A physical-chemical study of water resources in 5 hydropower projects

Estudo físico-químico de recursos hídricos em 5 projetos hidrelétricos

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ABSTRACT
Over the last 60 years, renewable energies have substantially developed; in 2021, around 12.8% of global primary energy came from these technologies. Thus, even though renewable energies have good global acceptance present challenges in quantifying the environmental, social, and cultural effects, generating a lack of knowledge of the impact caused. Nowadays, hydropower is the renewable source with the most significant participation; at the end of 2020, the hydropower installed capacity worldwide was 1,330 GW, and 4,370 TWh were generated in that year. Therefore, the manuscript aims to determine if there are changes in water quality due to the use of hydropower generation in five projects distributed in Ecuador, Argentina, and Uruguay. The methodology is quantitative experimental; experimental because it takes water samples to measure...
parameters and qualitatively compares the lab results to do statistical analyses. Based on the ten samples gathered, it concluded that from 14 physical and chemical parameters, the principal divergences fluctuated in the presence of dissolved solids (26%), total solids (21%), bicarbonates (15%), total hardness (14%), suspended solids (6%), and sodium (4%). Additionally, values show organic matter existence due to vegetation decomposition, and metabolites formed in dams such as Salto Grande, Hidroagoyan, Minas San Francisco, Baba, and Coca Codo Sinclair.

**Keywords:** energy, hydropower, impacts, samples, water.

**RESUMO**
Ao longo dos últimos 60 anos, as energias renováveis desenvolveram-se substancialmente; em 2021, cerca de 12,8% da energia primária global veio dessas tecnologias. Assim, embora as energias renováveis tenham boa aceitação global apresentam desafios na quantificação dos efeitos ambientais, sociais e culturais, gerando um desconhecimento do impacto causado. Atualmente, a energia hidrelétrica é a fonte renovável com maior participação; no final de 2020, a capacidade instalada de hidrelétricas no mundo era de 1.330 GW, e naquele ano foram gerados 4.370 TWh. Portanto, o manuscrito visa determinar se há mudanças na qualidade da água devido ao uso de geração hidrelétrica em cinco projetos distribuídos no Equador, Argentina e Uruguai. A metodologia é experimental quantitativa; experimental porque leva amostras de água para medir parâmetros e compara qualitativamente os resultados de laboratório para fazer análises estatísticas. Com base nas dez amostras coletadas, concluiu-se que de 14 parâmetros físicos e químicos, as principais divergências flutuaram na presença de sólidos dissolvidos (26%), sólidos totais (21%), bicarbonatos (15%), dureza total (14%), sólidos em suspensão (6%) e sódio (4%). Além disso, os valores mostram a existência de matéria orgânica devido à decomposição da vegetação e metabólitos formados em barragens como Salto Grande, Hidroagoyan, Minas San Francisco, Baba e Coca Codo Sinclair.

**Palavras-chave:** água, amostras, energia, hidrelétrica, impactos.

**1 INTRODUCTION**

As a result of the Industrial Revolution, fossil fuels have become a dominant component of the energy grid of most nations around the world. Consequently, the effects of global warming on the climate will significantly impact human health and the environment. There is no doubt that fossil fuel burning is responsible for three-quarters of all global greenhouse gas emissions. Furthermore, fossil fuels contribute to a large amount of local air pollution, leading to at least five million premature deaths annually (Giannakidis et al., 2018; Kapitonov et al., 2021).

But, in addition to environmental changes, energy, and economic development that depends on fossil sources, climate change is accelerated, triggered by uncontrolled
carbon dioxide emissions, causing incessant heat waves, droughts, and floods to a population that does not stop increasing and generating new energy demands.

1. Supplying the world's population requires energy expenditure with the decided increase in renewable and clean energies due to its ability to reduce the burning of fossil fuels. Over the last 60 years, renewables have been important development; as indicated in Figure 1, in 2021, around 12.8% of global primary energy came from renewable technologies (Naranjo-Silva, Punina, et al., 2022; Ritchie & Roser, 2022).

![Figure 1. Share of primary energy from renewable sources.](source)

As Figure 1, renewable energy growth from 1973 to 2021 has doubled from 6% to 12.8% of primary energies. Still, although renewable energies have good global acceptance that is growing, the current world situation of energy production presents several challenges in quantifying the effects that are often intangible environmental, social and cultural, generating a lack of knowledge of the impact caused by renewable energies, and among them hydropower as the largest renewable source globally (Llamosas & Sovacool, 2021; Uamusse et al., 2020).

Although hydropower is the renewable energy source with the most significant participation, ensuring it is sustainable requires a broad discussion. In general, in recent years, this source has had considerable development. At the end of 2020, the hydropower installed capacity worldwide reached 1,330 GW, and in that year, 4,370 TWh were generated, enough electricity to supply world demand for more than two months.
A development example of this renewable source is Latin America as the second region with the most deployment; in Ecuador, over the last 15 years, large hydropower constructions began, this deployment started operations in 2016 and opened many opportunities for economic and industrial development, due to a large amount of energy, investing approximately USD 4.9 billion in eight plants to add 2,832 MW to the country's total energy. However, at the same time, since the start-up of the new hydropower plants, challenges have been observed due to social changes and executed environmental regulations. Therefore, there is a need to establish state policies for energy efficiency and the development of sustainable energies, both in the medium and long term (Llerena-Montoya et al., 2021; Ponce-Jara et al., 2018; Rivera-González et al., 2020). Currently, in Ecuador, in 2021, there is an installed capacity of 5,071 MW of hydropower, representing 77% of its entire energy grid (International Energy Agency, 2022).

On the other hand, according to data from the International Hydropower Association, other Latin American countries such as Argentina and Uruguay manage various energy sources. Still, there is significant hydroelectric development, with 11,340 MW and 1,538 MW installed respectively in each country by 2020 (International Hydropower Association, 2021). An important plant is the Salto Grande hydropower project which contains a shared channel in a humid tropical border region that delivers energy to the two countries; this binational work formed an artificial lake with one of the largest dams in Latin America with 80,000 hectares of water surrounded by forests. It was also built in an area of rapids and rocky hills in the middle course of the Uruguay River, taking advantage of a natural slope called Salto, upstream from the cities of Concordia (Argentina), and Salto (Uruguay) for hydropower generation (International Renewable Energy Agency, 2020; Regional Energy Integration Commission of South America, 2021).

Based on these data of the hydropower deployment of the three countries, it was projected to know what the water resource characteristics are in two conditions, before generating hydroelectricity and after generating energy, to verify if the conditions change (Naranjo Silva & Álvarez del Castillo, 2020). In addition, the loss of water quality in hydropower production due to physical, chemical, and biological changes must be analyzed to manage water sustainability. Thus, to verify said quality, this study presents
the results of tests carried out through ten samples in five projects in Argentina, Uruguay, and Ecuador (Jimenez-Mendoza & Terneus-Paez, 2019; Naranjo-Silva, Rivera-Gonzalez, et al., 2022).

It is essential to mention that the novelty of this manuscript is to analyze changes in the leading natural resource due to hydropower dams: Fresh water is a finite resource, each year, it becomes more polluted, its properties change, and if it is not managed sustainably in the future, the effects will be on all natural ecosystems and human life (Bondarenko et al., 2019; Bongio et al., 2016).

Hydroelectricity in Ecuador, Argentina, and Uruguay is representative and is the leading renewable source in the world; therefore, the manuscript aims to determine if there are changes in water quality due to the use in hydropower generation.

2 METHODOLOGY

The methodology of the manuscript is quantitative experimental; experimental because it takes water samples to measure parameters; therefore, a protocol was defined empirically as follows.

a) To begin with, first 1 kilometer before the water resource enters the turbines in dams, and,

b) The second sample was taken 1 kilometer downstream of the hydropower plants, as shown in Figure 2.

Figure 2. Sampling example in Hidroagoyan hydropower central

Source: (Open Street Map, 2021).

Note: Upstream= Before passing the water = Entrance to the turbines = Dam
Downstream= After passing the water through the systems = Exit the water through the turbines
In order to collect data, the sampling period lasted between June and December 2021 (7 months), with pipettes used to fill two liters of water for each of the rivers superficially up to 25 cm inside in clean containers and then maintaining the water characteristics. These samples are tabulated into physical and chemical items, so Table 1 lists the parameters measured in the study.

| Item | Parameter | Characteristic |
|------|-----------|----------------|
| 1    | Physical  | Turbidity, presence of solids (dissolved, total, and suspended). |
| 2    | Chemical  | Minerals and inorganic indicators such as pH, hardness, iron, and calcium, as well as organic materials such as sulfates, alkalinity, magnesium, sodium, bicarbonate, chlorine, and phosphates. |

Source: (Kibaroglu & Gürsoy, 2015; van der Zwaan et al., 2018).

With the measurable physical and chemical parameters to be determined, the quantitative part of the methodology is based on analyzing each sample in the laboratory with 14 different items of interest. The statistical concepts below support the characterization of the quantified items, and the features of each hydropower project studied are listed in Table 2. All the plants are reservoir types, and the 10 samples were taken from the dams or turbines outlet with a code.

| Country | River | Project | Sample denomination | Place | Observation | Weather type |
|---------|-------|---------|---------------------|-------|-------------|--------------|
| Argentina & Uruguay* | Uruguay | Salto Grande | 1900MW | A1 | Before the hydroelectric Dam | Subtropical zone without dry season, characteristic of the northeast region of Argentina with an average temperature of 18.7 °C. |
|         |       |          |                     | A2 | After the generation of the reservoir Salto Grande | |
| Ecuador | Pastaza | Hydroagoyanan | 156 MW | E1 | Before the hydroelectric Dam Hydroagoyanan | The Interandean region of Ecuador, near the geometric center, has an average rainy tropical climate of 19 °C. |
|         |       |          |                     | E2 | After the generation of the reservoir | |
|         | Jubones | Minas San Francisco | 270MW | E3 | Before the hydroelectric Dam Minas San Francisco | In the subtropical region close to rainy climate forests, the average temperature is 19.5 °C. |
|         |       |          |                     | E4 | After the generation of the reservoir | |
|         | Baba | Baba | 42MW | E5 | Before the hydroelectric Dam Baba | Center-north of the coastal region of Ecuador, with a rainy tropical climate of 27 °C on average. |
|         | Coca Codo Sinclair | Coca Codo Sinclair | E7 | Before the hydroelectric Dam | It is located north of the Amazon Region of Ecuador. |
After the generation of the reservoir Coca Codo Sinclair with an average rainy tropical climate of 18 ° C.

Source: a. (Salto Grande - Binational Corporation, 2014); b. (International Hydropower Association, 2020; Ministry of Energy and Non-Renewable Resources, 2018)

Finally, with the laboratory values, two tabulations types are generated to define differences in the physical and chemical data of the samples, and then each Calculation determined at the researchers' discretion is specified.

\[
\text{Differential Calculation} = |\text{Entrance water} - \text{Turbinated water}| \quad \text{Equation 1}
\]

\[
\text{Proportional Calculation} = \frac{|\text{Entrance water} - \text{Turbinated water}|}{\text{Turbinated water}} \quad \text{Equation 2}
\]

Laboratory Labolab was used for the analysis of the samples, which used standards of the Ecuadorian Organizations, and according to ISO 17025 procedures, which are based on common methods (Standard Methods) that are conducted at a constant temperature of 24 degrees Celsius with a relative humidity of 37% (LABOLAB, 2021).

3 RESULTS

For the results, the analysis begins with the support of the laboratory verifying the 10 samples determining the 14 parameters of Table 3; there are 12 parameters of similar units that are grouped in alphabetical order from the third item, and the pH and turbidity are shown first because they manage different international units.

Table 3. Physical-chemical contrast results of water resources

| Projects          | Samples Code | Salto Grande | Hydroagoya n | Minas San Francisco | Baba | Coca Sinclair |
|-------------------|--------------|--------------|---------------|----------------------|------|--------------|
|                   |              | A1 | A2 | E1 | E2 | E3 | E4 | E5 | E6 | E7 | E8 |
| No. Parameters    | Unit | Befor e | After | Befor e | After | Befor e | After | Befor e | After | Befor e | After | Befor e | After |
| 1 pH              | Standa rd | 7.0 | 6.3 | 6.8 | 6.3 | 7.3 | 6.8 | 7.1 | 7.0 | 8.0 | 6.3 |
| 2 Turbidity      | NTU | 3.0 | 2.0 | 2.0 | 1.0 | 1.0 | 1.0 | 3.0 | 1.0 | 3.0 | 0.1 |
| 3 Bicarbonates   | mg/l | 29.1 | 49.9 | 169.8 | 33.2 | 59.5 | 138.5 | 47.7 | 9 | 61.9 | 151.7 |
| 4 Calcium        | mg/l | 5.1 | 11.8 | 32.1 | 4.0 | 7.2 | 22.8 | 8.3 | 8.0 | 18.2 | 26.3 |
| 5 Chlorides      | mg/l | 5.8 | 9.6 | 17.8 | 4.2 | 6.9 | 15.5 | 6.9 | 6.1 | 7.7 | 23.3 |
| 6 magnesium     | mg/l | 4.7 | 5.3 | 16.8 | 0.7 | 8.7 | 13.9 | 0.5 | 0.3 | 2.1 | 14.7 |
| 7 Phosphates     | mg/l | 5.1 | 7.4 | 9.1 | 1.8 | 6.2 | 3.8 | 0.1 | 0.1 | 0.1 | 0.4 |
| 8 Sodium        | mg/l | 3.0 | 5.0 | 37.0 | 2.0 | 8.0 | 25.0 | 4.0 | 6.0 | 4.0 | 19.0 |
| 9 Sulfates      | mg/l | 15.2 | 14.5 | 44.2 | 14.2 | 19.6 | 46.4 | 5.6 | 4.2 | 15.3 | 37.6 |
As established in the methodology, there are two calculation conditions to search for the critical and recurring parameters of change in the water samples, then the first differential calculation, with the average and total frequency per parameter defined in Equation 1.

Table 4. Differential tabulation

| No. | Item                  | |A1-A2| |E1-E2| |E3-E4| |E5-E6| |E7-E8| |Average| |Frequency |
|-----|-----------------------|------|-----|-----|-----|-----|-----|-----|-----|------|----------|
| 1   | pH                    | 0.6  | 0.5 | 0.5 | 0.0 | 1.7 | 0.7 | 0.2% |
| 2   | Turbidity             | 1.0  | 1.0 | 2.0 | 2.0 | 2.9 | 1.8 | 0.4% |
| 3   | Bicarbonates          | 20.8 | 136.7 | 79.0 | 0.1 | 89.8 | 65.3 | 15.4% |
| 4   | Calcium               | 6.7  | 28.2 | 15.6 | 0.3 | 8.1  | 11.8 | 2.8% |
| 5   | Chlorides             | 3.8  | 13.6 | 8.6 | 0.8 | 15.7 | 8.5  | 2.0% |
| 6   | Magnesium             | 0.6  | 16.1 | 5.2 | 0.1 | 12.5 | 6.9  | 1.6% |
| 7   | Phosphates            | 23.0 | 7.3  | 2.5 | 0.0 | 0.3  | 2.5  | 0.6% |
| 8   | Sodium                | 2.0  | 35.0 | 17.0 | 2.0 | 15.0 | 14.2 | 3.3% |
| 9   | Sulfates              | 0.7  | 30.1 | 26.8 | 1.4 | 22.3 | 16.3 | 3.8% |
| 10  | Suspended solids      | 11.0 | 32.0 | 71.0 | 7.0 | 3.0  | 24.8 | 5.8% |
| 11  | Total dissolved solids| 18.0 | 202.0 | 226.0 | 1.0 | 131.0 | 115.6 | 27.3% |
| 12  | Total hardness        | 19.1 | 136.8 | 74.7 | 5.3 | 71.9 | 61.6 | 14.5% |
| 13  | Totally iron          | 23.0 | 1.7  | 1.2  | 0.0 | 0.2  | 1.1  | 0.3% |
| 14  | Total solids          | 26.0 | 234.0 | 70.0 | 8.0 | 128.0 | 93.2 | 22.0% |
|     | **Total**             | **424.1** | **100%** |

As the second tabulation in Table 5, the proportional processing is presented defined in Equation 2; this Calculation serves as an additional study below the values in absolute difference, average, and incidence in frequency.

Table 5. Proportional tabulation

| No. | Item         | |(A1-A2)/A2| |(E1-E2)/E2| |(E2-E3)/E3| |(E4-E5)/E5| |(E6-E7)/E7| |Average| |Frequency |
|-----|--------------|------|-----|-----|-----|-----|-----|-----|-----|------|----------|
| 1   | pH           | 0.10 | 0.08 | 0.08 | 0.01 | 0.26 | 0.11 | 0.3% |
| 2   | Turbidity    | 0.50 | 1.00 | 2.00 | 2.00 | 29.00 | 6.90 | 22.0% |
| 3   | Bicarbonates | 0.42 | 4.12 | 0.57 | 0.00 | 0.59 | 1.14 | 3.6% |
| 4   | Calcium      | 0.57 | 7.12 | 0.68 | 0.04 | 0.31 | 1.74 | 5.5% |
| 5   | Chlorides    | 0.40 | 3.28 | 0.55 | 0.13 | 0.67 | 1.01 | 3.2% |
| 6   | Magnesium    | 0.11 | 23.06 | 0.38 | 0.42 | 0.85 | 4.97 | 15.8% |
With both differential and proportional tabulations, then in Table 6 a third average based on the data called weighted Calculation, the incidences of this control will verify the parameters that stand out the most in the end among the criteria of Equation 1, and Equation 2.

Further, based on the Pareto theory (80-20), the data is grouped by greater to lesser relevance. This can be achieved by applying statistical techniques to classify the information and identify the essential items, thus, proposing changes for them to be implemented

Table 6 shows Pareto’s values to understand that 20% of the causes originate 80% of the consequences, grouping the data in accumulated frequency (Cárdenas et al., 2021; Noblecilla-Alburque, 2020).

| No. | Item                  | Differential | Proportional | Weighted  | Average frequency | Accumulated frequency | Pareto |
|-----|-----------------------|--------------|--------------|-----------|-------------------|-----------------------|--------|
| 1   | Total dissolved solids| 115.6        | 4.3          | 59.9      | 26.3%             | 26%                   |        |
| 2   | Total solids          | 93.2         | 1.3          | 47.2      | 20.7%             | 47%                   | 80%    |
| 3   | Bicarbonates          | 65.3         | 1.1          | 33.2      | 14.6%             | 62%                   |        |
| 4   | Total hardness        | 61.6         | 2.5          | 32.0      | 14.1%             | 76%                   |        |
| 5   | Suspended solids      | 24.8         | 0.6          | 12.7      | 5.6%              | 81%                   |        |
| 6   | Sodium                | 14.2         | 3.9          | 9.1       | 4.0%              | 85%                   |        |
| 7   | Sulfates              | 16.3         | 0.7          | 8.5       | 3.7%              | 89%                   |        |
| 8   | Calcium               | 11.8         | 1.7          | 6.8       | 3.0%              | 92%                   |        |
| 9   | Magnesium             | 6.9          | 5.0          | 5.9       | 2.6%              | 95%                   |        |
| 10  | Chlorides             | 8.5          | 1.0          | 4.8       | 2.1%              | 97%                   | 20%    |
| 11  | Turbidity             | 1.8          | 6.9          | 4.3       | 1.9%              | 98%                   |        |
| 12  | Phosphates            | 2.5          | 1.2          | 1.8       | 0.8%              | 99%                   |        |
| 13  | Totally iron          | 1.1          | 1.0          | 1.1       | 0.5%              | 99%                   |        |
| 14  | pH                    | 0.7          | 0.1          | 0.4       | 0.2%              | 100%                  |        |
| Total|                       | 424.1        | 31.4         | 227.8     | 100.0%            |                       |        |

Table 6. Coincident and representative weighted values
4 DISCUSSION

With the Pareto Calculation in Table 6 the critical results of all the samples were verified, and then the six parameters with the highest average distortion of the weighted tabulation are illustrated in
Figure 3 to start the discussion and analysis.
In the weighted Calculation, the main discrepancies obtained affording to
Figure 3 are the Total dissolved solids with 26%, Total solids with 21%, Bicarbonates with 15%, Hardness 14%, Suspended solids 6%, Sodium 4%, and the other parameters, showing that these items are the ones that change the most due to the water use in hydropower generation.

From the results when comparing the water samples, it is differentiated that there is a higher concentration of total dissolved solids in the plants concerning suspended solids motive for the variance in color between the samples and the turbidity presence (Walsh et al., 2015). In addition, three of the six parameters that vary the most correspond to some solid (suspended, dissolved, or total). As a result of solids developing in the areas of the dams, light cannot pass through them, which indicates a lack of oxygen, as evidenced in the present study on five Latin American plants (Rasul et al., 2019; Reisancho & Rivera, 2018). Finally, the total solids represent that with water retention in the reservoirs, the hydrological regime of the resource currents is modified first, affecting the runoff processes, increasing the sediments, and changing the geomorphology of the rivers before and after the structures (Cabrera et al., 2021; Zhuo et al., 2020).

On the other hand, bicarbonate, hardness, and sodium represent those different characteristics formed in the dam by stagnating the water, generating micro porosities by calculating the samples, which causes more significant wear when entering the turbines. (Winemiller et al., 2016). Likewise, the concentration of nutrients related to bicarbonates, and sodium increases the production of phytoplankton which reduces the concentration of dissolved oxygen, and the water quality is diminished increasing biomass (Gaudard et al., 2016; Oviedo-Ocaña, 2018). From the organic material found, decomposition processes begin in the reservoirs over time and heat, promoting the production of greenhouse gases such as methane. The International Panel on Climate Change has estimated that dams contribute about 1.3% of greenhouse gas emissions to the global atmosphere, based on their data (Intergovernmental Panel on Climate Change, 2021; Reyes et al., 2021; Schaefli, 2015).

Another issue to discuss is that the five hydropower projects analyzed are presented in tropical climatic conditions where there are high ranges of precipitation, and humidity to proliferate the water abundance, in these areas, there are generally vast ecosystems with little human intervention; under this conception it necessary develop sustainability plans for all hydropower plants verifying the water conditions, and ecosystems monthly to monitoring climate behavior with nearby meteorological stations.
to issue improvements or fixes on an ongoing basis (Johnson et al., 2019; Naranjo-Silva & Alvarez del Castillo, 2022).

With this brief explanation of the main parameters that present modifications, it is also essential to discuss the comments generated by several authors regarding the variation by damming the water resource in hydropower projects; For example, Joerg Hartmann notes that few studies have been conducted that evaluate the potential effects of hydroelectric plants on the water, and that divergences in the inlet volume will be more important in hydropower plants with reservoirs (Hartmann, 2020; Zhang et al., 2018).

It has been found in other studies that hydropower development has a strong influence on local environmental structures, the biotic community changes environments, and the characteristics of water resources alteration, similar to what we have seen in this study (Eloranta et al., 2018; Vaca-Jiménez et al., 2020). In addition, turbidity of the samples is observed, which is related to organic material (slit, algae, and plants) in suspension produces opacity and endangers the natural development of nutrients (Carapellucci et al., 2015).

Although hydropower plants are friendly as they do not use fossil sources, to take advantage of river tributaries efficiently, it is necessary to create reservoirs and dams so that the flow of water remains continuous, creating impacts on the different life cycles of any species that is found in the area, either due to its construction or implementation, affecting the water basins to the point of impacting the animal's density or their reproduction processes (Liu et al., 2020; Majone et al., 2016).

Another problem is the pressure of the water in the dam by containing it on the ground alters its stability, generating landslides or induced seismicity (Zhong et al., 2019). All these changes to the natural conditions of the water significantly affect the biotic diversity in riparian ecosystems, producing a decrease in native species and promoting the anomalous dissemination of exotic species more adapted to lentic conditions (Hofstra et al., 2019).

Future lines could investigate the water quality to analyze improvements both in their efficiency and the representative water use that require the hydropower plants to generate energy, which leads to intangible impacts that are overlooked and must be analyzed as changes in water molecules when hitting the resource in the generation turbines.
5 CONCLUSIONS

Based on the ten samples gathered in the five plants of Ecuador, Uruguay and Argentina, it can be concluded that the divergences of the measured parameters can vary depending on the sample, but the fluctuating values ranges are significant in the dams, the principal items modified as the presence of dissolved solids (26%), total solids (21%), bicarbonates (15%), total hardness (14%), suspended solids (6%), and sodium (4%).

Several parameters associated with freshwater from Argentina, Uruguay, and Ecuador have been analyzed and found to differ after and before the hydropower. Therefore, the water passage upstream versus downstream results in some significant differences in the water resources characteristics, as indicated in Table 6.

Compared with the discharge water intakes, samples taken before the five hydropower plants are turbid, indicating that the construction of large infrastructures with dams generates suspended matter as silt, and living organisms, we observe algae and floating plants that contribute to the opacity appearance in the hydric source, this value shows organic matter existence due to vegetation decomposition, and metabolites formed in dams as Salto Grande, Hidroagoyan, Minas San Francisco, Baba, and Coca Codo Sinclair.

The results of the experiment indicate that hydropower projects with water accumulation systems (dams) place greater pressure on water resources and river flows because of their use of environmental conditions, which can lead to consequences such as damage to the water reserves located in reservoirs, hydrological changes due to large constructions and flooding of land upstream of the plants, resulting in natural phenomena changing.

This is a small study with only five hydropower plants with fourteen physical and chemical parameters measured. There is still a wide range of places where evaluations of water quality can be generated. It is recommended to take this study methodology, and generate more analysis in other hydroelectric projects.

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