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Use and Management of Water in a Scarcity Region. The CETYS University Experience in Northwestern Mexico.

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Abstract. CETYS University is located in the state of Baja California, Mexico. Water scarcity is the main environmental problem in the region. The historic accumulated rain from 1980 to 2021, shows an average of 200 mm/year, with a long-term drought affecting the zone. Considering this fact, CETYS University works to minimize and make more efficient the use of water in all its facilities. Wastewater treatment plants operated in two campuses provide recycled water (8.5 liters per second) for green areas and general use in restrooms facilities. Recycled water is stored in cistern tanks with a total capacity of 82,000 m^3, which significantly reduces the need to use external supply of clean city water; also, purification devices give drinking water for students, academics, administrative, and service personnel. Water-efficient appliance usage is a priority in CETYS policies. Considering hand washing taps, toilet flushes, and men's urinals, nearly 88% of the devices are water-efficient. CETYS University complies with the official regulations for preventing pollution from wastewater generated inside campuses. Wastewater goes to the internal treatment plant or the Municipality treatment facilities. Water management at CETYS is a priority to contribute to regional sustainability.

Keyword:
Water Scarcity, Water Management, Wastewater Treatment, Regional Sustainability

1. Introduction

CETYS University (Centro de Enseñanza Técnica y Superior –Spanish full name-) is a multicampus (3 campuses), private, non-profit university, founded in 1961 and located in the Mexican state of Baja California in the Northwestern part of Mexico. The total surface extension of CETYS is 771,139 square meters, with a total buildings area of 93,022 m^2; a ground floor area of buildings of 52,504 m^2, and 36057 m^2 of semiarid forest vegetation with 80,000 m^2 of planted vegetation. During the academic year 2022, CETYS has 5,277 regular students and 841 academic and administrative staff. The total open space area divided by total campus population gives a ratio of 117 m^2/person.

Mexicali Campus, the oldest and largest one (501,339 m^2) is located in the state capital Mexicali, a highly developed industrial and agricultural region. Tijuana Campus (96,617 m^2) is located in Tijuana city, one of the most dynamic cities in the country with industry, commerce and tourism, as well as having the highest population growth rate of the state. Ensenada Campus (173,182 m^2) located in Ensenada city is the youngest campus and recognized by its beautiful landscape and weather (tourism, wine production and internationally recognized high quality restaurants are the main economic engine).

Mexicali Campus is located in the urban area, 8.4 km east of the civic centre and 5.4 km of the international USA/Mexico border. Mexicali city has a population of 1,049,792 inhabitants (official census 2020) and Mexicali Municipality has a territorial extension of 14,528.3 km^2. Tijuana Campus is located in the urban area of Tijuana city, a high population density region which has 1,922,523 inhabitants and a territorial extension of 1,074.1 km2. Ensenada Campus is located in the urban area of Ensenada city and until 2015, Ensenada County was the largest Municipality in the country (52,000 km^2). In that year a new municipality was created, splitting the original Ensenada surface. The total population of Ensenada is 443,807 inhabitants and the new territorial extension is 19,526.8 km^2. Tijuana and Ensenada Municipalities are open to the Pacific Ocean and Mexicali County to the Sea of Cortez (one of the world's main marine biodiversity spot).

CETYS University has the largest solar photovoltaic power generation capacity of all the academic institutions in Latin America (1.20 Megawatts with 3,099 solar panels). Mexicali Campus has 2,873 solar panels and Tijuana Campus 226. Due to climatic characteristics, Mexicali region has the largest solar generation potential of the country. In Mexicali campus, the building of the Centre of Excellence in Business Competitiveness (CECE Spanish acronym), has a sustainable building skin element surrounding all the complex, designed to regulate the indoor temperature for energy efficiency (Figure 1).

Figure 1. Research centre CECE at CETYS Mexicali. Sustainable building skin for energy efficiency

The scarcity of water and the climatic conditions of the region are key elements in the search for sustainability at CETYS University. Mexicali campus has an arid climate while Tijuana campus has semiarid and Ensenada campus has semiarid/Mediterranean. Using information from 2019 [1], the renewable volume of water in Baja California state was 3,045 cubic hectometres (hm^3) of which 1,730 hm^3 comes from the Colorado River (located almost totally in the United States) by means of an international agreement, 363 hm^3 comes by surface rivers and 952 hm^3 through the exploitation of aquifers which are overexploited (23%) or salinized (21.3%) [2]. According with water scarcity characterization of the Food and Agriculture Organization of the United Nations (FAO) [3,4], Baja California state was located in the classification of "water scarcity" with a water amount in 2021 of 822.05 cubic meter/year/person. Additionally, the region California (USA)-Baja California (Mexico) suffered a long term drought, with a marked decrease in rain volume, having Baja California an historic accumulated annually volume of only 200 mm/year (see Figure 2) [5]. Under these extremely complex conditions, CETYS makes every possible effort to conserve and sustainably manage its own water resources and those of the cities where it is located, therefore the main objective of this paper is to present the actual measures taken by the institution to attain water sustainability in its campus and contribute with the alleviation of water scarcity in the region.

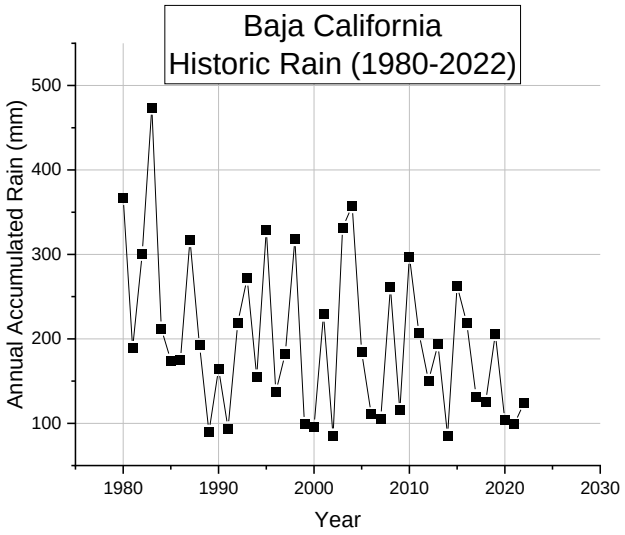

Figure 2. Historic annually accumulated rain in Baja California State

2. Results and Discussions

CETYS University through different processes, programs, policies, and actions seeks to minimize and make the more efficient use of water in all its facilities. At CETYS University two kinds of sewage management are in use: in the first case sewage goes directly to the Municipality conduction pipes for further processing according with the local regulations; in the second case, the sewage goes to the CETYS wastewaters treatment plants for recycling and use on Campus (see Figure 3). Tijuana and Mexicali campus have wastewater treatment plants in operation which fully recycle the water used in CETYS and in the case of Mexicali, even serve the wastewater of the surrounding neighbourhoods. Recycled waters are used 100% in the irrigation of CETYS green areas (planted vegetation) and when there are surpluses, they are used in public areas adjacent to the CETYS facilities.

Water efficiency appliances (e.g. hand washing taps, flush toilets and waterless urinals) are installed in average on 88% of CETYS facilities (see Table 1 and Figure 4). The remaining percentage are old appliances already in use for which policies already consider their replacement. By law, all Mexican toilets must comply with the Official Mexican Standard Norm 009 [6], which regulates the amount of water in each draw as a maximum of 6 litres, CETYS University complies with this regulation.

An internal process of water purification through inverted osmosis and chemical cleansing operates at campus Mexicali to provide pure water for human consumption in all the facilities.

2.1. Wastewater treatment plants at CETYS

Wastewater treatment plants at CETYS can recycle a water flow of 8.5 litres per second or 734.4 m^3/day. Recycled water is used to irrigate green areas or stored in cistern tanks with a total capacity of 82,000 m^3, which significantly reduces the need to use new clean water from the city facilities.

Figure 3. CETYS Tijuana and Mexicali campus wastewater treatment plants

2.2. Water-efficient appliances at CETYS

A direct visual registry of the water-efficient appliances was done in the three campus of CETYS, results and evidence can be found in Table 1 and Figure 4.

Table 1. Water-efficient appliances at CETYS University

Appliance	Total number	Total number of water efficient appliances	Percentage
Hand washing taps	263	232	88.2
Flush toilets	347	347	100.0
Men urinals	153	115	75.2
		TOTAL AVERAGE PERCENTAGE	87.8

Figure 4. Water-efficient appliances at CETYS University (evidence)

2.3. Water purification process at CETYS

At CETYS University campus Mexicali all drinking water for human consumption is produced internally (5,678 liters per day), with a drinking water treatment plant using reverse osmosis process, serving the following areas: classroom buildings, with direct feeding line to drinking fountains; administrative office spaces, with bottles and water coolers; cafeteria, with a direct power line to the coffee and/or drinks vending machines; an infirmary area, connected direct to the sink faucet for cleaning possible wounds and filling station for bottles and water containers, to supply services to offices and areas of sports fields in their training or daily practices (see Figure 5).

Figure 5. CETYS University (Mexicali) water purification plant and community drinking devices

There is a service policy with an external specialized company for equipment maintenance and a laboratory that periodically performing chemical tests on production water to guarantee the health of the CETYS community. The municipal network operator (CESPM) feeds the system directly, from that point the water is pressurized and sent to the Maintenance and Warehouse Building, where the water plant is located.

3. Conclusion or Concluding remarks

CETYS University is located in a region where water scarcity is the main environmental challenge, and a reason for economic and social concern. The institution has made enormous efforts for several years to reduce its water consumption through policies and actions to substitute the regular water appliances for waterless or water-efficient one; to treat and recycle wastewater (all the planted vegetation is irrigated with recycled water), and to purify internally water for human consumption.

Replacing vegetation planted years ago (regardless of water consumption) with low water consumption native species is a work in progress, which is part of the improvement initiatives on sustainability of the institution. New academic initiatives like fog catches prototypes or apps for monitoring water use in selected buildings, developed by students and professors open possibilities for improving the actual conditions.

The regional vulnerability to water scarcity leaves no room for errors or delays. CETYS University has assumed its commitment to make responsible and sustained use of water

resources.

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