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WATER SUPPLY IN ANCIENT ROME AS A CENTRAL THEME FOR SCIENTIFIC AND ENVIRONMENTAL EDUCATION IN THE COLOSSEUM COMPLEX

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Abstract

The Colosseum complex, considered one of the most historically and symbolically significant cultural heritages of Roman civilisation, represents an architectural and cultural legacy that expresses the values, social practices, and ways of life of ancient Rome. It is also widely recognised worldwide as one of the richest educational heritages of ancient cultures. In this context, this study proposes an interdisciplinary approach that articulates scientific, heritage, and environmental education, understanding the Colosseum Complex as a privileged space for critical analyses, investigations, and reflections of a socio-environmental nature. To this end, qualitative, exploratory, and theoretical-propositional essay was conducted, analysing the Colosseum Complex from the perspective of water supply in ancient Rome, highlighting its pedagogical role in environmental and historical discussions and in strengthening scientific and environmental education, both for visiting audiences and for educators who work with the subject of Ancient Rome in the classroom context.

Keywords: Colosseum Complex; Scientific Education; Water Supply in Ancient Rome.

1. Introdução

People's culture is one of the essential elements in preserving identities, transmitting values, and strengthening social culture over time. Furthermore, culture, according to Atalan (2018), is one of the material and spiritual factors that create values about the historical and social processes that shaped and allowed the development of society, as well as being a factor used to communicate to future and current generations, issues that were discussed by previous generations.

Even as indicated by Atalan (2018), when discussing the concept of culture, there is also an association with the concept of conversation, as convergent phenomena. This is because the integration and the "conversation of culture" linked to the educational aspect represent basic tools for the understanding of the importance of cultural heritage, and that we can protect both the present and the

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past. Therefore, culture can be understood as a set of practices, knowledge, and values of a people, which is intimately linked to the concept of cultural heritage, which is the materialisation and preservation of these expressions, guaranteeing their transmission to future generations.

Furthermore, as indicated by Nugroho & Hardilla (2020), cultural heritage is the tangible and intangible expression of a people and is the result of a synthesis of identities and reflections of their ways of life and thinking, as well as being spaces that manifest meanings of the life and history of peoples through visual clarity expressed by urban elements.

Therefore, cultural heritage can be understood as a set of material and immaterial assets that possess historical, cultural, artistic, and symbolic values for a nation or society and present the identity, memory, and way of life of people. This includes material elements, such as historical buildings, monuments, works of art, and documents, as well as immaterial elements such as popular festivals, dances, music, traditions, knowledge, and customs that are transmitted from generation to generation. Cultural heritage, therefore, is fundamental in preserving history and cultural values and ensuring that the knowledge and expressions of populations are maintained for future generations.

In this article, we will focus on the Roman Colosseum Complex, which is considered a cultural heritage site representing a historical, architectural, and symbolic legacy of Roman civilisation, preserving the memory, culture, and values of a society that was able to influence the entire historical context of the Western world. According to Vulpiani et al. (2025), the Colosseum Complex, or Flavian Amphitheatre, is indeed one of the most important historical monuments in the world and also one of the most iconic symbols of Rome, representing ancient Rome. Furthermore, it is one of the most visited places in Italy; in 2019, for example, more than seven million people worldwide visited the Colosseum complex.

Globally, the Roman Colosseum complex is one of the most well-known monuments and is present in the curriculum of numerous countries. In other words, it is a source of historical knowledge, and, therefore, from discussions in

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schools around the world, as well as in the preserved physical space in Rome, Italy, it is part of education, mainly associated with historical subjects. However, given its structural characteristics and preservation by the Italian government, it can be present in interdisciplinary discussions and also be part of other subjects with a different perspective, beyond the knowledge of ancient peoples.

Thus, the objective of this work is to discuss how the Colosseum Complex can be a space for discussing historical environmental issues, linking it to the fields of science education and environmental education. The importance of this work is justified because, while many scientific studies have analysed the Roman Colosseum complex from a historical and social perspective, discussing life in ancient times, research addressing the complex's environmental structure, especially regarding its potential for environmental education, is still scarce.

This work also stems from a partnership between Brazilian researchers in the field of education and science teaching and the Heritage Directorate of the Colosseum Complex.

2. Scientific and environmental education in heritage sites

Science education is a field of education focused on the systematic and critical learning of science, aimed at understanding scientific concepts, developing investigative skills, and making informed and conscious decisions. According to Cachapuz et al. (2005), science education involves learning science as a culture, should be carried out through exploration, experimentation, and reflection, and aims to make those involved think about science in social contexts and in fundamental decision-making.

Furthermore, for Sasseron & Duschl (2016), science education is a fundamental element in modern society, as it allows individuals to construct a scientific culture, understanding, interacting, acting, and reflecting on the social world using scientific knowledge and, through practical activities, enabling engagement and the possibility of expanding the dynamic and social character of science, showing that science and society are interrelated.

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Environmental education, on the other hand, is an educational process that aims to develop awareness, knowledge, skills, and values for more harmonious relationships between human society and the environment. According to Spazziani (2023), environmental education seeks to make society understand the relationships between society and the environment, associated with cultural, social, economic, and political aspects. For Reigota (2000), environmental education is interdisciplinary, as it integrates knowledge from the natural, social, and human sciences, works with the ethical and critical dimension, reflecting on values, rights, responsibilities, and human choices, and understanding the complex relationships between society and nature.

Cultural heritage sites are privileged spaces for working with scientific and environmental education, as indicated by Monteagudo-Fernández et al. (2021). This is because, through work with scientific and environmental education in the context of cultural and natural heritage, it is possible to carry out analyses, investigations, and understanding of the phenomena associated with heritage, from ecological to historical and cultural aspects. It is also possible, when analysing heritage, to reflect on the impact of the actions and contexts they represent in light of human actions upon them.

The integrated work between science, environmental, and heritage education also reveals an interdisciplinary approach, since scientific knowledge and socio-environmental understanding complement each other. This is because the exploration of historical sites, reserves, museums, and protected areas offers practical experiences, investigations, and reflective actions that are aligned with the objectives of science education, while strengthening the commitment to a dialogue on conservation and sustainability, mediated by environmental education.

In this context, Monteagudo-Fernández et al. (2021) highlight that heritage spaces are important domains in the educational process for audiences of all ages, since they allow the articulation of formal and informal learning contexts, as well as enabling the understanding of culture, science, and socio-environmental values. Furthermore, the authors add that visits to heritage sites reveal

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themselves to be educational experiences that go beyond the mere transmission of knowledge and passive connection, favouring interdisciplinary approaches capable of effectively connecting science, culture, and environmental awareness.

In other words, there are converging relationships between scientific, environmental, and heritage education. It is noteworthy that scientific education offers methods for studying natural and historical heritage, while environmental education is capable of contextualising heritage within its ecological and social value. And, in the context of heritage, these sites function as living laboratories where the population can observe, investigate, understand, and reflect on their importance to society. Furthermore, in scientific education, heritage sites act as a source of discussion about social responsibilities, sustainability, and critical preservation, reinforcing concrete actions of care and transformation.

3. Methodological Approach

The present study is characterized as a qualitative and exploratory investigation with an analytical-interpretative approach, aligned with a theoretical-propositional essay, insofar as it is grounded in the critical examination of existing theories and conceptual frameworks in order to address issues pertaining to social and environmental reality. From this analytical foundation, the research seeks not only to interpret phenomena but also to formulate proposals for solutions and new directions of inquiry. In this sense, theoretical-propositional essays transcend mere theoretical discussion, as they incorporate the development of interventions, models, and strategic frameworks that may contribute to addressing the problem under analysis, thereby integrating theoretical reflection with practical applicability in a critical and systematic manner.

According to Gil (2008), qualitative and exploratory research endeavors to comprehend social and scientific phenomena by identifying analytical possibilities and establishing relationships among empirical and conceptual variables. Similarly, Brevidelli, Bergerot, and Domenico (2023) emphasize that theoretical-propositional essays generate structured and theory-based propositions capable

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of informing practical and educational interventions, even in the absence of prior empirical validation. Within this methodological framework, the present investigation examines the Colosseum Complex from the perspectives of scientific education and environmental education, with a particular emphasis on issues related to historical water supply systems. The study seeks to identify the pedagogical potential of the complex and to evaluate its significance as a historical, cultural, and environmental heritage site, thereby contributing to interdisciplinary discussions that bridge historical analysis and environmental awareness.

Moreover, the research proposes actions, educational activities, and strategic approaches that may be implemented within the context of the Colosseum Complex, both during on-site visits and in pedagogical settings such as classrooms. These proposals aim to explore and contextualize the environmental and scientific dimensions of the complex, particularly in relation to water supply and infrastructure in Ancient Rome. By discussing and analyzing historical and environmental scenarios present within the complex, the study seeks to demonstrate how such elements can serve as educational resources that foster critical reflection and interdisciplinary learning.

Consequently, this article advances the argument that specific historical and architectural features of the Colosseum Complex may be examined through the lens of environmental education, particularly concerning themes of water supply and sustainability in historical contexts. It delineates relevant scenarios within the complex and proposes methodological strategies for their pedagogical utilization, whether through guided educational visits or classroom-based activities. Furthermore, the study underscores the potential for interdisciplinary integration between History and Science as a means of enhancing educational practices and promoting a comprehensive understanding of historical and environmental phenomena.

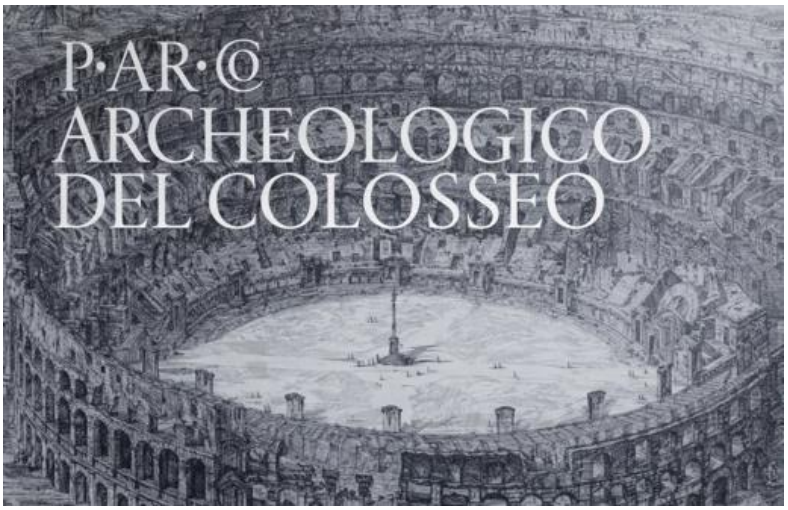
4. The Colosseum Complex and the Water System

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The Colosseum complex, encompassing the Flavian Amphitheatre, the Roman Forum, and the Palatine Hill, constitutes a heritage of extreme historical, cultural, and socioeconomic importance. This complex, preserved to this day, demonstrates the sophistication of Roman engineering and architecture, including construction, hydraulic, and drainage systems, as well as urban planning focused on organising public spaces for entertainment and political practices. Culturally, the Colosseum complex represents a universal symbol of Roman civilisation, preserving collective memory and sociocultural values, and is also included on UNESCO's list of World Heritage sites. Figure 1 shows a photograph of the plaque located at the main entrance to the Colosseum. The plaque identifies the monument, provides official heritage information, and situates the site within its historical and institutional framework.

Figure 1 - Photo of the plaque at the entrance to the Colosseum



Source: Obtained by the researchers, 2025.

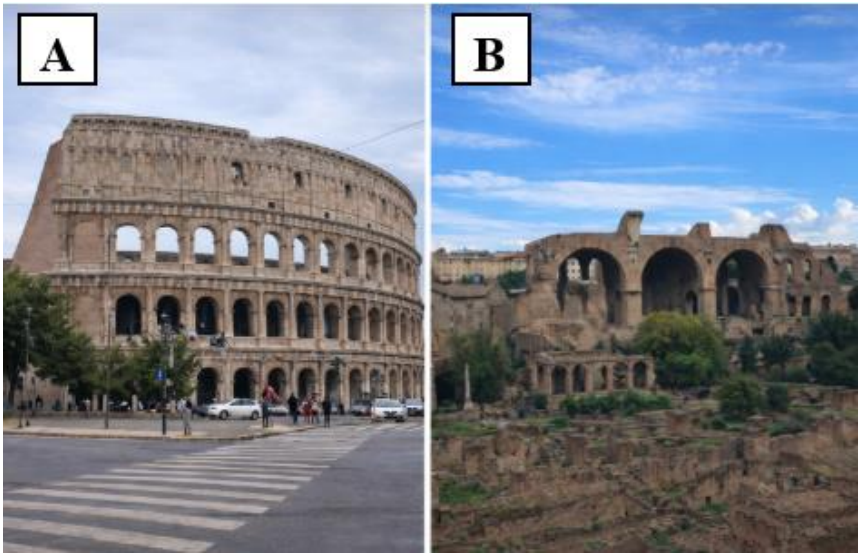
Vulpiani et al. (2025) highlight that designating the complex as a UNESCO World Heritage Site ensures its economic, social, and symbolic value, serving as an instrument that reinforces the collective memory and cultural identity of Rome. Furthermore, according to the authors, the complex is highly relevant in terms of tourism, heritage education, and cultural dissemination. Figure 2 shows two photos obtained by Brazilian researchers during a visit to the Complex. In image

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A, it is possible to see part of the Roman Colosseum as seen from one of the access streets, while in image B, it is possible to see the Roman Forum.

Figure 2 - (A) Colosseum and (B) Roman Forum



Source: Obtained by the researchers, 2025.

In addition, the Colosseum complex, due to the interconnected historical areas in the centre of Rome, which includes the Flavian Amphitheatre (Colosseum), the Roman Forum, and the Palatine Hill, demonstrates that this complex was not limited to the amphitheatre alone but also encompassed the political, social, and religious spaces of Ancient Rome, functioning as a multifunctional urban centre. The Colosseum served as a venue for public spectacles, while the Roman Forum was the administrative, commercial, and civic centre of the city, and the Palatine Hill housed imperial residences and temples. Together, they form a historical and archaeological heritage of global importance, offering evidence of engineering, architecture, urban planning, and social organisation in the ancient Roman Empire, as well as serving as a reference for studies in the fields of history, archaeology, and heritage conservation.

Furthermore, from an academic and scientific point of view, the Colosseum complex can be considered a living historical laboratory, as it provides resources for research in archaeology, conservation, heritage management, and urban sustainability. Moreover, the complex plays a relevant socio-economic role,

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functioning as a tourist hub, generating revenue, employment, and cultural diffusion, while simultaneously promoting heritage education and awareness of the preservation of historical heritage. Thus, it is evident that the complex presents itself as a multifunctional space that articulates past and present, memory and innovation, and culture and education, consolidating its importance as a cultural heritage of universal value.

The work developed by Piro & Goodman (2009) presents a series of archaeological investigations combined with geodetic surveys using ground-penetrating radar (GPR) carried out between 2001 and 2008 at the northeastern foot of the Palatine Hill and in the Colosseum valley, an area contiguous to the Roman Forum. These surveys conducted by the researchers identified buried structures, such as the foundations of houses from the Roman Republic, as well as the remains of a portico that bordered the road between the Colosseum valley and the Forum, in addition to part of a north-south sewer system and foundations related to the Elagabalus baths, which were previously unknown. From these combinations of GPR with confirmatory excavations, the authors were able to reconstruct a complex ancient urban network and demonstrate the historical continuity between the spaces that today comprise the Colosseum, Forum, and Palatine complex.

Regarding water supply, it is noteworthy that a survey reveals that most academic research on Roman water and sanitation treats Rome as a whole, that is, the aqueduct systems, sewers, and urban water supply, and does not focus specifically on the Colosseum complex. Furthermore, when the Colosseum is mentioned in texts discussing water, the discussion is generally more general, focusing on the topography, the valley where it was built, or the city's hydraulic context; thus, there is no study dedicated to establishing relationships between the Colosseum complex and water resources, even though connections are noticeable when visiting the site.

In the work developed by Crapper et al. (2022), there is a complex synthesis of the hydraulic engineering solutions developed in ancient Rome, highlighting aqueducts, distribution systems, reservoirs, and flow control devices, which were

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advanced technologies for the time. According to the authors, by using traditional methods of archaeological analysis, as well as contemporary approaches, including computational modelling, hydrodynamic simulations, and structural diagnostics, they demonstrate an interdisciplinary examination of these infrastructures, revealing aspects that are still poorly understood regarding hydraulic efficiency, urban water supply, and the resilience of Roman systems.

The work written by Hansen (1983) analyses in detail the complex water infrastructure that sustained the capital of the empire, highlighting how aqueducts, public fountains, baths, cisterns, sewers, and the sewage system—especially the Cloaca Maxima—formed an integrated network that guaranteed supply, urban hygiene, and sanitary control. According to the authors, water supply in Rome combined aspects of sophisticated engineering, structured public administration, and social practices strongly linked to the collective use of water, revealing an advanced urban system capable of serving a large population.

Within the Colosseum complex, which includes the amphitheatre, the Roman Forum, and the Palatine Hill, there are numerous historical structures directly related to water supply in ancient Rome. These spaces are not exhibitions about water, nor do they primarily address the issue of water; rather, they are archaeological testimonies of how the Romans collected, distributed, drained, and used water, thus allowing for connections to be made with environmental education, water supply, and sustainability.

4.1 Complex Structures

4.1.1 Point 1. Drainage Systems of the Colosseum

Underneath the arena floor, as well as around the structure, there are underground channels responsible for draining rainwater, controlling humidity, and preventing flooding in the hypogeum. These channels are still being studied by heritage teams, but they demonstrate Roman environmental engineering applied to the amphitheatre.

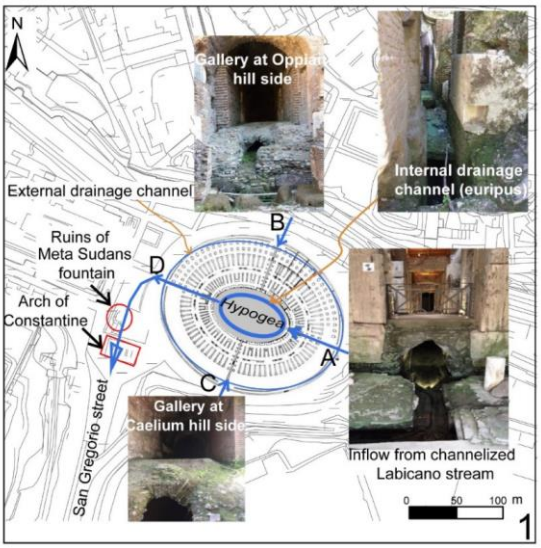
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The Colosseum possessed a highly efficient drainage system, composed of underground channels, sewers, and slopes strategically designed to collect and direct water. The structure had gutters and openings that channelled rainwater from the stands and facade to an internal network that emptied into Rome's general sewage system, the Cloaca Maxima. These mechanisms ensured that even such a large building remained functional, dry, and safe to accommodate tens of thousands of spectators.

In the study conducted by Di Salvo et al. (2020), there is a detailed analysis of the hydrogeological conditions of the Colosseum area, demonstrating how its foundation, as well as the surrounding land, was influenced by underground and surface water flows. Furthermore, by using a 3D geological model to map channels, conduits, and subsurface layers, the authors demonstrated that the site always required complex drainage systems to maintain the stability of the structure and control water accumulation. Figure 3 illustrates the system of axial galleries and underlying drainage channels associated with the Colosseum.

Figure 3 – System of axial galleries and underlying drainage channels.



Source: Obtido de Di Salvo et al.,2020.

It is also noteworthy that in the arena, wells and drains aided in the rapid drainage of water, allowing for both cleaning and the operation of the spectacles. It is noteworthy that, before the construction of the hypogeum, the floor could even

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be flooded for naval battle reenactments, something that also depended on the same drainage infrastructure for controlled filling and emptying. This hydraulic engineering demonstrates the technical sophistication of the Romans in relation to the durability of their systems, many of which still partially function today.

In addition, Di Salvo et al. (2020) show that since Antiquity, the Colosseum area was integrated into the Roman sewage system, such as the Cloaca Maxima, thus allowing for efficient drainage of water collected by the arena and galleries. These findings, as the researchers indicate, demonstrate that the proper functioning of the monument depended on a large and advanced hydraulic engineering system, planned to handle large volumes of water and ensure the conservation of the structure over the centuries.

4.1.2 Point 2. Canal and Conduit Systems in the Hypogeum

Underground within the Colosseum itself, there are supply and drainage channels that aided in cleaning the arena, operating the machinery, and circulating the water necessary for the amphitheater's daily activities. These are structural elements in understanding ancient techniques and water supply.

Furthermore, it is noteworthy that the Colosseum's Hypogeum was a complex underground system essential for the functioning of the spectacles. Its canal and conduit systems demonstrated the high level of Roman engineering. Built mainly in the late 1st century AD, during the reign of Emperor Domitian, the Hypogeum was located beneath the arena and housed corridors, service chambers, and storage areas, as well as lifting mechanisms. To maintain this operational space, the Romans developed an efficient network of drainage channels connected to the city's sewer system, including the Cloaca Maxima.

These channels served to drain rainwater, eliminating the water used for cleaning the area, thus preventing flooding in the subsoil and ensuring structural stability and the safety of workers and animals. Furthermore, the hydraulic conduits carried water to the complex for various uses, such as cleaning and maintenance. With the permanent construction of the Hypogeum, the naumachiae

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became unfeasible, as the fixed system of galleries prevented the arena from being filled. The precision in the inclination of the channels and the integration between drainage, circulation, and internal mechanisms demonstrate Roman mastery of hydraulic engineering and urban planning, principles that, evidently, continue to be admired to this day.

Crapper (2007) analyses the technical feasibility of filling and draining the Colosseum arena using principles of hydraulic engineering. The researcher proposes that water was conducted to the Colosseum through branches of Roman aqueducts, possibly from the Aqua Claudia, using conduits capable of providing a large flow rate in a few hours. According to the researcher, the existence of internal channels, underground galleries, and vertical shafts served as conduits for the conduction and distribution of water, as well as large drainage conduits located in the main axes of the arena, which were responsible for the rapid drainage of water after the performances.

Di Salvo et al. (2020), in performing three-dimensional geological modelling, identified that galleries A, B, and C of the Hypogeum are connected to an elliptical channel (called a euripus) that runs at the level of the hypogea and directs water to galleries such as D, which connects to the external sewage system. As shown in figure 3. Furthermore, the researchers highlight that the hydraulic sealing slots documented in galleries such as A and D suggest mechanisms for water retention and control, indicating that deep conduits may have served to drain accumulated water, while smaller galleries allowed water to enter the underground system. They also emphasise that the drainage channels of the hypogeum were obstructed from the 5th century AD onwards, which contributed to subsequent flooding episodes, and that the reactivation of channels connected to the ancient sewage system was necessary to keep the area dry, thus reinforcing the importance of these conduits for water supply in the Colosseum's subsoil.

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Figure 4 – Underground part of the Colosseum. The blue line indicates where there was a water passage



Source: Obtained by investigators, 2025

Figure 4 represents the Hypogeum of the Colosseum, that is, the underground sectors of the area, and the water was located in this region, since the water descended through openings and was carried by channels in the hypogeum, functioning as a sewer and drainage system, and the construction of channels in this space facilitated natural drainage without the need for pumping. Furthermore, the hypogeum, with its corridors, cells, elevators, and tunnels, was an ideal place to hide pipes, cisterns, drainage systems, and hydraulic mechanisms from the public.

4.1.3 Point 3. Sewers and Drainage Systems of the Roman Forum

The Colosseum complex includes access to the Cloaca Maxima, one of the oldest sewage systems in the world, which drained rainwater, urban waste, and excess water from the valley where the Forum is located. These structures are important for understanding basic sanitation in Antiquity.

The Roman Forum possesses one of the most important sewer and drainage systems of Ancient Rome, which was fundamental to urban life as well as the

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political, religious, and commercial functioning of the city. The Forum was originally situated in a swampy valley between hills (Capitoline, Palatine, and Esquiline), and thus, to make it a usable space, the Romans needed to drain the land, resulting in the creation of large sewers.

The oldest and most important sewer in Rome was the Cloaca Maxima, which was initially built in the 6th century BC, during the Etruscan period. Its function was to drain rainwater from the forum, transport domestic sewage, and also prevent flooding and the transmission of diseases. This sewer emptied into the Tiber River and was large enough to allow people to pass through for maintenance.

The Forum was served by a hierarchical network, meaning it had small sewers under streets and buildings (taverns, basilicas, and temples), as well as secondary canals that converged on the Cloaca Maxima. It is also noteworthy that many public latrines were directly connected to these canals, and the constant flow of water came from sewers and aqueducts, whose purpose was to clean the system. Furthermore, it is important to highlight that under the Forum's pavement there were stone conduits, gently sloping channels, and access covers for cleaning. The pavement was raised several times over the centuries to improve the drainage systems.

There were also limitations to this system: the lack of separation between sewage and rainwater, the final discharge into the Tiber River caused pollution, and the system was directly dependent on a constant flow of water. This engineering system is of great historical relevance and importance, as it allowed the transformation of a swamp into a centre of Roman life, reduced sanitary risks in a high-traffic area, and influenced later sewage systems in Europe.

Hopkins (2007) highlights that the Cloaca Maxima was one of the most important environmental and sanitary engineering works of Ancient Rome, as it played a fundamental role in transforming a swampy valley into a region of great influence in the ancient period, where the Roman Forum was located. The author also emphasises that the construction of this large sewer was not merely a practical solution for drainage but a monumental project that allowed for the

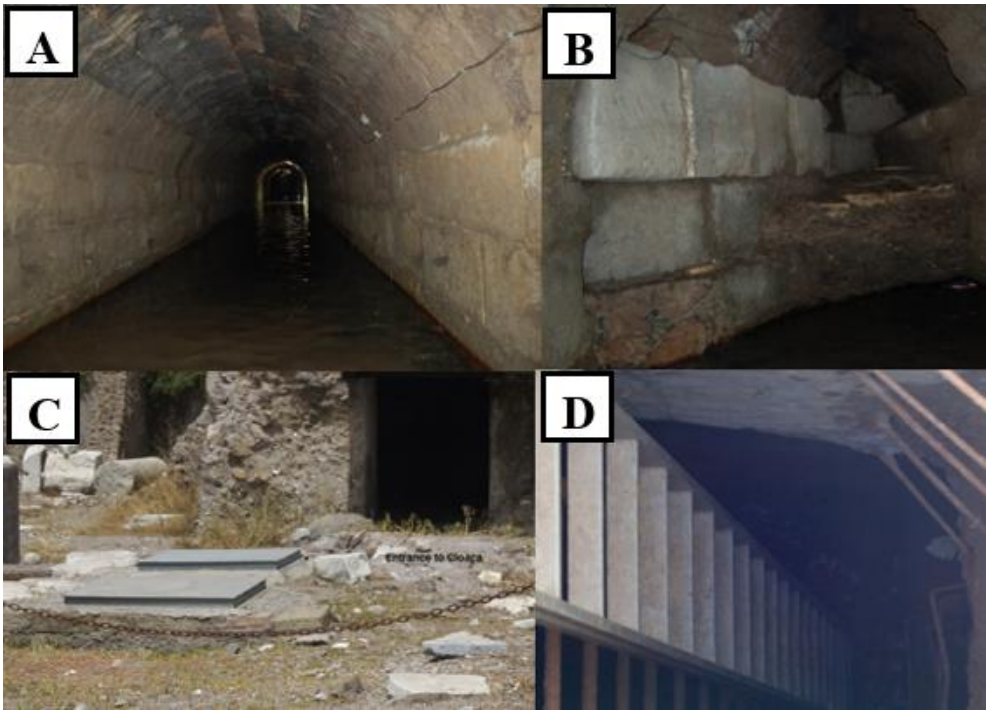
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control of rainwater and residential areas, thus enabling stable urban occupation of the area. It is therefore noteworthy that, without this system, the Forum would hardly have consolidated itself as a political, religious, and economic centre of the city.

Furthermore, Hopkins (2007) adds that the Cloaca Maxima is a symbol of Roman technical advancement and organisational power. It is also important that the large-scale manipulation of water during this period reveals an innovative urban conception, in which sanitary infrastructure, urban planning, and political authority were deeply interconnected. Thus, the author adds that this sewage system was essential for the empire, not only for the health and functioning of the city, but also for the development of Rome's identity as an urban power, which influenced engineering and urban planning models for many centuries. Figure 5 shows some of the sections of Cloaca Maxima, obtained through the work of Hopkins (2007).

Figure 5 – Cloaca Maxima



Source: Hopkins, 2007.

The images presented in Figure 5 were obtained by Hopkins (2007). Section A represents Cloaca Maxima in the interior of the closed Augustan section; B

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represents Cloaca Maxima, Augustan Track, Domitianic closure wall at the corner of the Temple of Minerva; C represents the Forum Transitorium, modern entrance to Cloaca Maxima; D represents Cloaca Maxima, view from the Forum Transitorium entrance to the floor of the canal. This researcher's work, in addition to historical reflections, discusses, through many images, the water structure of the Colosseum complex, therefore, Hopkins' (2007) article is one of the great discussions that can assist in pedagogical practices.

4.1.4 Point 4. Fountains and catchment basins around the Forum and Palatine Hill

Scattered throughout the Colosseum complex are functional and archaeological fountains, historically used for supplying drinking water, cooling the environment, and also for the daily activities of the population. It is evident that a good portion of these fountains were used by nearby aqueducts.

The Roman Forum is located in a natural depression between several hills, such as the Palatine, Capitoline, Esquiline, and Quirinal hills. Initially, this region was swampy and functioned as a natural catchment basin for rainwater and springs that flowed down from the neighboring hills. The Palatine Hill is an elevation with steep slopes, where water naturally flowed into the surrounding valleys, feeding the fountains and widened areas.

There are two springs around the Roman Forum: the Fountain of Juturna (Lacus Juturnae), considered one of the most important springs in the Forum, located near the Temple of Castor and Pollux, and associated with the nymph Juturna, goddess of the waters; this fountain was responsible for providing drinking water since the Archaic period and was monumentalized during the Republic and Empire, but its origin is natural; and the Fountain of Curtius, which, in fact, was not exactly an active spring, but rather a marshy depression in the center of the Forum, and was linked to Roman functional myths and symbolically represents the area's former humid condition before drainage. Figure 6 depicts the Fountain of Juturna, shown in a photograph by James Grout. The image captures

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the archaeological remains of the spring and surrounding structures, illustrating the integration of natural water sources within the urban landscape of ancient Rome. As a visual document, it supports historical interpretation by providing evidence of the spatial organization and cultural significance of water-related sites.

Figure 6 – Fountain of Juturna (Lacus Juturnaiba)



Source: James Grout.

Regarding the catchment and drainage basins of the forum, it is noteworthy that the forum, as a natural basin, received water from the slopes of the Palatine Hill, the Capitoline Hill, and higher areas of the Esquiline Hill; furthermore, rainwater and springs converged into this valley. The Cloaca Maxima, created during the royal period and traditionally attributed to the Etruscan kings, transformed the swampy area into a usable urban space and drained the forum's waters towards the Velabrum and then the Tiber River, which is clearly a crucial example of early Roman hydraulic engineering.

Regarding the springs and catchment on the Palatine Hill, the natural springs of the Palatine had their own sources, sufficient for the first settlements, and these springs explain why the hill was one of the first places occupied by Rome (9th–8th centuries BC). In addition, there was a domestic use, serving for daily consumption and religious rituals, and before the aqueducts, life on the Palatine depended on these local waters. Regarding the historical evolution of water use, it

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is noteworthy that in the Archaic period, there was direct use of natural springs and basins; in the Royal and Republican periods, there was systematic drainage (Cloaca Maxima); in the Imperial period, there were aqueducts that began to complement (but not eliminate) the use of local springs. It is also noteworthy that many of the ancient springs continued to be used for their symbolic and religious value, even after the arrival of aqueducted water.

In addition, the springs and catchment basins of the Forum and Palatine were fundamental to the founding of Rome, to the choice of settlement sites, the development of Roman hydraulic engineering, and the transformation of a natural landscape into a monumental political and religious center.

4.1.5 Point 5. Reservoirs and Cisterns on the Palatine Hill

On the Palatine Hill, there are cisterns carved into the rock, built to collect and store rainwater, irrigate imperial gardens, and supply the palaces. These reservoirs, therefore, reveal ancient practices related to sustainable water supply.

The reservoirs and cisterns of the Palatine Hill in Rome are ancient water storage structures that were fundamental in supplying the residences and palaces of the Roman elite who lived on this hill, including emperors and nobles.

Among their main characteristics and functions, the cisterns were large underground chambers that stored water originating from rain or from aqueducts, protecting it against evaporation and contamination. The reservoirs were tanks built to accumulate water before distributing it to houses, gardens, or baths, ensuring a continuous supply even during periods of drought, demonstrating the advanced Roman knowledge in hydraulic engineering. These also served as part of palatial complexes, integrating water distribution systems for fountains, pools, and ornamental gardens.

In her article, Schmölder-Veit (2011) highlights that, before the arrival of the great Roman aqueducts, the supply of water to the residences on the hill was provided by cisterns carved into the rock to collect rainwater. These cisterns also served as reservoirs for the local aristocratic population, ensuring domestic water

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use in the absence of aqueducts. The presence of these cisterns provides archaeological evidence of a primitive and independent form of water supply during the Republican period, important for understanding how water was stored and used at the top of the ancient city.

Furthermore, as demonstrated by Schmölder-Veit (2011), with urban development and the construction of aqueduct branches during the Imperial period, these original storage structures were integrated into more complex distribution systems, demonstrating the evolution of water use and Roman hydraulic technology, which includes the transformation of reservoirs and cisterns into part of a larger infrastructure. This approach helps to understand not only technological aspects, but also the social organization and the importance of water resources for daily life, and the monumental nature of the Palatine Hill.

4.2 Social Reflections and Environmental Education: The Case of the Colosseum Complex

When discussing the hydraulic system of the Colosseum, it is possible to establish a dialogue with critical Environmental Education, particularly in connection with the ideas proposed by Carlos Frederico Loureiro (2007) and Isabel Carvalho (2009). According to these authors, Environmental Education should not be limited solely to changes in individual behavior; rather, it must encourage subjects to problematize the structural foundations, economic policies, and models of social organization that shape the use of natural resources. From this perspective, analyzing the Colosseum complex enables a shift from a purely descriptive historical approach to a critical examination of how environmental management is embedded in broader social and political structures.

Regarding Ancient Rome, historical evidence demonstrates that water was not merely a technical resource but an essential constitutive element in social relations, power disputes, and historical processes of territorial organization. Thus, the pedagogical approach may incorporate categories such as environmental justice, economic rationality, and distributive conflicts, thereby broadening the

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interpretative scope of historical heritage. Studying Roman hydraulic systems reveals how infrastructure functioned not only to meet practical needs but also to structure urban life and reinforce political authority.

Problematizing the relationship between water use and power in Ancient Rome implies recognizing that hydraulic infrastructure also served as an instrument of political legitimation. The construction and maintenance of aqueducts, public fountains, and drainage systems were directly associated with imperial authorities and elite prestige. Moreover, control over water distribution reinforced social hierarchies, since not all inhabitants had equal access to supply networks. Monumental works such as the Cloaca Maxima and the aqueducts not only addressed sanitary concerns but also symbolized the organizational capacity of the Roman state. As indicated by Simon Ellis (1996), water supply functioned as a technology of governance, articulating engineering, administrative centralization, and the production of social consensus.

When comparing Ancient Rome with contemporary cities, it is necessary to acknowledge the complexity of the phenomena under analysis,since demographic, technological, climatic, and economic conditions differ radically between periods. While Rome operated through slave labor and strong political centralization, modern cities are embedded in global industrial systems and mass consumption chains. Furthermore, current environmental impacts, stemming largely from the Industrial Revolution and extending into the present, such as climate change and large-scale chemical contamination, possess unprecedented magnitude and complexity. Therefore, comparisons should emphasize structural differences, scales of impact, and distinct technological regimes rather than seeking simplistic or direct equivalences.

According to Dylan Kelby Rogers (2018), water in Roman society was a symbol of power, prestige, and social identity. Aqueducts, monumental fountains, and public water systems were visible symbols of the government’s ability to dominate the environment and provide essential goods, thus implying a political dimension within hydraulic infrastructure. In other words, water supply was closely

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linked to relations of authority and social distinction in the city and throughout the Empire.

Rogers (2018) also notes that there were institutions responsible for managing the use and distribution of water, both in public contexts, such as fountains, and in private contexts, through domestic connections. This raises reflections on water justice, as it encourages critical thinking about how different social groups did not have equitable access to water resources in Ancient Rome.

Water supply was also not uniform; that is, practices and priorities of access to this resource were shaped from region to region, thereby creating an implicit and pragmatic politics of inequality in water use that stemmed from geographical, social, and local infrastructural conditions. Rogers (2018) further emphasizes that water was embedded in contexts of religion, spectacle, aesthetics, and consumption, making it more than a mere technical utility; it was part of cultural and identity expressions, revealing and reproducing social power relations and cultural values in different societies.

Thus, this historical understanding of water distribution is connected to the field of Environmental Education, as it allows students to recognize that water, an essential natural resource for life, also functioned as a symbol of power during this period and was distributed unequally among different social strata of the population.

4.3 Educational Competencies

Working with the theme of water in the context of the Colosseum complex can engage multiple competencies and potentials within the educational field. Regarding epistemic potential, when learners move beyond viewing the complex as mere monumental contemplation and begin to understand the hydraulic systems integrated with the Roman Forum and the Palatine Hill, they are required to identify concrete urban problems such as swampy valleys, insufficient drainage, and irregular water supply. This process leads to the reconstruction of hypotheses about Roman technical solutions and comparison with contemporary

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infrastructure. Furthermore, epistemic potential becomes evident when students and visitors analyze material evidence—such as underground channels, slopes, and cisterns—interpret their functionality, and develop causal explanations for the durability of these structures. Rather than merely describing monuments, examining the complexity of the water supply system guides the production of inferences about how technical decisions were linked to social organization, political control, and urban sustainability.

Additionally, the proposed activities mobilize specific epistemic practices. Modeling is activated when participants construct diagrams representing drainage and storage systems. Inference is required when interpreting archaeological remains as evidence of hydraulic planning. Evidence-based argumentation is developed as students are asked to support their claims using material data and reliable sources. The activities also foster competencies in reading topographic maps, conducting spatial analysis of the Forum valley, and making historical comparisons between the Cloaca Maxima and contemporary sanitation systems.

Regarding the critical environmental dimension, this is operationalized when participants analyze the limitations and impacts of the Roman system, such as the mixing of rainwater and sewage and resulting pollution. Instead of formulating generic statements about sustainability, the proposal directs learners to identify historical continuities between ancient floods and current extreme events, water scarcity, and inequalities in access to infrastructure. Students are guided to compare urbanization rates, discuss collective responsibility in sanitation, and evaluate how technical decisions reflect power relations. In this way, water is treated simultaneously as a natural resource, a structuring element of urban space, and cultural heritage, enabling analyses that articulate engineering, society, and environment.

Finally, by integrating guided visits with classroom activities, the plan connects historical heritage and scientific inquiry. The complex is analyzed as a multifunctional urban system in which drainage, supply, and storage form an interdependent network. The approach encourages the formulation of investigable problems, the collection of in situ evidence, and the construction of well-supported

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explanations. Thus, the study of the complex moves beyond historical narrative and becomes an exercise in systemic analysis, through which students learn to correlate hydraulic infrastructure, social organization, and material continuity over two millennia.

4.4 Itinerary: guided tour

It is important to emphasize that the Colosseum complex is extensive and features numerous structures that, in guided tours with historical discussions aimed at understanding all the structures and historical facts, require a long visit of more than one day; therefore, the activities described in the Guide cannot be carried out in isolation but rather must be integrated into already scheduled visits. This is because, in addition to historical knowledge, it is important to understand how the water supply system was fundamental to life in Ancient Rome.

Guided Activity: Environmental Education in the context of the Colosseum Complex.

Theme: “Water, City and Sustainability: Environmental Lessons from Ancient Rome”

Target Audience: Visitors to the Colosseum-Roman Forum complex – Palatine Hill.

Duration: 1h30 to 2h.

General Objective: To promote environmental education through understanding the hydraulic systems of Ancient Rome, stimulating reflections on water supply, sustainability, urban planning, and heritage conservation.

Specific Objectives:

1) To understand how the Romans dealt with drainage, supply, and water storage.
2) To relate ancient water supply practices to current environmental challenges;
3) To raise awareness among visitors about the importance of water as a natural and cultural resource;

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4) To stimulate the development of critical views on urban infrastructure, sanitation, and sustainability.

Itinerary:

Moment 1 – Introduction (15 min)

Location: Colosseum exterior area.

Activity: Begin the activity by asking visitors questions such as: a) What happens to rainwater when it falls in a large city?; b) Do you think ancient cities faced problems with flooding and sanitation? After the dialogue with the visitors, discuss the Colosseum Complex, not only as a historical monument, but also as a complex environmental system, highlighting aspects such as underground drainage, humidity control, and integration with the Cloaca Maxima. At this point, it is important to emphasize to the visitors that water is a structuring element of cities and is highly relevant in the context of sustainable urban planning.

Phase 2 – Guided Thematic Tour (45-60 min)

For this activity, the discussions are expected to be divided into 4 main stations.

Station 1. Drainage of the Colosseum and Hypogeum

In this station, it is important to explain the underground channels, wells, sinkholes, and slopes; discuss flood control and structural stability; and compare them with modern urban drainage systems.

Activity: Show visitors these structures and discuss how environmental risks could arise if these systems did not exist, as well as how they acted in flood prevention, adaptation to natural conditions, and urban resilience.

Station 2. Cloaca Maxima and Roman Forum.

In this station, it is important to present the Cloaca Maxima as a solution for a swampy valley, discuss basic sanitation in Antiquity, and address the limitations of the system, such as the mixing of sewage and rainwater and the pollution of the Tiber River.

Activity: Show visitors the structures and discuss which environmental problems persist today, even with the presence of advanced technology, and also

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the importance of sanitation for public health, and issues associated with water pollution and collective responsibility.

Station 3. Natural Springs and Basins.

This station, held at the Juturna Spring and around the Palatine Hill, should include a discussion about natural springs, the religious symbolism of water and its sustainable use, and the importance of natural catchment basins.

Activity: Introduce visitors to the structures, discuss natural springs and their associated symbolism, and address current issues such as the importance of preserving urban springs and the challenges they face today. Also, discuss the protection of natural resources and water as a cultural and ecological heritage.

Station 4. Cisterns and Reservoirs of the Palatine Hill.

This station, to be held on the Palatine Hill, should explain the use of cisterns for rainwater harvesting, the integration of water, gardens, palaces, and daily life, and compare it to water reuse today.

Activity: Present the structures to visitors and discuss the water storage system, connecting it to aspects of reuse and conscious consumption.

Phase 3. Synthesis and Reflection Activity (15 min)

In this phase, which can be carried out in the open area of the Palatine Hill or Forum, visitors should be engaged in dialogue about urban planning, the rational use of water, the integration between nature and the city, and the durability of structures.

Even though this itinerary is short in relation to the complexity of the facts and contexts that can be explored in the Colosseum complex, it is expected that including discussions on environmental issues, especially those related to water, will result in greater environmental understanding among visitors, a greater understanding of water as a finite and structuring resource for cities, an appreciation of historical heritage as a source of environmental learning, and an encouragement of reflections on sustainable solutions inspired by the past.

Furthermore, it is noteworthy that water has always been a central element in the development of human societies, especially in urban contexts, from the past to the present day. Regarding Ancient Rome, the management of water resources

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was directly associated with the city's urban planning, as well as hydraulic engineering and social organization. It is also noteworthy that the complex represents a historical example of how drainage, supply, storage, and sewage systems were integrated into the urban landscape since antiquity. Therefore, it can be said that the study of these systems transcends the fields of history and archaeology, becoming an important tool in the field of environmental education as well, allowing for reflections on sustainability, rational water use, urban infrastructure, and the conservation of historical heritage. It is also important to highlight that analyses of Roman solutions for water control allow for critical dialogues on contemporary environmental challenges, such as floods, water scarcity, and basic sanitation. Another important message that can be conveyed when discussing the context of water in the Colosseum complex is that Ancient Rome teaches us that great cities only survive when they know how to manage water.

Classroom Activity:

The study of Ancient Rome is part of the History curriculum in numerous countries, and the topic of water supply can be addressed in an interdisciplinary way.

As teaching strategies, one can work through expository and dialogic lessons, such as locating the Colosseum, the Roman Forum, and the Palatine Hill on maps, showing the swampy valley, explaining why drainage was essential, and presenting the Cloaca Maxima as an urban solution found by those peoples.

It is also possible to carry out group activities, in which each group is responsible for one of the following items: 1. Drainage system of the Colosseum; 2. Canals and conduits of the Hypogeum; 3. Sewers and sewage of the Roman Forum; 4. Fountains and catchment basins; 5. Cisterns and reservoirs of the Palatine Hill. To do this, the groups should be guided by the questions: What water problems are associated with this?; What solutions did the Romans find?; What are the implications of this phenomenon for water supply today?

In higher education, it is possible to carry out activities through the analysis of academic sources, for example, understanding phenomena using GPR

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methods, 3D modeling, archaeology; discussing the main discoveries and the reasons for understanding, in addition to the issues of life and monuments of ancient societies, the water supply system.

This lesson plan can be used in an interdisciplinary way between the subjects of History and Science.

Theme: The Colosseum Complex and water supply in Ancient Rome.

Subjects: High School (2nd or 3rd year)

Lessons: 2 lessons of 50 minutes each.

Objectives: To understand the Colosseum Complex as a multifunctional urban space in Ancient Rome, analyzing the relationship between hydraulic engineering, social, political, and cultural organization.

Specific Objectives:

1) To understand the importance of water and sanitation in Roman urban organization;
2) To analyze the role of hydraulic engineering (drainage, sewers, cisterns, and aqueducts);
3) To relate Roman water supply solutions to contemporary urban problems;
4) To develop historical reading skills based on archaeological evidence.

Content to be covered: Ancient Rome and urbanism; Colosseum Complex; Roman hydraulic engineering; Cloaca Maxima and Sanitation; Social, political, and symbolic use of water; historical heritage and cultural memory. Furthermore, the activities suggested here can be carried out in schools without a set time limit, as this can be adapted by teachers; therefore, the ideas are presented as pedagogical moments.

Initially, it's necessary to raise students' awareness by asking thought-provoking questions, such as: How did a city with over 1 million inhabitants, one of the largest in the past, manage water 2,000 years ago? Why was the Colosseum built in a valley? At this point, the teacher should present the activity using images, maps, and plans of the Colosseum complex.

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In the second stage, through dialogue, the teacher should discuss with the students the formation of the Roman Forum valley, the Cloaca Maxima, the Colosseum as a space for spectacle and engineering, and the Palatine Hill and its cisterns. During the explanation, the teacher should also discuss with the students the formation and structure of modern cities and make comparisons.

In the third stage, the class can be divided into five groups, and each group will be responsible for one of the following themes: 1) Drainage systems of the Colosseum; 2) Hypogeum and underground canals; 3) Sewers of the Roman Forum; 4) Fountains and catchment basins; 5) Cisterns and reservoirs of the Palatine Hill. To this end, each group should receive a section of the base text (see above) that highlights a little about each of these structures and also carry out complementary research with the aim of answering the questions: 1) What urban problem existed?; 2) What solution did the Romans create?; 3) What does this reveal about Roman society?

In the fourth stage, students should present the ideas they have raised, and, through a group discussion, the teacher should complement what the students have said, correcting concepts and reinforcing the relationship between water, power, urbanism, and culture. Then, still within the group discussion, students should summarize their understanding in a sentence and share it with their peers, discussing the topic.

The Colosseum complex should not be understood merely as a monument, but as part of a complex urban system where water supply was fundamental to the functioning of the city and to Roman power. Scale models are also interesting tools to reinforce learning and discussion of the structures.

5. Final Considerations

It is evident that addressing these issues depends on the tour guides, or the visitors themselves who go independently, but in the classroom, the teacher can work on them. Thus, the next step is to work with these issues in the classroom and assess the students' appropriation of them.

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This study aimed to analyze the Roman Colosseum Complex as an interdisciplinary axis for Scientific and Environmental Education, based on the theme of water supply and management in Ancient Rome. By understanding the Colosseum, the Roman Forum, and the Palatine Hill as an integrated urban system, the research sought to highlight how Roman hydraulic solutions—such as drainage, sewers, cisterns, underground canals, and fountains—can be mobilized as pedagogical resources for critical reflections on sustainability, urban planning, and the rational use of water.

The research indicates that the Colosseum Complex is a privileged space for the articulation between Scientific, Environmental, and Heritage Education, functioning as a "living historical laboratory". Analyses have shown that Roman hydraulic structures reveal a high level of technical skill and urban planning, allowing parallels to be drawn between ancient water supply practices and contemporary environmental challenges such as flooding, basic sanitation, water scarcity, and the conservation of historical heritage.

The importance of the research lies in broadening the perspective on the Colosseum Complex, traditionally approached from a predominantly historical and architectural standpoint. By incorporating the environmental and scientific dimension, the study contributes to strengthening interdisciplinary educational practices, both in formal teaching contexts and in non-formal spaces, such as guided tours and educational activities in cultural heritage sites, promoting an education focused on citizenship, sustainability, and the appreciation of heritage.

Among the limitations of the study, the scarcity of specific research that directly relates the Colosseum Complex to the theme of water supply from an educational and environmental perspective stands out. In addition, the research has a predominantly qualitative and theoretical-interventional character, not contemplating, at this stage, the systematic empirical application of educational proposals with different audiences, which restricts the evaluation of direct impacts of the suggested actions.

As next steps, it is suggested that field studies be conducted involving the practical application of the proposed educational itineraries, both within the

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Colosseum Complex itself and in school settings, allowing for the analysis of the perceptions of students, teachers, and visitors. It is also recommended to deepen comparative investigations between ancient and modern water systems, expanding the dialogue between past and present, and strengthening the role of cultural heritage sites as strategic spaces for Scientific and Environmental Education.

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