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Comprehensive Management of Water Resources: A Step-By-Step Path Towards a Sustainable Campus at The U.D.C.A (Bogotá, Colombia)

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Abstract. Universities are recognized as essential agent of change since future decision-makers related to sustainability are going and will pass through their classrooms. This circumstance becomes an excellent opportunity to demonstrate, with example, and instill in the students how these types of organizations control and approach implementing practices that guarantee sustainability and the appropriate use of resources over time. The Universidad de Ciencias Aplicadas y Ambientales has undertaken different actions related to the Integrated Water Resources Management (IWRM) on campus since 1990. This work focuses on the actions carried out by the Integrated Environmental Management System (latest institutional management model) between the 2014-2016 period to improve the university campus's IWRM (drinking water and wastewater management) from a systemic point of view. The actions implemented were part of the project: Reusing treated water at the University's Wastewater Treatment Plant (WWTP). This project included the following objectives: 1) Reduce the volume and economic costs of sludge water disposal; 2) Reduce drinking water consumption; and 3) Promote environmental education about water resources in students of the different programs of the University. The results were: 1) A decrease of 68.3% in volume and 69.5% in costs of sludge water disposal; 2) A 41.2% saving in drinking water consumption; and 3) 2,475 members of the university community impacted by issues related to the management of water resources.

Keywords:
Reuse and recirculation of treated water, Sustainable campus, Water conservation, Water management.

1. Introduction

Water is one of the most essential resources, as it is the main component, by weight, of all living beings, hence the importance of water as a sustenance of life throughout the planet

[1]. It is the main constituent of the hydrosphere, and through its movement in the so-called "Water Cycle", it generates a marked influence on the regulation of climate and the general state of ecosystems [1,2,3]. Water is recognized as one of the nine processes that control the Earth's stability and resilience, included in the general framework of planetary boundaries [4].

At the same time, the Natural Capital (NC) of countries considers water as part of it since it allows the sustainability of socio-ecological systems by stating that a minimum stock is required to maintain the set of environmental assets and human-nature interactions on which human beings depend on, including climate regulation, human health, agriculture, recreation, and tourism, to mention a few [2,3,5]. The concept of NC is related to Ecosystem Services since nature produces resources that allow the survival and well-being of human settlements and, from there, derive benefits that can be economically accounted for depending on how the resource is considered and conceptualized at a given time [5,6]. For this reason, organizations producing goods and services must strive to conserve and manage water resources since it is essential to guarantee a prosperous and sustainable future for present and future generations and the production process itself [2,7].

This last point is important because, based on this link and other related conceptual approaches (e.g., water management, water footprint, water governance), makes clear that the degradation of ecosystems has significant social, economic, and environmental impacts on human groups settled in different territories throughout the world [3,4,8]. The magnitude of the degradation of one or more resources (including water) in time and space can lead to accelerated loss of livelihoods for some communities that depend directly on natural resources (e.g., fishers and farmers) and can increase the vulnerability of these communities, or others (with indirect dependence), in the face of natural disasters (e.g., floods and droughts). Hence, the urgent need to generate sustainability in the use of resources for maintaining the balance between the present and future needs of people and the healthy functioning of ecosystems [3,6,9].

Likewise, Richardson et al. [4] mention that under the framework of planetary boundaries, the process of Freshwater Change is towards the middle part of the Increasing Risk Zone, both in terms of Green Water (invisible water, retained in the soil and plants in farms, forests, etc.), and Blue Water (water visible in rivers, lakes, etc.). Although this does not represent an imminent danger of shortages in the immediate future, it does imply that people use more water than nature can make available for use (renewal of the resource). For this reason, if adequate actions are not taken now, socio-ecosystems could present scarcity soon [2,3,4,10].

Integrated Water Resources Management (IWRM) is a response to the global water crisis, which has been raised since the Stockholm Earth Summit (1972). It sought to reverse the trend of overconsumption and pollution and conserve water resources as a common good. The bases for this were laid from Dublin's Declaration and the subsequent adoption as an integrated approach by the Rio Summit (1992) and its implementation through Agenda 21 [8,10], taken up and complemented through Agenda 2030 [2]. In this sense, IWRM is a strategy with multiple instruments of planning, control, economic, financial, and governance generation [12,13].

IWRM is defined as "a process that promotes the coordinated development and management of water, land, and related resources to maximize the resultant social and economic welfare equitably without compromising the sustainability of vital ecosystems" [8]. It is a concept with multiple approaches that must align with users' needs. We must not forget that water is a finite natural resource that requires adequate management for its conservation [2,12,14]. IWRM in Colombia has two main approaches to its implementation: 1) the conservation and use of water as a natural resource and 2) the vision as a domestic public drinking water service. The country has developed all water-related actions with these approaches in the last 50 years, including various research and knowledge management topics [7,12,13,14].

On the other hand, universities are recognized as an essential agent of change since future decision-makers related to sustainability are going and will pass through their classrooms. This situation is an excellent opportunity to demonstrate, with example, and instill in students how these types of organizations control and approach implementing practices that guarantee sustainability and the appropriate use of resources over time [15,16,17,18]. In this sense, the Universidad de Ciencias Aplicadas y Ambientales (U.D.C.A) has undertaken different actions related to IWRM on the university campus since approximately 1990 [19,20,21].

Finally, it is necessary to mention that this article presents the actions carried out by the Integrated Environmental Management System (SIGA in Spanish) of the U.D.C.A to improve the institutional IWRM as part of achieving a sustainable campus.

2. Context and problem

The U.D.C.A. is a private Higher Education Institution legally recognized by Colombia's Ministry of National Education (MEN in Spanish) through Resolution 7392 of May 20, 1983. It has several academic spaces of its own in the cities of Bogotá D.C., and Cartagena. This article refers to the actions carried out between 2014 and 2016 to improve IWRM in the Main Campus (Bogotá D.C.), specifically on the so-called Campus Sur (CS in Spanish and henceforth) property. The CS is geographically located at 4°47'58''N; 74°03'00''W; Altitude: 2,559m, and was acquired in 1985 by the Institution. CS has an area of 63,782 m2, with 18,048 m2 built (9,423 m2 at first floor). It has 7,438 m2 of forest, 1,284 m2 of planted vegetation, and many surfaces for water absorption, including an artificial wetland, which acts as a conservation and rainwater flood control area. The Main Campus is in an area of environmental sensitivity in the northern sector of Bogotá D.C., in the transition between urban and rural land. CS is bordered to the north by the Thomas van der Hammen Forest Reserve, and to the east (±700m) is the Guaymaral Wetland (Figure 1), recognized as a RAMSAR area and sponsored as a conservation area by the University since 2017.

The Main Campus is in the "Parcelación El Jardín" neighborhood. It has had a drinking water supply since 1999 (provided by Cojardín S.A. ESP), but it does not have a sewerage service provided by the city [21]. For this reason, the University built two Wastewater Treatment Plants on this property (veterinary WWTP [primary type] and main WWTP [tertiary type]) and their respective sewerage system, the so-called Interconnection System (SI in Spanish and henceforth), to control the environmental impacts generated in the daily work of the different training programs offered by the University. As the property is flat, their slope cannot be used in favor of the SI (Figure 2). So, the SI comprises septic collection boxes with a pumping system on each, which drives wastewater from one box to the next until it reaches the main WWTP (1 to 2 days of retention).

By 2014, the SI cart all wastewater to the main WWTP for treatment. The SI was separated into two sections: one for non-domestic wastewater (NDWW: Veterinary Clinic, animal and human amphitheaters, laboratories, restaurants, and dairy and meat production plants) and another for domestic wastewater (DWW: sinks, urinals, and toilets). The NDWW entered the main WWTP (Figure 3) directly through the anaerobic reactor. This reactor had six cells; the first was the inlet (with pump included), which controlled the inlet flow. The next four had trickling filters; the last was the outlet with subsequent filtering (vertical activated carbon filter) at the end. The output cell had a pump to force the passage through the filter and subsequent mixing (after filtering) in the homogenizer (meeting the DWW line). The DWW entered directly into a screening box (8cm, mesh eye), with subsequent passage to the homogenizer. From the homogenization box, the mixed wastewater was pumped, in a controlled manner, to the aerobic reactor (activated sludge bed) after manual removal of waste that is difficult to treat (toilet paper, sanitary napkins, condoms, paper towels for hands, etc.). The excess sludge was removed from the aerobic reactor and stored for subsequent disposal by an authorized third-party company. This situation implied (in 2014) high costs of disposal of sludge water since between 30 and 60 m3 per day, six days a week, were produced.

On the other hand, the drinking water system had two storage tanks built in concrete, with its own pumping and pressurization system. The distribution system for drinking water did not have blueprints, so the distribution of the different inlet pipes for each building was unknown. Nor was there an adequate record and control of the consumption of drinking water and the conditions of the micrometers at the entrance of each of the properties. Likewise, the consumption value recorded in the supplier's invoices (Cojardín S.A. ESP) was not adequately reviewed.

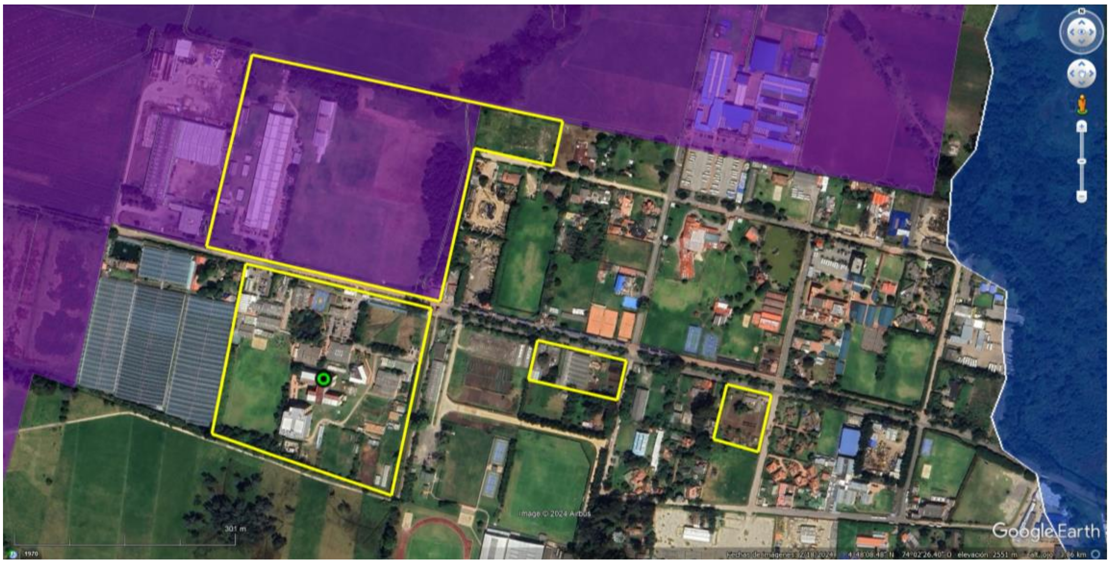

Figure 1. The Main Campus of the U.D.C.A. comprises four properties (yellow lines): Campus Sur (lower left box with a green dot), Campus Norte (upper left box), El Remanso (central box), and Oriental (box on the right). The reserve areas Guaymaral Wetland (Blue Shade), established in 2004, and Thomas van der Hammen (Purple Shade), established in 2011, surround Campus Sur.

Figure 2. Panoramic view (2018) of Campus Sur and Campus Norte (Main Campus). Left: View towards the northeast from the Campus Sur (bottom) and Campus Norte (top). Right: View towards the southeast of the Campus Sur.

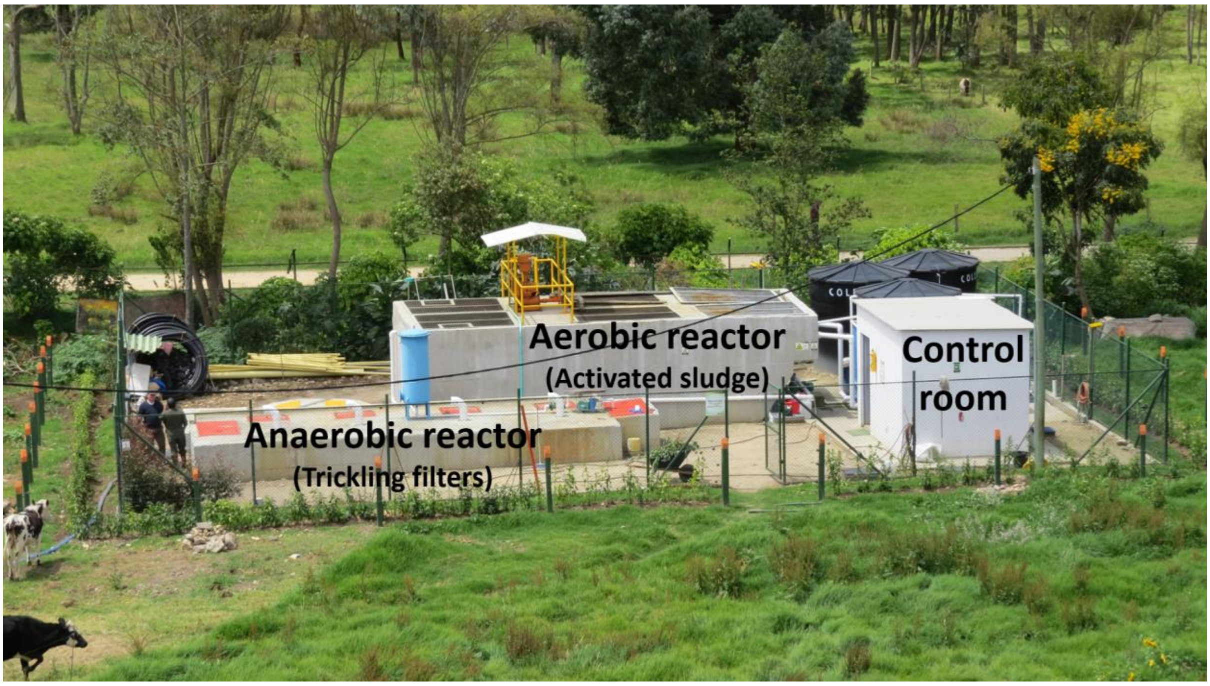

Figure 3. Wastewater Treatment Plant (main WWTP) in 2014.

3. Implementation and results

Several activities were undertaken between 2014 and 2016 to improve IWRM on the university campus. The activities are divided into 2014 and 2015-2016 periods.

3.1. Year 2014 (Base Year):

Between 2013 (second semester) and 2014, the University structured a project for a new environmental management model called the Integrated Environmental Management System (SIGA in Spanish), whose initial purpose was to improve the environmental performance of the University and influence the substantive functions of Training, Research and Social Projection of the different training programs offered by the Institution. An administrative unit depending on the Rector's Office came with the new model, with its own budget and an interdisciplinary group of collaborators [22]. As part of conducting the initial environmental review and determining the baseline of actions from which the new model would start, the high economic costs caused by the disposal of sludge water were detected, and some environmental aspects were prioritized.

The University changed the sludge water disposal's service provider in March because the rates it managed were so high, and the quality of the service provision was inadequate. Once a new supplier was introduced, the rates were renegotiated because of the large volume of water (180 to 360 m3) available weekly. Due to the new rates, 51.1% of economic costs of the year were avoided (Figure 4).

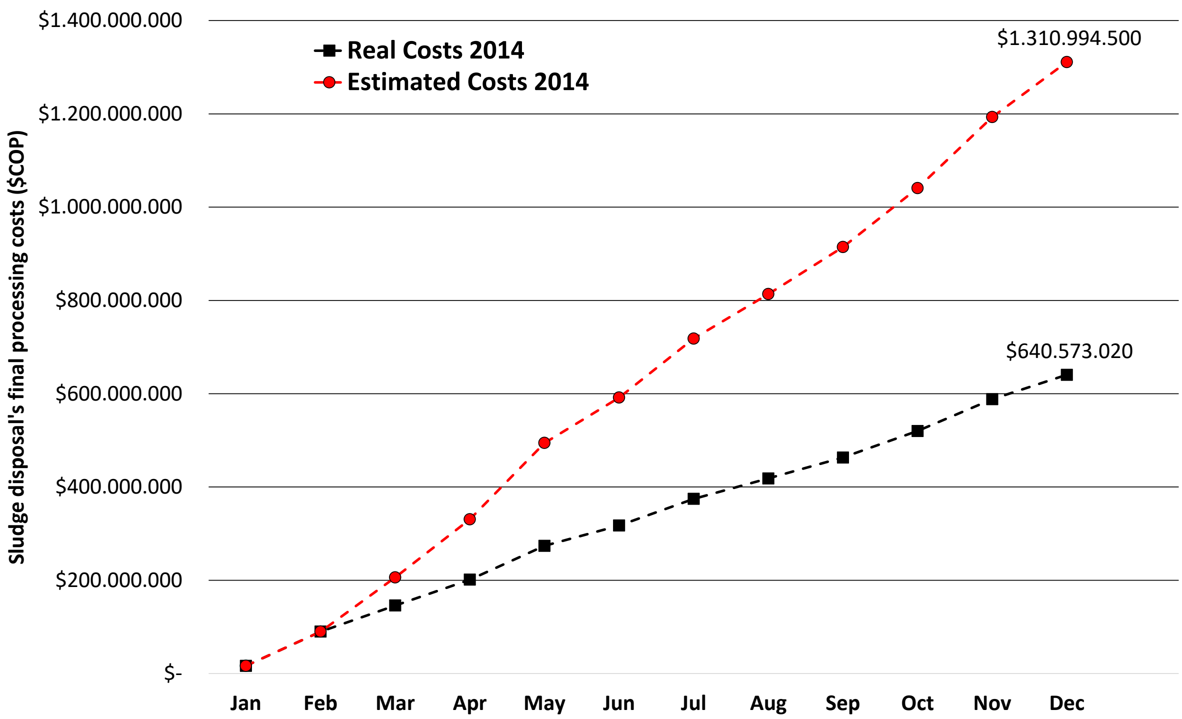

Figure 4. Final costs and estimated costs (without rates renegotiation) of the total accumulated sludge disposal for 2014. Estimated costs were calculated based on the final sludge water disposal volume at the January rate (before changing service provider).

The results and the avoided costs obtained with the implementation of the proposed action during the year agree with what is indicated by Rodríguez-Miranda et al. [23] about the difficulties in obtaining appropriate data for comparison since many aspects of that join in at the time of operating a WWTP, and its subsequent incurred cost calculation. Additionally, Colombia's wastewater and sludge water disposal market is not regulated. Many actors participate in the value chain, and subcontracting outsourcing is the order of the day, resulting in some companies inflating their rates excessively (C. Peraza personal observation).

On the other hand, in October 2014, the data from the micrometer installed in the CS connection began to be recorded daily to determine the potable water consumption pattern. The data were taken from Monday to Saturday (working days) between 6:00 and 9:00 a.m. to guarantee representativeness of approximately 24 hours in consumption per day (yellow dots in Figure 5), except for the weekend, which represented a period of 48 or 72 hours (red dots in Figure 5), considering that Sundays and holidays Mondays are not working days for most of the University's staff.

A regular pattern was expected in weekly consumption, but this did not happen. Consumption was erratic (without a specific pattern), not only between days and weeks but the same day of the week between weeks was also not similar (Figure 5). For example, on a weekend (red dots Figure 5), water consumption was expected to drop due to the lack of activity on campus. If the expected was true, the resulting graph should show this behavior since the changes between these data represent the time range (24h to 48h or 72h). So, to determine the daily data, it is necessary to divide the recorded value by the number of days represented (#1, 2, and 5 Figure 5), thus indicating a lower drinking water consumption during each of those days. However, if the value were to increase, it would imply no decrease in consumption during low activity (#2 Figure 5). Some weeks, they behaved very differently in their daily consumption. For example, one week was erratic daily, and another was more stable (#3 and 4 Figure 5). These data can only be explained by an undetected water-leaking pipe.

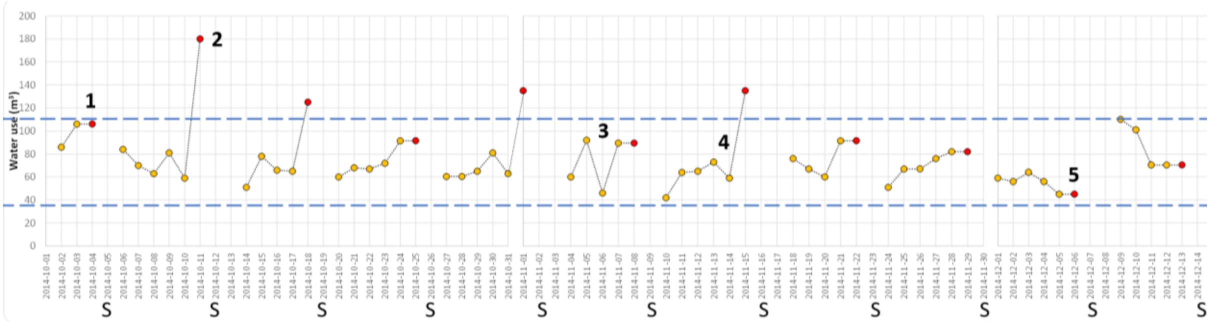

Figure 5. Daily drinking water consumption on Campus Sur (Oct 01 to Dec 14). Maximum and minimum consumption values for October-December 2014 (blue dotted lines). Consumption from Monday to Friday (yellow dots), Saturday consumption (red dot). The letter "S" indicates Sundays. (See text for the explanation of numbers 1-5).

The behavior of data in Figure (5) accounts for most inefficiencies in drinking water distribution systems. In some countries, it is around 41% due to the lack of replacement and maintenance of the distribution networks, deficiencies in connections, and derivations without adequate planning [24].

3.2. Years 2015 and 2016

Considering the results obtained from the activities carried out during 2014, in 2015, the project "Reuse of treated wastewater in the WWTP of the U.D.C.A" was structured to implement several aspects considered in the concept of IWRM in Colombia. Since this project had several specific objectives, included results are shown for the following: 1) To reduce the volume and economic costs of sludge water disposal; 2) Reduce drinking water consumption; and 3) To generate Cultural Capital around the importance of water resources in the members of the university community.

The construction of the infrastructure needed to develop the project began in June 2015. This infrastructure included the expansion of the WWTP, the construction of the distribution network of treated wastewater to the CS buildings, the corresponding pumping system, and the dual system (potable-treated wastewater) for the supply of water to toilets and urinals exclusively in each of the buildings included in the project. The operational tests were carried out in November and December of the same year. The resulting data for 2016 were compared with the values of the previous two years.

Table 1. Volume (expressed by weight) of sludge water disposed of with an authorized manager and economic costs of disposal for the years 2014-2016. The decrease percentage between years and from the base year is indicated for each data, except for the number of truck trips necessary to dispose of the sludge water. NA: Not applicable.

Year	Natural Capital (pollution avoided)				Economic Capital (costs avoided)		
	Truck trips	Total Sludge Disposal (kg)	% decrease from the previous year	% decrease from base year (2014)	Total Sludge Disposal Costs ($COP)	% decrease from the previous year	% decrease from base year (2014)
2014	856	7.973.945	NA	NA	$ 640.573.020	NA	NA
2015	762	7.279.150	8,71	8,71	$ 526.583.000	17,80	17,80
2016	263	2.531.180	65,23	68,26	$ 195.273.600	62,92	69,52

Environmental costs are often overlooked or underestimated due to the underlying paradigm of seeing ecological management as a loss rather than a benefit in the daily operation of organizations. This usually leads to the economic value paid for a service not being reviewed, mainly if the market is not regulated, thus generating unnecessary additional costs for organizations [25]. In fact, on several occasions, this situation is exacerbated by stating that the environmental issue does not cost anything when it only masks a lack or absence of adequate management of the economic resources associated with the ecological issue (C. Peraza personal observation).

For goal two, drinking water consumption was reduced between 2015 and 2016 by 41,2% (Figure 6). By 2015, and thanks to a coincidence, the broken pipe (see year 2014) was found during the excavations to build the distribution network of treated wastewater. This situation allowed its prompt repair and avoided the waste of drinking water, highlighting the importance of having updated blueprints for the distribution network and establishing operational controls.

The results obtained highlight the importance of the proper application of IWRM in the organizational context [2,7,8,12] since it should not only control the excessive consumption of drinking water but also the waste due to inefficiencies due to lack of maintenance and control of the distribution systems within the organizations.

For objective three, the results were satisfactory. Although the generation of Cultural Capital began in 2014 and 2015 with groups of students who would learn about the system and the WWTP and carry out training practices, in 2016, the proposal around IWRM showed the interest of the university community in training in these topics, and other additional environmental ones that were included during that year. The program was so successful that other Bogotá D.C. universities also began visiting U.D.C.A (Table 2).

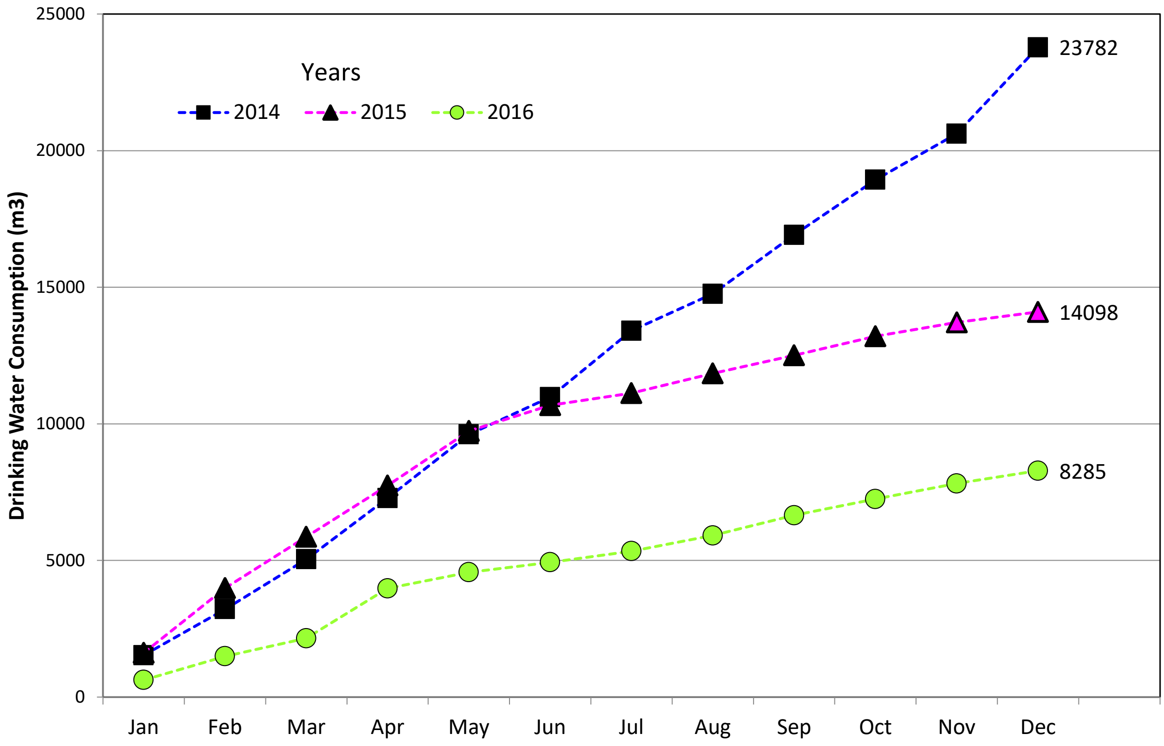

Figure 6. Cumulative drinking water consumption in CS (years 2014-2016). The colored triangles at the end of 2015 (November and December) represent the months of pumping tests.

Table 2. Cultural Capital Training related to environmental issues, including IWRM INT: International student.

HEI	Activity	Country	HEI's group	Years			Total
				2014	2015	2016	
U.D.C.A	Teaching-Practicing		Students and Academic staff	39	72	113	224
	Internal tours		Students and Academic staff	176	180	626	982
	Internal tours		Administrative staff	0	13	57	70
	Environmental knowledge		Administrative and Academic staff	0	0	35	35
	Environmental knowledge		Students	0	0	1064	1064
Others	Teaching-Practicing		Students and Academic staff	1	1	34	36
	Practicing	INT	Students	0	1	0	1
	Internal tours		Students and Academic staff	0	0	47	47
	Internal tours		Administrative staff	0	0	16	16
			Total by year	**216**	**267**	**1992**	**2475**

4. Conclusions

IWRM requires inter- and transdisciplinary approaches to generate coordinated water management, with approaches to water use and conservation and the vision of public service simultaneously, to meet users' needs for use and create an awareness of responsible resource use. In the case of the University, the institutional importance of being an agent of change is corroborated by generating Cultural Capital in the university community members. It is also clear that specific training programs can be an exciting and novel task for acquiring knowledge and understanding the importance of water resources and contributing to establishing the foundations of water governance. Topics that contribute to the environmental, social, and economic sustainability of water resources while helping to build a sustainable campus that improves the experience of students and university community members during their training or work, respectively.

References

1. Curtis H, Barnes NS, Schenek A, Massarini A. Curtis Biología. 7.a ed. Buenos Aires: Médica Panamericana; 2008.

2. ONU Medio Ambiente. Progreso sobre gestión integrada de recursos hídricos. Referencia global para el indicador ODS 6.5.1: Grado de aplicación de la ordenación integrada de los recursos hídricos (0-100). UNEP; 2018.

3. Burton J. Integrated water resources management on a basin level: a training manual. Canadá: UNESCO; 2003.

4. Richardson K, Steffen W, Lucht W, Bendtsen J, Cornell SE, Donges, JF, et al. Earth beyond six of nine planetary boundaries. Sci. Adv. 2023; (9, N°37):1-16.

5. Hernández-Blanco M, Costanza R. Natural capital and ecosystem services. En: Cramer G, Paudel K, Schmitz A. Editores. The Routledge handbook of agricultural economics. 1st ed. New York: Routledge; 2019. p. 254-268.

6. Quijas S, Romero-Duque LP, Trilleras JM, Conti G, Kolb M, Brignone E, et al. Linking biodiversity, ecosystem services, and beneficiaries of tropical dry forests of Latin America: review and new perspectives. Eco. Serv. 2019; (36):1-10 https://doi.org/10.1016/j.ecoser.2019.100909

7. Ministerio de Ambiente, Vivienda y Desarrollo Territorial. Política nacional para la gestión integral del recurso hídrico. Bogotá, D.C.: MAVDT; 2010.

8. Global Water Partnership. Integrated water resources management. Stockholm: GWP; 2000.

9. Naranjo LG. Imaginarios de naturaleza y el futuro de la biodiversidad. Rev. Acad. Colomb. Cienc. Ex. Fis. Nat. 2019; (43, N°168):480-488.

10. World Water Assessment Programme. Informe mundial de las Naciones Unidas sobre el desarrollo de los recursos hídricos 2023: alianzas y cooperación por el agua. Combella, Perugia: UNESCO; 2023.

11. Global Water Partnership. Agua para el siglo XXI: de la división a la acción para América del Sur. Buenos Aires: GWP; 2005.

12. Cardona-Almeida C, Suárez A. Gestión integrada del recurso hídrico en Colombia, una perspectiva histórica. Amb. Soc. Säo Pau. 2024; (27):1-23. http://dx.doi.org/10.1590/1809-4422asoc0170r1vu27L1AO

13. Montoya-Domínguez E, Rojas-Robles R. Normatividad del agua en Colombia ¿Democratización o privatización? Rev. Luna Azul. 2019; (49):126-145.

14. Hernández SM, Posada A. Avances de la investigación sobre la gestión integral del recurso hídrico en Colombia. Rev. U.D.C.A Act. & Div. Cient. 2018; (21, N°2):553-563.

15. Sustainable Development Solutions Network. Accelerating education for the SDGs in universities: a guide for universities, colleges, and tertiary and higher education institutions. New York: SDSN; 2020.

16. Serna G. Campus vivo: una apuesta por la sostenibilidad. Aprop. 2019; (3):15-19.

17. Suárez ML, Vidal-Abarca MR. Biodiversity, ecosystem services and teaching: do our students understand how functioning of ecosystems contributes to human well-being? Limn. 2017; (36, N°2):479-490.

18. United Nations Environmental Programme. Greening universities Toolkit 2.0: transforming universities into green and sustainable campuses. Melbourne: UNEP; 2014.

19. Anzola G, Cabrera LM. Contribución de la Universidad de Ciencias Aplicadas y Ambientales al desarrollo humano sostenible. En: Sáenz O. Comp. 3er seminario internacional universidad y ambiente. Bogotá D.C.: U.D.C.A, PUJ, RCFA; 2005. p. 47-57.

20. Anzola G, Espinosa MT. Gestión ambiental de la U.D.C.A: hacia el desarrollo humano sostenible. En: Sáenz O. Comp. IV seminario internacional universidad y ambiente: gestión ambiental institucional y ordenamiento de campus universitarios. Bogotá D.C.: U.D.C.A, Politécnico Grancolombiano, RCFA; 2007. p. 127-147.

21. Román YC. Sistema Ambiental Universitario: modelo integrado de gestión para la inclusión de la dimensión ambiental y urbana en la educación superior. Bogotá D.C.: Universidad Piloto de Colombia; 2016.

22. Peraza CA. Secretaría Técnica del Sistema Integrado de Gestión Ambiental (ST-SIGA): una apuesta por la sostenibilidad ambiental institucional de la Universidad de Ciencias Aplicadas y Ambientales (UDCA). En: Sáenz O, Plata AM, Holguín MT, Mora W, Callejas MM, Blanco N. Comp. Universidades y sostenibilidad: experiencias de las instituciones de educación superior en Colombia. Bogotá D.C.: Universidad Sergio Arboleda; 2018. p. 33-35.

23. Rodríguez-Miranda JP, García-Ubaque CA, Penagos-Londoño JC. Analysis of the investment costs in municipal wastewater treatment plants in Cundinamarca. Dyna. 2015; (82, N°192):230-238.

24. IDEAM. Estudio nacional del agua 2022. Bogotá D.C.: Ministerio de Ambiente y Desarrollo Sostenible; 2023.

25. Vera-Solano J. Los altos costos como variable limitante en la gestión ambiental de la PYME. Inf. Téc. 2024; (88, N°1):103-118.