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PLAN OF ACTIVITIES TO IMPROVE THE QUALITY OF WATER IN RECREATIONAL AREAS OF PINAR DEL RÍO, CUBA

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ABSTRACT

Water bodies in Pinar del Rio, Cuba, may be used by water sport athletes as well as the general public for recreation. Use of natural water bodies has increased lately worldwide, provoked by, among other causes, the rise of world population relative to the limited availability of swimming pools and the free access to educational, recreational and tourist facilities. However, water quality problems in these natural water bodies may affect recreational users' health. The goal of this study was to monitor the quality of water of lakes used for recreation by citizens near the campus of physical culture, University Pinar del Río. To evaluate use, we conducted interviews and to evaluate water quality, we measured the temperature, pH, water turbidity, and dissolved oxygen in the lakes. We found that the dissolved oxygen was low and turbidity was high in all of the lakes and the pH was low for two the lakes and high for the other three. Given that these conditions indicate impairment, this work serves as a starting point to improve the conditions of the water bodies for recreation. This study reinforced the knowledge and attitude of students concerning the water preservation as well as their interactivity in the community.

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INTRODUCTION

A brief reference about Monitoring of water quality: Global population growth near water bodies increases every year for tourism, sports or physical activity in general. With the increasing threat of climate change and limited environmental education, these water resources have been experiencing drastic impacts. While some studies have focused attention on natural disasters such as hurricanes, long droughts, and floods, the most worrying cases of impaired water quality have been linked to inadequate water management. Many authors have attempted to research on water monitoring based on different indicators ,(Guzmán, et al2016;Mantilla, 2016;Castelló, et al, 2016; Seisdedo, et al 2017; González, & Ceballos 2017; Ríos-Tobón, et al 2017;Betancurt−González, 2017; Chávez, 2018), and Medina, & Lazo, 2018), but these works have been more focused on drinking water, environmental sanity in areas with weak septic systems, or comparative analysis of two water bodies in order to determine the origin of contamination or poor water quality. Some of these studies have also used biological assemblages, rather than sophisticated laboratory analyses of water quality to evaluate the threat to the water bodies. In some cases, scrutiny has been more focused in microbiological indicators to describe poor water quality for human use. On the other hand, some analysis has been addressed to the quality of water in rivers which have been affected by industrial run off. In each of these studies, the investigators have used diverse methodology to determine the origin of water pollution. These studies have called public attention and involved academic institutions and government officials to find a solution to the present deficiencies and mismanagement. This goal, in short, must be the responsibility of sciences nowadays.

Water monitoring and Sustainability: With the overwhelming influence of the social sciences along the integration of all sciences at present times, there is a high demanding of governmental decisions upon scientific grounds. That said, it is vital to highlight water control experiments based on biological and chemical studies but above all things, based on social diagnosis which will make this study contextualized and sustainable. Guzmán et al (2016) focused

on diagnosing the experiences of health authorities in the exercise of surveillance of drinking water quality in Colombia. They used a Delphi methodology, which was based on a questionnaire applied to surveillance coordinators in 12 municipalities and 27 departments, to evaluate the structure, processes, and results of this surveillance program. .This study revealed the inefficiency of this local surveillance program in Colombia, which was decentralization and needed a better governmental control mechanism by the government. Similarly, Mantilla, (2016)also measured poor water quality and sanitation conditions throughout rural areas of Colombia. This study reached the governmental audience, but is was one of many other reports already viewed, and so it was doomed to be just an object of critics rather than an impetus to create an immediate strategy to solve the existing problem.

These studies were warnings to the territorial communities in Colombia, but this century of XXI, in which a wide array of ecological systems are at stake, requires a tool beyond communication. The Earth has currently an urgent need of involvement, compromise and transformation on behalf of sustainability. Education must go on this direction to guide and inspire the new generations.

In contrast,Castelló, et al, (2016) unveils a comparison between the results obtained regarding the self−control through the basic activities in the Monitoring Program and Control of Water Re−use in the region of Murcia, Spain. During a period of supervision during 2012−2014 and after the introduction of the technical instruction, self−control increased in the region confirmed that the Control of water re-use confirmed to be much more efficient that the one carried out in the self-control through the basic activities. This comparison was promoted by the service of environmental sanitation service in the locality to encourage an efficient and healthy reutilization of water. The outcome of this study was very positive because it motivated the use of ecological methods, the engagement and the participation of technical forces such as lab technicians, water engineers and experts. Nevertheless, it might be more far−reaching if it were more cross-disciplinary and involved some other social sectors like education, sports, and culture for one common target. The study of Seisdedo, et al (2017)was technically much clearer about the scientific parameters used to evaluate water quality. They used a 5L Niskin bottle to collect water at the surface and on the bottom of the lake and they measured, pH, temperature, conductivity, and dissolved oxygen (DO) using standardized equipment. In the two monitored water bodies, only pH and DO varied during periods of rain and drought. According to a particular interpretation of this research, there must be said that the methodology of data searching was very accurate regarding microbiological factors. Here they presented a detailed statistics of how to measure the level of pollution or water affection. This study, as a descriptive study of the pollutant origin, was very effective, however it didn´t prove to be sustainable because it didn´t call people´s attention concerning the mismanagement of sanitation water treatment, that´s why it is indispensable the collaboration of social sectors to succeed in this kind of research.

In contrast, Ríos-Tobón, et al (2017) and Betancurt-Gonzalez (2017)focused on monitoring water quality using microbiological tests. Rios-Tobon et al. (2017)identified safe and harmful microorganisms in water used for human consumption. Although the method was feasible, the effect was socially minimal. There was no intention of spreading use of the method to other regions in Columbia or to put into practice ambitious plans to stop pollution through collective compromise. Betancurt−González, (2017) had slightly different objectives, his study was focused on wetlands through the implementation of the method BMWP (Biological Monitoring Working Party). These wetlands were affected by the waste of used water, from the activities carried out by locals close to a bio−park generating a high degree of contamination and reduction of the water quality . This impact not only affected the water related to human uses but else it polluted the habitat of macro invertebrates found in the area of sampling. The method BMWP was very viable to discover the properties of water, but it underestimated the adverse water conditions in the area."

The contribution of Bentacurt-Gonzalez (2017) to the water monitoring in natural water resources is valuable because it not only investigated the state of water itself but also the life of the ecosystem around this water. He depicted and classified the biodiversity existing in the waters under study and this information was used in the mapping and natural diagnosis of the region. Each of these studies used slightly different methods to evaluate the water used for municipal supply, agriculture, tourism, industry, or for habitat**.** However, inonly a few of the studies was there a focus to integrate many of the social sectors that are also affected directly or indirectly by the inadequate management of the water. Considering this gap between the science and society, we undertook research that involved a group of University students with the goal of determining the state of the recreational water in some territories within Pinar del Río, Cuba.By including students in the research, they can contribute to the solution of the problems around these recreational waters.

MATERIAL AND METHODS

For this research, 10 of the 20 students of the Environment and Sports Fan Club, University Pinar del Río, campus Physical Culture, were selected to participate in the study. This group was selected and coordinated by the author of this paper, just to contribute to the scientific training of University students in the campus of sports. This issue is meaningful to their academic formation, taking into account the implication of water quality in sports and the physical recreation in the communities. This ecologist fan club was formed 5 years ago based on this research as a continuation of a project entitled "Environment and Sports" closed institutionally in 1917. In the coming years, we expect more students to join to this scientific movement so that these learning experiences These 10 students are selected attending diverse criterion, among them:

1. Students with major level of knowledge, skills, responsibility, enthusiasm, and compromise towards the environmental tasks.
2. Students who live in different territories of the province (so the monitoring of the water bodies can be as most representative as possible, according to the water diversity of the province)

The recreational waters at the campus of Physical Culture include ponds, lakes and rivers, beaches and any water bodies in which the active population spends its physical recreational leisure time. The water bodies evaluated in this study were

selected based on proximity to the students' residences and likelihood of water pollution: San Juan y Martínez, La Palma, Minas de Matahambre, Consolación del Sur,and Mantua. We evaluated each water body through direct observation, a survey of nearby residents, an interview of local water managers, and a water quality assessment using the World Water Monitoring Challenge (WWMC) methodology. The scientific observation evaluated environmental characteristics of the location of the recreational water body, such as the natural landscape, the nearest social, industrial, or agricultural center in the town under study. The survey was applied to 15 individuals, living in municipalities around the five water bodies under study (75 total).The questions evaluated the knowledge that of inhabitants concerning the physical state of the water resources that they use for recreation and about the measures they can take to protect the health of its waters. The interview was applied to five local water managers for each of two municipalities (10 total). Like the survey, the questions evaluated the physical state of the local water resources where the people of the town recreate and about the measures they can take to protect the health of its waters. The World Water Monitoring Challenge (WWMC) methodology is part of an International program to encourage local initiative to promote awareness of the local and global state of the water. The program donates monitoring equipment through an international program coordinated by the Water Environment Federation (WEF) and the International Water Association (IWA). Although this non−governmental project no longer exists due to budget cuts, a similar project called "The Earth Echo" has replaced it. However, the Academic Fan Club received the equipment of the WWMC program, prior to its defunding, and used this equipment to carry out a descriptive characterization of the recreational water bodies. This WWMC kit contained equipment to measure temperature, DO, pH, and turbidity. The goal of this study was to evaluate water quality problems that might affect the ecology of the water bodies as well as human health.

RESULTS

The Descriptive Data: The observation described the five water bodies evaluated; thesewere located in rural areas, less than 3 kilometers far from the town where most of the young people run their recreation in their spare time. There were no sources of industrial or agricultural pollution;San Juan y Martínez Riverwas situated near a tobacco farm, but the fertilizers usually used are made from organic and natural ingredients. In fact, even motorized vehicles are rare near the water bodies; the transportation used to reach these water resources includedfoot traffic, bicycles, or horseback

For the survey,the 75 young people selected responded as follows:

- 75% did not know about the quality of water where they develop their recreation.
- 85% did not know about any actions to tackle the environmental hazards that might have the quality of water where they develop their recreation.
- 95% had never received any information through the community leaders about how to prevent water pollution or how to protest any actions that could affect the water´s health.
- 85% did not have enough information about the relationshipbetween the health of water, the ecosystem in and around the water body, or the responsibility of the people to look after this system.
- 100% stated that they did not have a social space to denounce the problems regarding the water health care.

In the interview, the 10 water managers who were selected for the study were linked to the awareness of the public about water sanitation, but they also had other administrative responsibilities for water management.Regardless of this inherent conflict, they allagreed to be interviewed by the students as an academic task assigned by the university professor. The answers of these leaders included:

- Only 35% managers stated that the water bodies were not sufficiently equipped for swimming or any leisure activities, that despite these conditions, some people used to spend their weekends taking a bath into their waters.
- 45% of the managers described some elements of actions that can be taken to prevent recreational water pollution.
- 15% gave some ideas about how to create spaces for people to denounce inadequate actions towards the health of the water bodies.
- 85% show themselves friendly, open and cooperative towards the idea of creating projects on behalf of the public water sanitation coordinated between the university and the Community Administration Board (All the communities in the region have a different one and they all respond respectively to a provincial Administration board)

The WWMD methodology is a global one, however it has been assumed by the Academic Fan Club "Environment and Sport" from a local perspective. The target has been based on micro biological facts with a pedagogical and social approach. In this opportunity the members of the team will have a more complete mission; they must diagnose, students are able to communicate and perform a plan of transforming activities this time. This review will be explained in the corresponding steps:

The *Quantitative Data:* The Diagnosis:Using the WWMD methodology, the qualityof the water bodies was diagnosed as warm and turbid, with low dissolved oxygen (Table 1). The pH was low for two of the five water bodies assessed (La Palma and Consol acion del Sur) and high for the other three. The collection was carried out strictly according to the methodology suggested, they collected a sample of water in the given jar into the kit and then they shed some water in the specific disposals for measurement.

Communication with the Constituents: Once the students collected the data, they exchanged information among themselves and began a discussion as a team. As soon as they prepared their data, they invited the leaders of the relevant communities to communicate the results of the monitoring process and to start a dialogue to find possible actionsthat could be used to tackle the problems found in the investigation.

The plan of Activities: In conjuction with the University and the relevant community officials, the Fan Club started discussions with all the members of the community,

Table 1. Results of the Water Monitoring in the 5 selected water bodies

Parameter	Site1	Site 2	Site 3	Site 4	Site 5
Date	17/01/19	21/02/19	23/03/19	12/04/19	15/05/19
Lake	La Palma	Consolación del Sur	San Juan y Martínez	Minas de Matahambre	Mantua
Air Temperature	28 ^{0}C	28 ^{0}C	29 ^{0}C	29^{0}C	29^{0}C
Water Temperatura	30 ^{0}C	28^{0}C	28^{0}C	30^{0}C	29^{0}C
DO	4ppm	4ppm	4ppm	4ppm	4ppm
pH	6	6	8	8	8
Turbidity	100JTU	100JTU	100JTU	100JTU	100JTU

Legend: Dissolved oxygen was measured in units of PPM (Parts per Million); this measurement typically ranges between 4 and 12 ppm in healthy freshwater bodies (Kalff 2002).JTU (Jackson Turbidity Unit) was used to describe the turbidity of the water; drinking water should have no higher than 4 JTU (WHO 2017)

particularlythose people who make use of the water bodies nearby for recreation, about promoting water quality. These discussions described the geographical characteristics of the region around the water bodies, the possibilities for public contribution, and a timelinefor working on the public contributions., The public contributions included:

- Chats for public communication and training
- Clean ups around the water bodies
- Protection of the area from municipal toxic substances runoff or neglect in the use of the water such as toxic chemicals from homes down the sewers.
- Use of the international Ecoflag to symbolize the activities already realized.
- Reforesting around the fields of the water bodies (whenever possible or necessary)
- Work with environmental education with children and young people through a painting contest, ecological music, and other artistic activities.
- Meetings to make a final report and to establish a debate about the activities developed.

DISCUSSION

This research highlighted 1) potential water quality problems in the vicinity of the campus of Physical Culture at the University of Pinar del Rio and 2) the role that students can play in promoting improvement to water quality. During the monitoring process, guided by the professor, the students team were motivated to produce information that they usedto present and discuss discusswater quality issues in the communities. They presented theinformation collected to give an overall evaluation of the monitoring results. The student team organizedtheir final report of the monitoring and the discussion into two general items: Potentialities and Weaknesses.

Potentialities

- Students felt motivated and well instructed through the running of the monitoring and the activities.
- Participants in the whole process cooperated and gave all the necessary information.
- The possibilities of interaction between the university and the community agents were strong.
- The tropical Cuban climate and the water body diversity in Cuba motivate, people to use lakes, river and springs for recreational uses, that issue activates people their concern for water quality.

Weaknesses

- The pH in most of the monitored water bodies was either tooacidic or too alkaline. This deviation suggests pollution provoked by mismanagement of the water by local agents.
- The dissolved oxygen concentration in the water was low for aquatic organisms, so fish, invertebrates and plants may be endangered.
- Most of the surveyed people did not have sufficient knowledge about the condition of the water bodies that they use for recreation.They also had little knowledge of the possible actions that they could take to reduce the pollution and mismanagement; this lack of information may accelerate the deterioration of the places and the loss of environmental value in them.
- Most of the interviewed water managers did not show competent responsibility regarding the care of the water bodiesused for recreation. This lack of responsibility likely reduces the understanding what is required to promote sustainability of these water resources.

Conclusions

As a way of conclusion, this work served as a starting point to improve the conditions of the water bodies for recreation. The methods used were applied in a nonconfrontational and professional way,using undergraduate students who do not have yet official responsibilities as educators or research professors. The information acquired in this study was transmitted to the corresponding communities and local agents to help identify solutions of the problem. This research also helped to develop a cooperative relationship among the students of the Academic Fan Club through a theory and practice plan of activities. This research is also part of the activities realized by the Cuba GSA (Global Sports Alliance) team which frequently posts its activities by using the international Ecoflag. The reports of these activities can be found in the website: https://www.gsa.or.jp/english.

Competing interests: As the main author of this manuscript I declare that I do not have any competing interests in this article. PhD Fernando E. Valladares Fuente

Authors' contributions: The only co-author who really collaborated with the provision and the writing of this manuscript is already mentioned in this work. He is PhD Luis Alberto Cuesta Martínez

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APPENDIX

Photos about the monitoring process in some of the municipalities:

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