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Vorgeschlagene Zitierweise/Suggested citation:
Kuroiwa, Julio M. (2016): Historic examples of water management in pre-columbian andean society. In: Hydrolink 2016/3. Madrid: International Association for Hydro-Environment Engineering and Research (IAHR). S. 73-75. https://iahr.oss-accelerate.aliyuncs.com/library/HydroLink/HydroLink2016_03_Latin_America.pdf.

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HISTORIC EXAMPLES OF WATER MANAGEMENT IN PRE-COLUMBIAN ANDEAN SOCIETY

BY JULIO M. KUROIWA

Resumen

En este artículo se presentan algunos ejemplos del manejo del agua en culturas andinas precolombinas que ocuparon el territorio entre el Sur de Colombia hasta el Norte de Chile y Ecuador y que posteriormente fueron conquistados por el Imperio Inca. Se presentan ejemplos de manejo de agua para fines agrícolas en Caral (3000 A.C), las galerías filtrantes de la Cultura Nazca (200 – 800 D.C.) y las obras hidráulicas en las ciudadelas de Macchu Picchu y Tipón del Imperio Incaico (1450 D.C.). Estas soluciones de ingeniería podrían inspirar soluciones a problemas hídricos en el mundo actual.

Figure 1. Truncated pyramid in Caral, ancient site located 200 km North of Lima. This city was built around 3,000 B.C. and is considered the oldest city in America

Pre-Columbian American societies have been known to have developed capabilities in water management, particularly in those regions where this resource is scarce. This article summarizes some of the evidences of water management and engineering techniques in the Andean cultures that occupied the territory that spans the area from Southern Colombia to Northern Chile and Argentina and that, eventually, were assimilated or conquered by the Inca Empire.

We know that the first American urban center emerged in the Supe River Valley approximately 5000 years ago. This urban center was built by the Caral Civilization and is located 200 km North of Lima, Peru's modern-day capital. This culture was contemporary with the Sumerian Civilization in Mesopotamia, the Harappa Civilization in India, the Chinese Civilization and the Egyptian Civilization in Northern Africa. However, the Caral Civilization developed in complete isolation while there is evidence that Asian and African cultures interacted. During the era of the Caral Civilization irrigation canals and water reservoirs were built and terraces were formed to contain earth. Farm fields were fertilized with seabird manure and fish head waste. The Caral Culture influenced the Andean cultures that emerged in the next millennia. Evidence has been found in artistic manifestations of the design of civil works (Shady-Solís et al., 2006). Figure 1 shows a truncated pyramid built in the ancient city of Caral.

In Pre-Columbian Andean history there have been periods of marked territorial expansion of a particular culture as evidenced in construction and manufacturing techniques, the arts, etc., in the areas of its influence. These periods are called Horizons and where followed by periods

Figure 2. Cobble walls of Nazca canal downstream of filtration galleries. This irrigation structure is still in use

of division called Intermediate periods in which local cultures were formed.

The Nazca Culture flourished between the first and the eight century of our era in the so called Early Intermediate period along the Central Coast of Peru. The Nazca people built systems to divert underground water to channels that, in turn, irrigated fields and supplied water to small cities. Rodríguez-Zubiate (2005) summarized a study conducted by Delgado-Gutarra (2003) in which the latter was his advisee. In this research project the design and construction techniques of the filtration galleries built by the Nazca people were analyzed. Underground water was intercepted before it entered the alluvium substrate of the Aija River, which was dry 10 months a year. Trenches were excavated in the Nazca desert to capture underground water coming from higher areas. The uppermost reach of the trenches was covered and the downstream reach was left open forming filtration galleries whose water was conveyed to irrigation canals and provided supplies to population centers. The cross section was approximately rectangular and its base measured between 0.4 m and 1.8 m. The walls of the filtration galleries were covered by cobbles that both provided stability and were permeable enough to allow underground water to pass through the openings as seen in Figure 2. The gallery "roof" was either made out of stone or the wood of a local tree called Huarango (Prosopis pallida). Maximum depth of the galleries was 6.8 m. Access to the filtration galleries for inspection and maintenance was allowed by short spiral walkways as seen in Figure 3.

Wright and Valencia-Zegarra (2000) and Wright (2006) analyzed two important centers of the Inca Empire (Late Horizon) from the engineering viewpoint: Macchu Picchu and Tipon. Macchu Picchu is a small Inca city, now a World Heritage

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Figure 3. Spiral access hole to filtration galleries in Cantayoc, Nazca. It is located 450 km South of Lima

Figure 4. Rock canal and waterfall in Tipon, a small Inca urban center located 24 km South of Cusco City. Notice that energy losses are induced upstream of the waterfall by creating a sinuous path. Consequently, the jet trajectory stays close to the stone wall

Figure 5. Water fountain in Tipon. It was entirely built using igneous rock

Site, discovered by Hiram Bingham in 1911 (Bingham, 1913) and is located in southeast Peru in the Cusco Region. Water was supplied by a spring located uphill in a mountain right next to this archeological site. Analysis of water samples taken during the research conducted by Wright and Valencia-Zegarra showed that water quality is good even by today's standards. Water was conveyed by a 749 m long canal built with granite rocks. Clay was used to waterproof its base. The main canal supplied water to fountains built in series. The geometry of the fountains allowed the placement of a large water container called "aribalo" used to carry water to the houses. Macchu Picchu also had a very efficient underdrainage system that kept water away from the ground surface even during very intense rainfall events. During excavations conducted at Macchu Picchu's main plaza it was shown that the Inca engineers had provided underdrainage by placing stone chips (in essence, the byproduct of rock carving) under this open area. Terraces, locally called "andenes", provided stability to the mountain by controlling erosion and landslides and to allow cultivation of crops. Retention walls and gravel underdrains were included in the terrace design. Wright and Valencia-Zegarra (2000) indicated that crops partially provided food supply to the city and it is certain that most of the food supply was provided by nearby farms. Figure 4 shows a canal in Tipon. Notice that alignment changes rapidly just upstream of the waterfall to induce head losses and diminish the spread of the jet. Figure 5 shows a water fountain at Tipon.

Andean Pre-Columbian Civilizations ingeniously solved water resources related problems, by adapting engineering techniques to local conditions and, in essence, without negatively affecting the environment. These examples of good planning and engineering may provide hints to solve water-related problems in the present time! ■

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