusions

WQI lets to define the use and the final disposal of water of Lake Chapala. Average WQI of 56 points in the scale was found, indicating a medium quality water. This type of water is useful for various purposes including the recreation or garden irrigations ones with previous treatment. Water is not recommendable for direct drinking use for sites 12-LERR, 13-LERD, 14-JAMA and 18-SARD under the principle of prevention. This study could contribute for a preventive plan to reduce the potential risk to public health that should include a more strict regulation of municipal and industrial wastewaters, and an adequate drinking water treatment to assure the water quality supplied to the population. The future researches should be oriented to the detection of emerging contaminants.

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Acknowledgments

The authors would like to thank CONACYT (Consejo Nacional de Ciencia y Tecnología, Mexico) for the granted financial aid during this research (CONACYT PDCPN2014-01-248408) and MSC. Juan Galindo for technical assistance.