Ancient Hydrosonic Purification Visualizer

Methodological Note for Comparative Modelling of Modern Hydrodynamic Cavitation and Ancient/Natural Water-Shaping Systems

Not a drinking-water safety determination. This model is for academic comparison, visualization, and hypothesis generation only. It must not be used to determine whether any water source is safe to drink.

1. Overview

The Ancient Hydrosonic Purification Visualizer compares a modern hydrodynamic cavitation benchmark against ancient or natural water-management analogues. The tool deliberately separates visually dramatic water motion from verified disinfection. Ancient systems are modelled as plausibility cases involving turbulence, vortex flow, aeration, residence time, sediment settling, filtration, heat, sunlight, wetland contact, and cultural engineering intelligence.

The modern benchmark is not treated as evidence that ancient systems achieved the same cavitation intensity. Instead, it provides a transparent calibration position. Users can then adjust ancient/natural analogues and compare efficiency, mechanism fit, and evidence confidence side by side.

2. Comparative Model Architecture

Layer	Purpose	Examples
Modern benchmark	Reference physics and default parameter field	Venturi or vortex hydrodynamic cavitation
Ancient/natural analogue	Cultural and archaeological comparison case	Stepwell cascade, Maya reservoir, amuna, cistern, fishpond
Mechanism scores	Estimate mechanism relevance without claiming potability	Cavitation potential, settling, aeration, filtration, heat, wetland contact
Confidence scores	Keep source quality separate from visual output	Evidence confidence, ancient plausibility, purification confidence
Report layer	Export a bounded academic interpretation	Professional bordered Stella Nova PDF report

3. Cavitation Index

Hydrodynamic cavitation depends on pressure falling near or below the vapor pressure of water and on subsequent bubble collapse as pressure recovers. The model uses the cavitation number as a primary physical anchor:

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sigma = (P - Pv) / (0.5 * rho * v^2)
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where P is local static pressure, Pv is vapor pressure, rho is water density, and v is local velocity. Lower sigma values imply greater cavitation likelihood. In the visualizer, cavitation potential is a normalized plausibility score, not a direct measurement.

4. Flow Regime and Turbulence

The Reynolds number estimates whether flow is laminar, transitional, or turbulent:

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Re = rho * v * D / mu
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Turbulence contributes to mixing, shear, bubble entrainment, and particle suspension. In ancient analogues, turbulence may arise from cascades, constricted channels, rough stone, sluices, weirs, pouring, or vortex basins. The model does not assume turbulence alone disinfects water.

5. Residence Time, Settling, and Filtration

Residence time is essential for sedimentation, filtration, wetland polishing, sunlight exposure, and heat treatment. It is represented as:

```
t_r = V / Q
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Because the interface is a comparative teaching model, user-facing residence time is entered directly as a slider. Long residence times improve settling plausibility but can also increase biological risk in real conditions; this is why the tool does not produce safety determinations.

6. Composite Confidence

The visualizer uses bounded component scores for mechanism relevance. A composite confidence can be represented generically as:

```
C_total = 1 - product(1 - C_i)
```

where C_i are individual bounded mechanism scores. The implemented interface also includes evidence confidence and ancient plausibility so that a visually impressive system does not outrank a better-attested but less dramatic one.

7. Dataset Scope

Region	Starting analogue set
Mesoamerica	Classic Maya reservoirs, zeolite/sand filtration, constructed wetland analogues, chultuns, canals.
India	Stepwells, baori/baoli/vav systems, cascades, settling, boiling/sun/copper textual traditions.
Egypt	Nile basin management, settling basins, canal residence, alum/coagulation references.
Greece/Rome	Greek cisterns and infiltration wells; Roman aqueducts, castellum, settling and maintenance.
Andes	Amunas, infiltration canals, qochas, wetlands, water-sowing and delayed spring release.
Polynesia	Native Hawaiian loko i'a fishponds, tidal exchange, sluice gates, wetland interfaces.
US Native American	Chaco canals, Ancestral Pueblo springs/cisterns, Tucson Basin canal systems.

8. Visual Output Rules

The side-by-side loop is designed to make comparative mechanism visible: modern engineered pressure drop on the left, ancient or natural cultural analogue on the right. Fixed tone presets alter the rendering aesthetic but do not change the underlying calculation. The water-shape rendering uses Faraday-wave and streamline-inspired visuals for interpretive clarity; it is not presented as photographic measurement.

PDF exports should preserve the actual modern and ancient canvas panels, the selected parameters, the benchmark comparison table, warning language, and the methodological source frame.

9. References and Source Anchors

Sun, X. et al. 2020. A review on hydrodynamic cavitation disinfection: the current state of knowledge. Science of the Total Environment.

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A comprehensive review of the potential of stepwells as sustainable water management structures. 2022. Water 14(17):2665.

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Ochoa-Tocachi, B. F. et al. 2019. Potential contributions of pre-Inca infiltration infrastructure to Andean water security. Nature Sustainability 2:584-593.

Ku Hou Kuapa: Cultural restoration improves water budget and water quality dynamics in Heeia Fishpond. 2019. Sustainability 11(1):161.

Water uncertainty, ritual predictability and agricultural canals at Chaco Canyon, New Mexico. Antiquity.

A summary of 25 years of research on water supplies of the Ancestral Pueblo people. 2024. Water.

10. Safety and Ethics Boundary

The model is intentionally conservative. It does not provide health advice, water-treatment advice, engineering certification, or drinking-water approval. Any real water source requires established treatment, testing, and regulatory assessment. The purpose of this tool is to help researchers and students see the physical intelligence embedded in ancient and natural water systems while keeping evidence, mechanism, and speculation visibly separated.