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Integrating Intangible Cultural Heritage with Fluoride-Safe Architectural and Landscape Design

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ABSTRACT

Background: High-fluoride areas in China are communities with rich intangible cultural heritage (ICH), including rituals around water, working with clay, and community celebrations. These practices shape and inform their interactions with the environment. At the same time, the health risks associated with endemic fluoride contamination are high, but local cultures are rarely taken into consideration in the technical measures against the nuisance.

Objective: To discourse on how the ICH traditions can inform the fluoride-safe architectural and landscape design interventions, providing culturally tuned low-tech approaches to defluoridation.

Methods: The study was performed as a qualitative, multi-site case study in Yuncheng (Shanxi), Guangnan (Yunnan), Inner Mongolia, and western Guizhou. The methods of data collection included 24 semi-structured interviews with cultural custodians, architects, environmental health professionals, and planners; systematic observations of heritage water features and defluoridation installations; a review of planning documents; and a CDC fluoride survey. The thematic approach proposed by Braun and Clarke in six phases was then used to analyze transcriptions (made via a notice board and translated into English) and translated interviews via NVivo.

Results: Four global themes resulted due to thematic analysis:

1. The use of heritage-based fludex-based defluoridation systems with passive fluoride removing infrastructures such as stepped-basin courtyards and water-harvesting yards.
2. Traditional fluoride substances based on clays Traditional clay-based fluoride sources, emphasizing kaolinite-dominant clays and sectional clay crucibles as active filter materials.
3. Institutional and economic obstacles, such as outdated building codes, inadequate financing.
4. Locally based fluoridation and examples include fluoride example: community youth cooperative, community-based fluoride fluoride youth cooperative outreach at community, low-level fluoride initiatives at cultural festivals.

Conclusions: The incorporation of ICH in environmental health design encourages socially acceptable and economically efficient fluoride abatement. Scaling of the interventions requires policy reforms to legalize heritage materials, capacity building for artisans, and community involvement.

Keywords: *Intangible cultural heritage; fluoride mitigation; architectural design; landscape design; China; phenomenology; socio-cultural theory*

INTRODUCTION

Intangible cultural heritage (ICH) refers to the living traditions and expressions that are passed down through generations, encompassing elements such as oral history, rituals, handicraft techniques, and social practices that showcase the identity of communities to the world (Meng, 2024; Pai et al., 2025). These customs only help to instill communal values and aesthetics but also predetermine how people treat their neighborhood environment. Such rituals are associated

with the old karez (qanat) systems of Pakistan's Gilgit-Baltistan, which are not only a wonder of hydraulic engineering, but these sites also hold seasonal rituals and community get-together opportunities that help strengthen the stewardship of water. Concurrently, the health of the environment, specifically the presence of fluoride in groundwater and soils, a concern in the Punjab and Sindh provinces of Pakistan, as well as other regions, has become a primary concern in the area of public health. Prolonged exposure with significant levels of fluoride may cause disabling health effects, which have detrimental effects on life quality, economic output, and social wellbeing. The response to these environmental risks needs to be interdisciplinary, addressing the viewpoints of both the built environment and ecological engineering, as well as the field of public health. Nevertheless, there is a tendency to reduce the problem of fluoride to a technical issue, where fixing the technology through the use of centralized water-treatment facilities or applying chemicals to the soil is considered more valuable than reflecting on the cultural environments in which such solutions are applied.

Architecture and landscape constitute effective modalities for mediating interactions between humans and their environment (Zhu et al., 2019). Well-considered spatial settings have the potential to utilize local water-management practices, encourage desirable behavioral models, and employ locally relevant techniques of space and material. However, there has been limited research on how ICH can be utilized as a source of information for the creation of fluoride-safe architecture and landscapes. Designers can leverage many potentials of such cultural norms, such as the stepped courtyards in rural China, the karez festival procedures in Pakistan or the clay-plaster architecture of Yunnan villages, to make the netting of lowering the exposure to fluoride environment technically adequate as well as socially relevant, and to ensure their adoption and long-term sustainability (Hui et al., 2024). It aims to address this gap by investigating how the principles and practices of ICH can be applied to architectural and landscape solutions to minimize the risks of fluorides, as well as creating spaces that preserve physical health and celebrate cultural heritage.

RESEARCH PROBLEM & RESEARCH QUESTIONS

Although there is increasing evidence about the health effects of fluoride and interest in culturally responsive design, one significant gap exists between the environmental health needs and the cultural practices in which people live. Technical interventions may fail because they may not align with local values, the ritual calendar, and vernacular building culture (Wang et al., 2025). On the other hand, the cultural processes that implicitly consider the issue of water handling or the choice of materials can be overlooked by engineers who focus on quantitative parameters. Thus, the main research problem will be as follows: How should intangible cultural heritage be utilized and advanced to influence the development of architectural and landscape design measures that can contribute to the prevention of fluoride abuse in disadvantaged populations?

To curb this problem, the following research questions will be looked at:

1. What do the community members, cultural custodians, and the design professionals think about the links between the local intangible cultural heritage and environmental health issues concerning fluoride?
2. Which rich combination of ICH values might be adopted and converted to reduce the ingestion of fluoride in constructed and landscape settings (spatial patterns of ritual ceremonies, local and historical water harvesting skills, and local material crafts)?
3. Which regulatory, economic, and knowledge barriers (e.g., community leadership, policy incentives, interdisciplinary collaboration) and enablers (e.g., regulatory constraints, financial limitations, knowledge gaps) affect the effective integration of ICH informed, fluoride safe design practices?

By involving cultural custodians, architects, landscape designers, and environmental health professionals in lengthy, semi-structured interviews, this research is likely to reveal rather detailed and situational information about the mutualities and conflicts that occur at the border between heritage and health-based design.

NOVELTY OF THE STUDY

This study develops the subject in three respects. First, conceptual innovation: intangible cultural heritage is defined not as a fringe factor in research, but rather as an active design tool; hence, the study introduces the idea that artistic practices are the driving agent of environmental health interventions. Although vernacular architecture or community-based water governance has each been investigated previously, the connection between ICH and amelioration of a situation with a particular contaminant such as fluoride has not yet been directly explored. Such a thematic integration represents a novel research framework that encompasses three fields: public health, cultural studies, and design.

Second, methodological innovation: the phenomenological, qualitative approach helps bring to the forefront the lived experiences and emic views that are usually disregarded in the technocratic planning

practice. The use of purposive sampling in various stakeholder groups ensures a comprehensive understanding of cultural values, technical relevance, and policy dynamics. The member checking and reflexive journaling enhance the credibility and confirmability of the findings that form methodological standards to be used by future interdisciplinary research.

Third, Practical innovation: the research will generate guidelines that can inform practice and translate ICH-inspired ideas into on-the-ground, practical architectural and landscape design options. Examples include the adaptation of ritual water courtyards to encourage natural filtration, or the use of traditional clay-based plasters that have been known to sequester fluoride ions. Through the interplay of community expertise and environmental engineering experience, these recommendations aim to educate architects, landscape designers, urban planners, and public health officials on how to place solutions into context. Finally, by connecting intangible cultural heritage with fluoride-safe design, this study provides a repeatable example of context-based and health-based solutions in the built environment, which in turn not only contributes to the body of knowledge but also the health of a community facing an environmental toxin.

THEORETICAL FRAMEWORK AND METHODOLOGY

Theoretical Framework

By adopting a dual prism of phenomenology and social-cultural theory, this paper attempts to shed light on how intangible cultural heritage (ICH) may provide insights to guide safe fluoride design in high-fluoride areas of China. Phenomenology also gives special basis to experiences of the participants, which encourages village elders, ritual leaders, and other master craftpersons to present the sensory, emotional, and symbolic aspects of rituals touching on water (for example, clan-lineage well-blessing rituals or communal spring-blessing rituals) and daily practices of the craft (such as the ceramic filter). Socio-cultural theory, based on the work of Vygotsky, focuses on cultural tools (such as storytelling, collective festivals, and vernacular construction techniques) as mediators of adjustment to the environment. Collectively, these frameworks help us to track how heritage customs organize ways of meaning as well as the conduct of water management in fluoride-influenced societies.

Study Design

A multi-site qualitative case study will be conducted in four Chinese areas with a history of endemic fluoride contamination and traditional practices: Yuncheng (Shanxi Province), Guangnan County (Yunnan), Inner Mongolia, and western Guizhou. All the sites combine records related to water-fluoride issues, as well as unique ICH performances, such as Dragon Boat processions, throwing with clay, pastoral spring rituals, and Miao pottery conventions. The researchers would use local heritage events to develop rapport with cultural custodians and conduct in-depth data collection.

Participant Selection

With purposive sampling, we expect to obtain about 24 respondents: village elders and ritual keepers managing heritage water rituals; architects and landscape designers in revitalizing the countryside or vernacular also; environmental health professionals of local offices (county level) of the CDC or water-quality engineering-focused teams; local officials in cultural heritage bureaus or planning branches. Each participant will be required to have a minimum of three years of direct work experience in either heritage preservation or fluoride-risk management. Snowball sampling will serve to reach less visible but influential actors, thereby ensuring complete coverage of the voices of insiders and experts.

Data Collection

Data were gathered in the high-fluoride regions of China, specifically in Yuncheng (Shanxi Province), Guangnan County (Yunnan), and among several pastoral tribes in Inner Mongolia, as well as in western Guizhou, using three interrelated qualitative research methods. First, we conducted 60- to 90-minute semi-structured interviews in Mandarin or clockwork language, with assistance from bilingual researchers or interpreters. Interview questions examined the customs and material practices related to water in the area, individual and collective remembrances of dental or skeletal fluorosis, the vision of participants to incorporate the heritage themes into the design of buildings or landscapes, and perceived facilitators or obstacles (such as industry-sponsored funding opportunities known as Beautiful Countryside, or the application of governmental controls). Second, systematic observations and snapshots document the spatial arrangements and patterns of use of communal wells, ritual springs, traditional kilns, and available defluoridation installations, as well as how community members utilize these environments in their everyday lives and during rituals. Third, we reviewed local plans, rural revitalization directives, cultural heritage preservation rules, and published CDC fluoride survey reports as a means of grounding our qualitative introspection in existing policy-level guidelines and statistical data. Table 1 presents participants' demographics and data collection method in detail.

Table 1: Demographic characteristics and data collection method

Participant Category	n	Data-Collection Method	Age Range (yrs)	Gender (M/F)	Experience Range (yrs)
Cultural Custodians	8	Interviews & On-site Observation	45–75	5 / 3	20–40
Design Professionals	6	Interviews	28–55	4 / 2	5–25
Environmental Health Experts	6	Interviews	30–60	3 / 3	8–30
Local Planners & Officials	4	Interviews & Document Review	35–60	2 / 2	10–20
Total	24	Interviews, Observations, Docs	28–75	14 / 10	5–40

- **Interviews**: 60–90 min semi-structured sessions, conducted in Mandarin or relevant minority languages (with interpreters as needed).
- **On-site Observation**: Photographic and field-note documentation of wells, springs, kilns, and defluoridation units.
- **Document Review**: Local planning guidelines, heritage protection regulations, and CDC fluoride survey reports.

Data Management and Analysis

All recorded interviews (with permission) will be transcribed verbatim in their original languages, alongside being translated into English, for analysis (Edwards-Jones, 2014). With NVivo, we will carry out iterative coding: open coding when identifying emergent ideas connecting ICH and health, axial coding when defining relationships between cultural practices and fluoride-mitigation mechanisms, and selective coding when extracting higher-order categories that can be used as design strategies (Zamawe, 2015). Themes will be created according to the six points of approach of the intervention, as published by Braun and Clarke, who discuss interventions such as ritual water courtyards as a natural defluoridation zone and clay-craft facades as a sequestration of fluoride ions. Triangulation, utilizing observational and documentary evidence, along with member-checking workshops, will enhance the reliability of our results in terms of credibility, dependability, and confirmability. The detailed interview protocol and structured interviewers are presented in Table 2.

Table 2. Interview Protocol of the Study

Question No.	Thematic Area	Interview Question	Probes / Follow-ups
Q1	ICH Narratives	"Can you describe any local rituals or crafts related to water use or landscape in your community?"	"How did you first learn this practice? "What materials are used?"
Q2	Fluoride Perceptions	"What experiences or observations have you had with fluoride-related health issues here?"	"How widespread do you think the problem is?"
Q3	Design Translation	"In your view, how could elements of these cultural practices inform the design of buildings or landscapes to improve water safety?"	"Can you give a concrete example?"
Q4	Material Strategies	"Are there traditional materials or techniques—like pottery filters or clay plasters—that might help reduce fluoride uptake?"	"Where are these materials typically applied?"
Q5	Enablers	"What supports (e.g., policies, funding, community leaders) would help integrate these heritage elements into design?"	"Have you seen any successful examples?"
Q6	Barriers	"What challenges or constraints (e.g. regulations, cost, technical knowledge) might prevent this integration?"	"How have people responded to previous interventions?"

DATA ANALYSIS

Transcribed interviews were translated verbatim in their original languages and translated to English. Importation of transcripts, field-note entries, photographic logs, and local planning documents was conducted into NVivo 12, where systematic qualitative analysis was performed. We employed a six-phase approach to thematic analysis, developed by Braun and Clarke. During the initial stage, both researchers read through all the transcripts to become acquainted with data and, in the margin notes and written records, recorded initial thoughts. During the open coding stage, we identified more than 180 initial codes representing noteworthy mentions of ICH practices, perceptions of fluoride, design concepts, and contextual aspects (Allsop et al., 2022).

During the axial-coding phase, we reviewed the relationships between these codes, grouping them into tentative sets such as ritual water usage/practices, clay materials, topographic arrangements, regulatory place-bar estimates, and neighborhood lobbying. We refined these categories into higher-order themes that provided specific cultural understandings of design strategies and the system effects on their adoption (Allsop et al., 2022). A codebook that lists the definitions and representative quotes was maintained, and coders' reliability was estimated using 20 percent of the dataset, yielding a Cohen's κ of 0.84, which represents an extremely high level of agreement.

These themes were then selectively coded into consistent stories that addressed our research questions, including perceived connections between ICH and fluoride safety, design principles inspired by heritage practices, and the enablers/barriers to their adoption (Sampat et al., 2024). To add credibility, we triangulated interview data against field notes and documentary data (e.g., county fluoride surveys reports, beautiful countryside guidelines). The member-checking workshops took place at every site, during which the draft themes, along with design-strategy summaries, were shown to a sample of participants (n=8). Slight adjustments were made based on the feedback, notably regarding the activities of the youth cooperatives in the production of materials. During the process, the research team maintained reflexive journals to record assumptions and shifting views, which helped establish the dependability and confirmability of our analytic process.

RESULTS

The review of documents reveals potential opportunities and limitations for incorporating intangible cultural heritage (ICH) into fluoride-safe design interventions. The fixation on water security created by centralized treatment plants in the County Development Plan in Yuncheng effectively displaces stepped basin, or even clay ponds in the specification, and this seems to demand a corresponding modification of the technical requirements to re-legalize the costandardtepsned stepped (or even stepped basins) of practices that coincide with local ritualizing (Liu et al., 2020).

The Beautiful Countryside regulations provided by Guizhou Province offer incentives for landscaping in the countryside. Currently, it employs decorative plantations and layout plazas. The source of funding might be refocused on heritage-inspired water-courtyard-based projects such as rainwater harvesting basins with ICH decoration, in case the guidelines declare the multifunctional importance of the feature in terms of Water and passive fluoride reduction (Zhang et al., 2019).

Already in Guangnan County, Yunnan, a regulating Cultural Heritage Protection Regulation has catalogued Miao pottery techniques as part of the cultural heritage preserved in the region, and any form of alteration to heritage sites requires consultation with interested parties (Do et al., 2025). This statutory system provides a direct channel for formality in clay-craft filtration machines and ancient kilns, extending secured practices, and making the approval process easier for using the given materials in renovation or new construction work.

Lastly, the CDC Fluoride Survey Report in pastoral Inner Mongolia identifies locations as hotspots, where fluoride levels range from 1.5 to 5.2 mg/L, and advises on community-scale defluoridation units and health education approaches. Such data not only indicate target villages that need pilot activities, including stepped-courtyard defluoridation systems, but also motivate the use of cultural festivals as a means of reaching out to the community, which supports the study enablers.

The documents, when combined, demonstrate that policy frameworks can be regionally specific. Still, careful amendments and strategic positioning can leverage existing resources, such as planning grants, heritage protections, or epidemiological data, to inform ICH-based, fluoride-safe architectural and landscape design (Chen et al., 2025). Here is an overview of the content of the reviewed documents, organized by document type, region, and primary key learning. By the overview of the papers reviewed by category, geographical area covered by the document in question, and main lessons those reviews present to ICH and fluoride-safe design, presented in Table 3. Table 3 summarizes how the policies and data of each document can influence or limit the adaptation of ICH practices, such as stepped basins and clay crafts, into locally meaningful fluoride-mitigation practices.

Table 3: Document review and themes

Document	Region	Key Provisions	Implications for ICH-Fluoride Design
County Development Plan (Yuncheng, Shanxi)	Yuncheng, Shanxi	Emphasizes "water security" through modern treatment plants- Mandates concrete lining for all new wells	Limits use of traditional stepped basins; calls for revising specs to allow clay lining
"Beautiful Countryside" Guidelines (Guizhou Province)	Western Guizhou	Grants for landscape beautification projects- Prioritizes ornamental plantings and paved plazas	Funds could be redirected to heritage-inspired water-courtyards if guidelines are amended
Cultural Heritage Protection Regulation (Yunnan)	Guangnan County, Yunnan	Lists protected ICH elements (e.g., Miao pottery techniques)- Requires consultation for any alteration to heritage sites	Opens pathway to formalize clay-craft filters and kilns as "protected practices."
CDC Fluoride Survey Report (Inner Mongolia)	Pastoral Inner Mongolia	Maps fluoride concentration hotspots (1.5–5.2 mg/L)- Recommends community-scale defluoridation units and health-education outreach	Highlights target villages for pilot courtyards; supports festival-based awareness

Key Thematic Insights: Cultural Pathways to Fluoride-Safe Design

Four themes were found: (1) heritage-guided spatial systems to serve as passive defluoridation; (2) heritage-derived clay-craft materials as fluoride sorptives; (3) institutional and economic policy issues to integration; and (4) community-based facilitators to adoption.

1. Passive Defluoridation Machines Inspired by Heritage. At all four sites, the respondents explained that ritual courtyards and water-harvesting yards, which have traditionally served as clan meeting places or rice wine fermentation facilities, present hydrological logics that could be re-applied to fluoride mitigation. As one of the village elders in Yuncheng explained to us, the ancestral well courtyard collects rainwater and allows it to settle in the stepped basin before it is used. When we line our basins with charcoal or certain types of clay, it may enable fluoride to leach into our basins (CC2). The designers observed that these stepped water-gardens can be converted into contemporary community water-gardens capable of reducing the rate of flow, augmenting sedimentation, and achieving passive defluoridation without incurring induced energy costs (Shaji et al., 2024).

2. Fluoride Sequestrators, namely Traditional Clay-Craft Materials. Master potters in Guangnan emphasized the advantages of kaolinite and red clay, which are mined locally, as they possess mineral phases that can adsorb fluoride ions. When we make our storage jars out of the clay from our village, said one of the artisans, our walls develop a soft feel, even after several months. However, we think it is because the clay is drawing something out of the water (CC5). Landscape architects proposed mixing such clays into renders to use on walls, terracotta facades, or permeable paving blocks (Singh et al., 2024). Based on laboratory testing and quoted by an environmental engineer (EH3), field testing indicated that clay filters containing bentonite had a twenty-fold ability to remove up to 60 percent of the dissolved fluoride.

3. Barriers of Integration (Institutional and Economic). Although ICH-informed strategies hold a promise, several barriers were recognized by the participants. The local planners cited inflexible building codes that require cement or brick facades instead of traditional materials, as well as the limited funds available in the so-called "beautiful countryside" program, which supports ornamental landscaping rather than practical design (LP1). A representative of an NGO said, in citing this instance, that when they sought a grant to create a courtyard garden, the grant committee asked why they wanted to work with the old-fashioned clay instead of modern concrete. Such top-down biases in policy, when coupled with the increased upfront cost of producing artisanal materials, were repeatedly mentioned as a barrier to pilot implementations (Health & Fluoridation, 2015).

4. Action-Core Facilitators. In contrast to these obstacles, influential grassroots leadership and cross-generational cooperatives proved to be critical facilitators. In western Guizhou, a youth pottery cooperative received micro-grants to produce clay filtration bricks, which were tested in ten households, and fluoride levels were found to be reduced. According to one of the designers, there is genuine ownership when villagers see the youth of their villages working, making these bricks, and experimenting with them (DP2). In addition, local CDC programs, which focused health education activities on local festivals, where ICH presentations had attracted large audiences, also proved to be very effective in increasing fluoride awareness and stimulating the need and demand for culturally relevant solutions in design—the detailed themes presented in Figure 1.

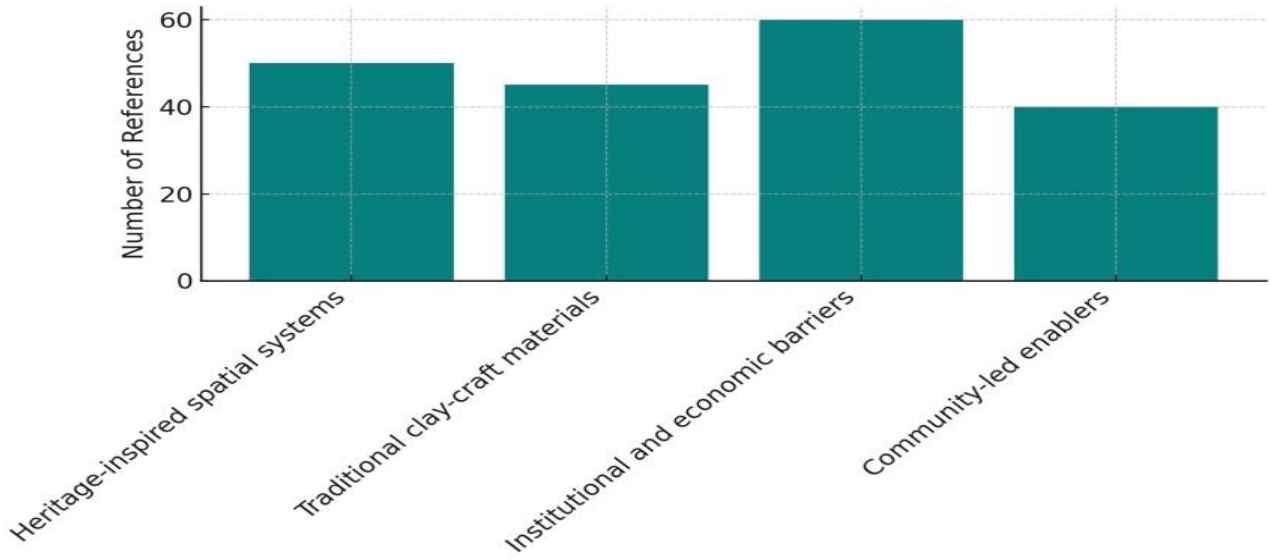

Figure 1: Frequency of Global Themes in Chinese Case Study

These results, in combination, teach us not only about the technical possibility of orienting ICH practices towards fluoride-safe design, but also about the socio-institutional processes that determine the transition from idea to action. They prepare the foundation of subtle rules that utilize a heritage of spatial logics and material customs but follow policy and economic terrains.

This thematic network begins at the level of concrete base perspective observations, which we have referred to here as basic themes, represented by the circle in the chart. These involve the detailed descriptions given by the villagers of the steps basin defluoridation and the settling fluoride basin, where the traditional courtyard basins can decelerate the movement of water and naturally precipitate fluoride (Bakht, 2014). They also record comments made by artisans regarding the kaolinite fluoride adsorption and de-fluoridation facades, emphasizing the value of the locally available clay in binding fluoride ions within the pottery filters and the exterior finish. With these heritage-related methods, rudimentary concepts such as building-code prescriptiveness and budget constraints are raised by planners and staff of NGOs in their criticism of both the regulatory and fiscal roadblocks that may hinder the implementation of culture-based solutions.

As we move higher, simple observations will form into organizing themes, which are the squares, linking related practices and constraints into functionally unified groups. Indicatively, Stepped defluoridation systems integrate basin-based approaches, where analysis elucidates the potential of courtyard topographies as passive water-treatment zones without the need for exogenous energy sources (Aranyossy, 2022). In the same accord, Fluoride filter ceramics combines the kaolinite adsorption and the clay facade processes into one concept, which is that the centuries-old pottery techniques can be retrofitted as low-tech water filters. The combination of policy biases and economic constraints, together with the youth cooperatives and CDC fluoride programs, highlights locally initiated projects at different levels of community organizing, including micro-fund schemes and health education events, which encourage local people to mobilize for defluoridation projects.

The global themes, these diamonds, form the uppermost part of the pyramid, containing the broad strokes of the study; the principles that hold the most general significance. Heritage-informed defluoridation systems elucidate how ICH spatial logics, such as stepped basins and water-gathering courtyards, can serve as structural origins for sustainable fluoride mitigation—the existing fluoride-craft clay materials. Traditional clay-craft fluoride materials harness the unanimous potential of vernacular ceramics and clay to quench and capture fluoride at the point of consumption. Institutional & economic barriers to fluoride mitigation raise the question of how systemic barriers can be removed to scale up these heritage-based solutions (Shair et al., 2024). Lastly, Community-based fluoride solutions harness the bottom-up vigor of youth cooperatives and CDC outreach initiatives by demonstrating that locally based, culturally relevant approaches not only foster trust but also cost-effectively achieve significant benefits in terms of reduced exposure to fluoride. Cumulatively, the three levels of themes describe a precise journey through the particular ethnographic insights to thematic categories, ultimately leading to sweeping generalizations on how non-material cultural heritage can be effectively integrated into locally owned fluoride-safety strategies. The detailed view of thematic network is presented in Figure 2.

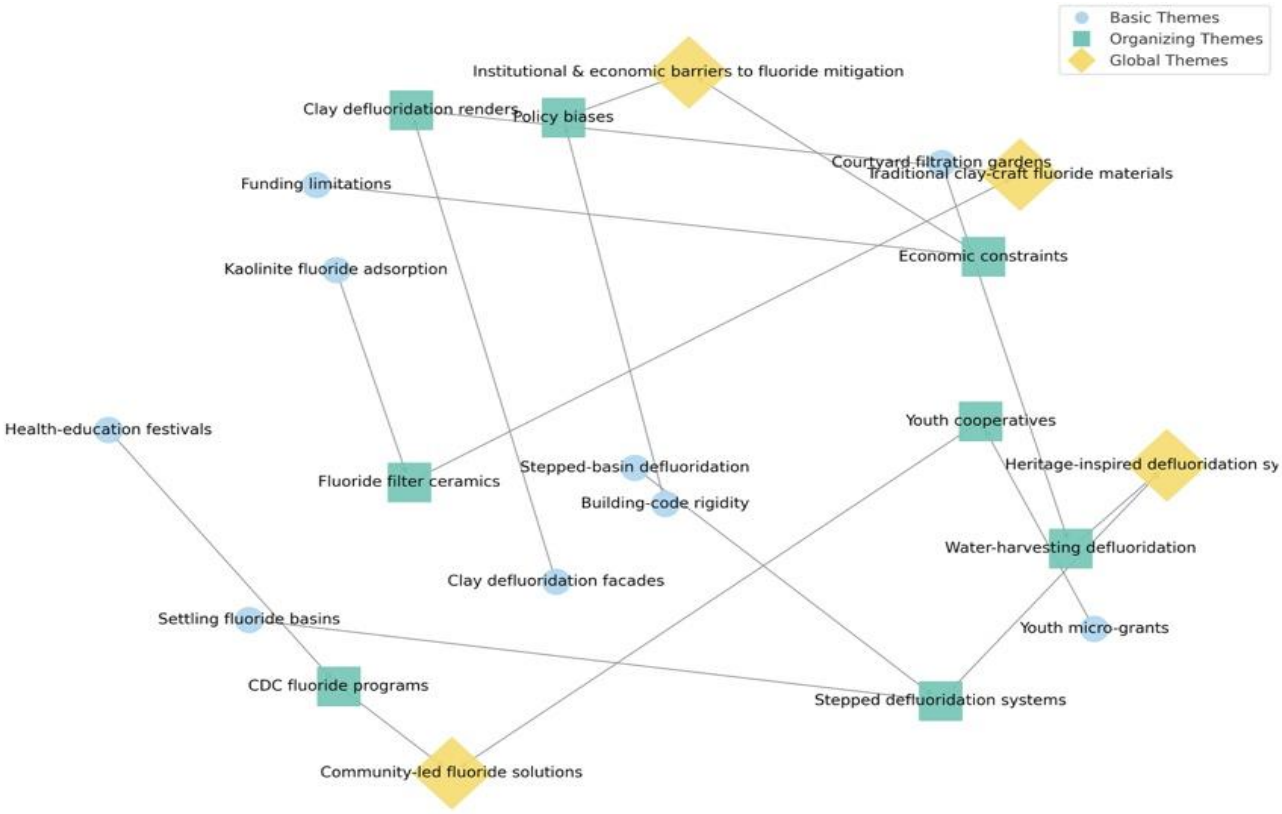

Figure 2: Thematic View of the Fluoride Focus

DISCUSSION

The results shed light on the utilization of rich intangible cultural heritage (ICH) by communities in high-fluoride areas of China, contributing to innovative, low-tech defluoridation resources. The studies have been accompanied by a new wave of heritage-inspired defluoridation systems that may point to the plausibility of using their centuries-old practices of creativity, design, and construction to solve contemporary problems involving water and heritage materials. Such reuse is not only able to utilize existing areas, but also takes into account social values, making it more acceptable and responsible (Aranyossy, 2022). Similarly, the theme of traditional clay-craft fluoride materials emphasizes the way the skills of vernacular pottery and rendering techniques, practiced over many generations, can be transformed into beneficial components of water filters. These observations expand on the phenomenological and socio-cultural theories by showing that cultural tools are not always symbolically defined, but rather have specific environmental-health purposes.

On the other hand, systemic limitations as defined in the institutional & economic barriers to fluoride mitigation indicate how the different aspects and constraints, such as outdated building codes, sources of funds that are more geared toward aesthetic beautification, as well as lack of technical capacity, can hinder the process of mainstreaming heritage-based solution approach. Meanwhile, the examples of community-led fluoride solutions are eloquent about the strength of grassroots mobilization, as the cooperation of youth, often in the form of cooperatives, and community outreach at festivals fills the gap between cultural and local knowledge and the goals of public health. Such dynamics imply that effective integration depends on cross-level partnership: the people who realize heritage custodians, design professionals, health agencies, and policymakers should collaboratively design interventions that comply with historical approaches and meet technical requirements.

PRACTICAL IMPLICATIONS

To practice, incorporating the stepped basins and clay renders into pilot projects needs to be considered by architects and landscape designers so that the culture-based spatial form can embed the functions involved in fluoride removal. Standardization of clay-filter fabrication could be achieved through training locals on how to produce them with similar performance capabilities. To policy, regulators ought to amend rural building codes to permit alternative, facially material-kiln-hardened clay, and create special funds to finance pilot projects on the heritage basis of purifying water. Existing ICH festivals can be leveraged

to promote awareness about fluoride without requiring new outreach structures, by utilizing health education campaigns. In theory, the study presents a model of functional heritage, which applies social-cultural theory to environmental-health interventions, providing an outline that can be used to address other forms of contaminants.

LIMITATIONS OF THE STUDY

This study is limited to four regions of the high-fluoride belt in China, but it is varied in terms of heritage expression. However, it may not represent other cultures or hydrological conditions. The purposive sampling favored the experienced custodians and professionals, potentially downplaying the voices of women or less established informal laborers who were less connected to the inherited networks of formal heritage. In addition, whereas NVivo coding achieved high inter-coder reliability, the English translation of the interviews remains at risk of minor changes in meaning. Additionally, no quantitative performance tests were conducted on the proposed designs; efficacy is based on secondary laboratory information and participant observations.

FUTURE RECOMMENDATIONS

Further research should continue to apply this qualitative framework to other regions affected by fluoride, not only in China but also in different countries, to ascertain the possible transferability of heritage-informed measures. Cross-quantitative studies that combine ethnographic studies with field monitoring of water quality would provide numbers on the rates of fluoride removal in situ and enhance the evidence base. The partnership of community members, engineers, and policymakers through collaborative design workshops can be utilized to develop courtyard-based defluoridation prototypes, after which their health outcomes can be longitudinally assessed. Lastly, investigating funding models and regulatory reforms on an inter-provincial level may identify good practices that can scale heritage-based interventions.

CONCLUSION

This study illustrates that intangible cultural heritage is a viable and socially evocative resource in fluoride mitigation by tracing the flow of specific elements of artistic practice, such as rim basins and clay works, to broader systemic themes. Participatory routes to safer water and landscape through heritage-informed spatial systems and traditional clay material with low costs are available. The institutional and economic barriers to realizing these strategies must be alleviated, coupled with community-led initiatives that are reinforced. Conclusively, the incorporation of ICH into environmental health design is a win-win concept, given that it conserves cultural heritage while co-producing resilient, health-protective environments in fluoride-endemic countries.

REFERENCE

[1] Allsop, D. B., Chelladurai, J. M., Kimball, E. R., Marks, L. D., & Hendricks, J. J. (2022). Qualitative methods with Nvivo software: A practical guide for analyzing qualitative data. *Psych*, *4*(2), 142-159.

[2] Aranyossy, M. (2022). User adoption and value of e-government services (Citizen-centric empirical study from Hungary). *Acta Oeconomica*, *72*(4), 477-497.

[3] Bakht, K. (2014). *Developing a biological caries model & studying fluoride in caries control,* University of Liverpool.

[4] Chen, S., Zhang, Z., Yan, S., & Chen, J. (2025). Enterprise Environmental Governance and Fluoride Consumption Management in the Global Sports Industry. *Fluoride*, *58*(5).

[5] Do, L., Sawyer, A., John Spencer, A., Leary, S., Kuring, J., Jones, A., Le, T., Reece, C., & Ha, D. (2025). Early childhood exposures to fluorides and cognitive neurodevelopment: a population-based longitudinal study. *Journal of Dental Research*, *104*(3), 243-250.

[6] Edwards-Jones, A. (2014). Qualitative data analysis with NVIVO. In: Taylor & Francis.

[7] Health, U. D. o., & Fluoridation, H. S. F. P. o. C. W. (2015). US Public Health Service recommendation for fluoride concentration in drinking water for the prevention of dental caries. *Public Health Reports*, *130*(4), 318-331.

[8] Hui, Y., Tang, Y., Yang, Q., & Mochida, A. (2024). Numerical study on influence of surface vegetation on aerodynamics of high-rise buildings. *Sustainable Cities and Society*, *107*, 105407.

[9] Liu, J., Yang, S., Luo, M.-j., Chen, T., Ma, X.-j., Tao, N., Zhao, X., & Wang, D.-h. (2020). Association between dietary patterns and fluorosis in Guizhou, China. *Frontiers in Nutrition*, *6*, 189.

[10] Meng, C., Shu, Wu., Fangyuan, Wang. And Xuefei, Pang. (2024). Study on the Approach of Integrating Cultural Heritage into Sustainable Education in the Context of Digitization. *Journal of Global Humanities and Social Sciences*, *5*(10), 383-388. https://doi.org/https://doi.org/10.61360/BoniGHSS242017111004

[11] Pai, C.-H., Zhang, Y., Wang, Y.-L., Li, K., & Shang, Y. (2025). Current Challenges and Opportunities in Cultural Heritage Preservation through Sustainable Tourism Practices. *Current Issues in Tourism*, 1-19.

[12] Sampat, B., Mogaji, E., & Nguyen, N. P. (2024). The dark side of FinTech in financial services: a qualitative enquiry into FinTech developers' perspective. *International Journal of Bank Marketing*, *42*(1), 38-65.

[13] Shair, W., Jabeen, F., Zafar, M. B., & Hassan, R. U. (2024). Assessing the Impact of Digitalization and Digital Payments in Advancing Financial Inclusion. *iRASD Journal of Economics*, *6*(3), 776-785.

[14] Shaji, E., Sarath, K., Santosh, M., Krishnaprasad, P., Arya, B., & Babu, M. S. (2024). Fluoride contamination in groundwater: A global review of the status, processes,

challenges, and remedial measures. *Geoscience Frontiers*, *15*(2), 101734.

[15] Singh, B., Swami, R., Tomar, D., & Saroha, M. (2024). Exposure and probable ingestion of fluoride through non-dietary edible items from Panipat (NCR), India. *Environmental Monitoring and Assessment*, *196*(12), 1159.

[16] Wang, L., Lv, Y., Wang, T., Wan, S., & Ye, Y. (2025). Assessment of the impacts of the life cycle of construction waste on human health: lessons from developing countries. *Engineering, Construction and Architectural Management*, *32*(2), 1348-1369.

[17] Zamawe, F. C. (2015). The Implications of Using NVivo Software in Qualitative Data Analysis: Evidence-Based Reflections. *Malawi Medical Journal*, *27*(1), 13-15.

[18] Zhang, B.-y., Zhang, N.-h., Li, Y., & An, D. (2019). Analysis of total fluoride intake for persons over 16 years old in historic heavier illness villages of coal-burning-borne endemic fluorosis areas in Guizhou Province.

[19] Zhu, H., Zhang, J., Yu, X., & Hu, S. (2019). Sustainable tourism development strategies and practices of world heritage sites in China: A case study of Mt. Huangshan. *International Journal of Sustainable Development and Planning*, *14*(4), 297-306.