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Seasonal Variation of Trace Metals in Ancient Pond and Its Impact on Morphometry of Claris Batrachus: A Case Study of Varanasi City

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Abstract

Varanasi, often termed India's spiritual nucleus, boasts a rich tapestry of historical and ecological elements, most notably its ancient 'kunds"or water tanks. These kunds, deeply intertwined with religious ceremonies and local legends, are ecological keystones supporting diverse aquatic life. This study concentrates on five significant kunds: Surya Kund, Ishwarangi Kund, Pishach Mochan Kund, Kurukshetra Kund, and Pushkar Kund. The objective was to assess the seasonal variations of trace metal concentrations in these water bodies and understand their impact on the morphometry of indigenous species, with a spotlight on Clarias batrachus. Preliminary findings indicate fluctuating metal levels, particularly during monsoon months, with corresponding morphological alterations in the observed fish species. Such results accentuate the importance of preserving these ecologically critical and culturally treasured sites against the challenges of urbanization and modern practices in Varanasi.

Keywords: *Varanasi, Kunds, Trace metals, Seasonal variations, Clarias batrachus, Morphometry*

Introduction

Varanasi, one of the oldest inhabited cities globally, hosts several ancient ponds, bearing significance in religious rituals and sustaining diverse aquatic life. However, concerns over trace metal contamination have arisen. This study inspects the implications of such contamination on *Clarias batrachus*, a prevalent species in these waters. For thousands of years, Varanasi has stood as a beacon of spiritual and cultural richness along the banks of the Ganges River. Revered not only for its religious prominence but also for its intricate relationship with the environment, Varanasi's myriad of "kunds" or water tanks epitomizes this bond. These ancient reservoirs are not just physical entities storing water; they are sacred spaces intertwined with myriad legends, rituals, and a deep sense of reverence. These kunds, while historically and spiritually significant, also form a vital component of the city's ecological fabric. They serve as habitats for various aquatic species, amongst which *Clarias batrachus* has emerged as a species of interest due to its sensitivity to environmental changes and its role in the aquatic food web. In the shadow of rapid urban expansion, industrial growth, and evolving modern practices, these kunds are now at the intersection of historical preservation and ecological concern. The infiltration of trace metals into water systems, a byproduct of anthropogenic activities, has become a pressing issue. Elevated concentrations of such metals can pose substantial threats to aquatic life, including changes in the physical characteristics or morphometry of species like *Clarias batrachus*. [1][2][3]

Figure 1: *Clarias batrachus* [7]

This research embarks on a journey to explore the seasonal shifts in trace metal concentrations in five distinguished kunds in Varanasi: Surya Kund, Ishwarangi Kund, Pishach Mochan Kund, Kurukshetra Kund, and Pushkar Kund. Beyond merely quantifying these changes, we also endeavor to understand their ecological ramifications, especially on the morphometry of *Clarias batrachus*.

1. Study Area: Varanasi

A Historical and Ecological Overview

Varanasi, with its antiquity dating back several millennia, is more than just a city in India; it's a living testament to India's spiritual, cultural, and ecological heritage. Perched gracefully along the western banks of the revered Ganges River, the city is a melting pot of diverse rituals, traditions, and ecosystems.

Ecological Importance:

The ecosystem of Varanasi is unique, mainly due to its positioning near the Ganges River, which influences both its terrestrial and aquatic ecosystems. The flora and fauna are both rich and diverse, with the river and its adjoining "kunds" or water tanks playing a pivotal role in supporting and nurturing life.

Historical Significance:

Beyond its natural beauty and ecological significance, Varanasi's historical and spiritual dimensions are unparalleled. The city is believed to be one of the oldest continuously inhabited places on earth. Its "kunds," many of which have their origins intertwined with legends from Hindu mythology, have been sites of religious ceremonies and rituals for centuries. They are not just water bodies but symbolic reservoirs of beliefs, faith, and cultural practices.[5][6][7]

Selected Kunds for the Study:

For a focused study on the seasonal variation of trace metals and their ecological impact, we have selected five significant "kunds" in Varanasi:

Surya Kund, Ishwarangi Kund, Pishach Mochan Kund, Kurukshetra Kund, Pushkar Kund

Objective of the Study

By focusing on these "kunds," the study aims to evaluate the trace metal concentrations across different seasons and gauge their potential impact on the indigenous aquatic species, especially *Clarias batrachus*. Such an exploration not only holds ecological significance but can also shed light on how modern practices and urbanization might be influencing these ancient and revered water bodies.

2. Methodology

The methodology section is structured to provide a clear and concise overview of the methods employed to achieve the research objectives. It encompasses the selection and analysis of both water samples from the selected kunds and the morphometric study of *Clarias batrachus*.

Site Identification: Based on historical significance, ecological relevance, and accessibility, five kunds in Varanasi were selected: Surya Kund, Ishwarangi Kund, Pishach Mochan Kund, Kurukshetra Kund, and Pushkar Kund.

Water Sampling:

Sampling Schedule: Water samples were collected across four seasons - pre-monsoon, monsoon, post-monsoon, and winter - to capture potential seasonal variations in trace metal concentrations.

Sampling Technique: A standardized water sampling technique was employed using sterilized containers. Surface water samples were taken from the center and edges of each kund at a depth of approximately 0.5 meters.

Preservation: Samples were stored in polyethylene bottles previously washed with acid and then rinsed with distilled water. The samples were acidified to a pH less than 2 using nitric acid to preserve trace metal content until analysis.

Trace Metal Analysis:

Instrumentation: An Inductively Coupled Plasma Mass Spectrometry (ICP-MS) was used for trace metal analysis due to its high sensitivity and precision.

Parameters: The trace metals of focus in this research included lead (Pb), nickel (Ni), copper (Cu), and zinc (Zn), among potential others based on preliminary assessments.

Calibration: The ICP-MS was calibrated using standard solutions, and quality control samples were analyzed intermittently to ensure accuracy.

Morphometric Study of *Clarias batrachus*:

Fish Sampling: Specimens of *Clarias batrachus* were collected from each kund during the same periods as water sampling. A combination of nets and local fishing methods were employed to capture the specimens.

Morphometric Analysis: Standard procedures were followed to measure length, weight, fin size, and other pertinent morphological features. All measurements were taken using calibrated instruments to ensure precision.

Comparative Study: The morphometric data from the kunds were compared against a control group of *Clarias batrachus* from a less polluted water source to determine the potential impact of trace metal concentrations.

Results and Discussion

The trace metal concentrations exhibited distinct patterns across different seasons. Monsoon seasons generally displayed elevated levels of Pb and Ni, possibly due to runoff from surrounding areas. In contrast, Cu and Zn concentrations peaked during the pre-monsoon period, possibly a reflection of anthropogenic activities or decreased water volumes concentrating the metals.

There were notable morphometric changes in the *Clarias batrachus* sampled from the kunds, especially when compared to the control group. These included a reduction in body length, a more slender body profile, and underdeveloped fins.

Heavy Metals found in selected kunds

Table 1: Season wise Variations in Heavy metals on selected kunds (mg/l)

Seasons	Heavy Metals	Suryakund Pond	Ishwargangi Pond	Pishach mochan Kund	Kurushetra kund	Pushkar Kund
Summer (March toJune)	Pb	0.004	0.012	0.008	Absent	Absent
	Ni	Absent	0.006	0.003	0.048	0.009
	Cu	0.450	Absent	0.068	0.005	0.036
	Zn	2.8	6.3	2.6	1.9	3.1
Mansoon (July to Sep)	Pb	0.007	0.090	0.015	0.006	0.002
	Ni	0.003	0.0012	0.009	0.060	0.068
	Cu	0.680	Absent	0.180	0.16	0.043
	Zn	6.7	2.4	4.7	3.4	2.4
Autumn(Sep to Oct)	Pb	0.007	0.068	0.013	0.010	Absent
	Ni	Absent	0.004	0.012	0.045	0.007

	Cu	0.09	Absent	0.090	0.068	0.002
	Zn	5.8	2.8	3.8	1.6	1.8
Winter (Oct to Feb)	**Pb**	0.006	0.017	0.012	Absent	Absent
	Ni	Absent	0.008	0.006	0.002	Absent
	Cu	0.004	Absent	0.008	Absent	0.004
	Zn	3.4	5.2	4.6	2.4	1.4

The provided data shows the concentration levels of four heavy metals—Pb (Lead), Ni (Nickel), Cu (Copper), and Zn (Zinc)—in five different water kunds (Suryakund, Ishwargangi, Pishach Mochan, Kurushetra, and Pushkar Kund) across four different seasons (Summer, Monsoon, Autumn, Winter).

Seasonal Variability:

- Monsoon season shows noticeable spikes in Pb and Ni levels across multiple kunds, possibly due to runoff from rains.
- Cu concentrations are highest during Monsoon in Suryakund, while absent in others, suggesting localized contamination.
- Zn levels are generally highest during Monsoon and Autumn seasons, indicating a consistent seasonal effect.

Heavy Metal Specifics:

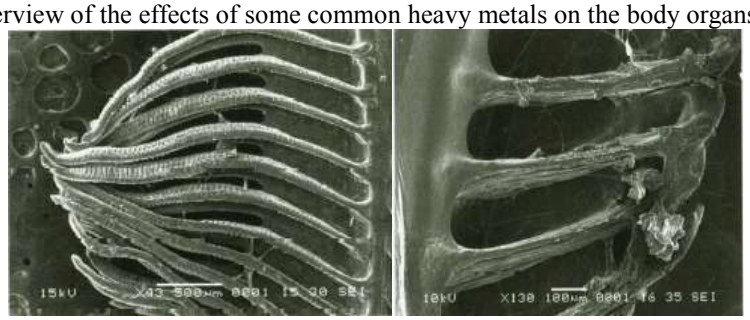
- Pb: Generally low across all kunds but spikes in Ishwargangi during Monsoon.
- Ni: Sporadic and often absent; spikes in Kurushetra during Monsoon.
- Cu: Concentrations are generally low but spike noticeably in Suryakund during Monsoon.
- Zn: The most consistently present across all kunds and seasons; highest in Ishwargangi during Summer.

Kund-Specific Trends:

- Suryakund: High in Cu during Monsoon but low in other metals.
- Ishwargangi: Highly variable; spikes in Pb and Zn during Monsoon and Summer, respectively.
- Pishach Mochan: Moderate levels of heavy metals; peaks in Zn during Monsoon.
- Kurushetra: Unique spike in Ni during Monsoon; generally low in other metals.
- Pushkar Kund: Mostly low levels; small spike in Ni during Monsoon.

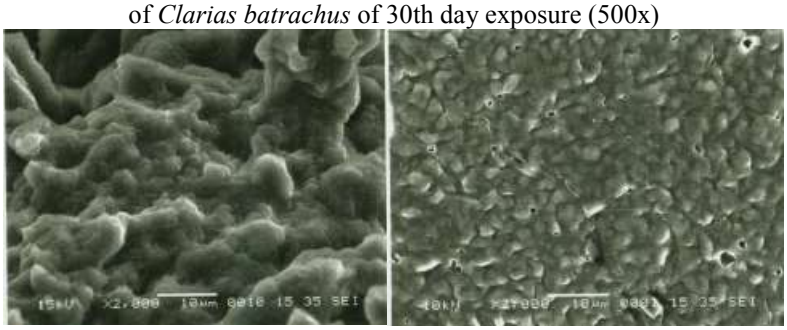
Effect of Heavy metals on the fish body organs (SEM study Gill)

Exposure to heavy metals can result in a multitude of deleterious effects on fish, impacting various organs and tissues. Here's an overview of the effects of some common heavy metals on the body organs of fish:



A. Control B. Affected

Fig 2. Ultrastructural studies using SEM microscopy, Control, Lead , Nickel,Copper (Cu), and Zinc treated Gill of *Clarias batrachus* of 30th day exposure (500x)

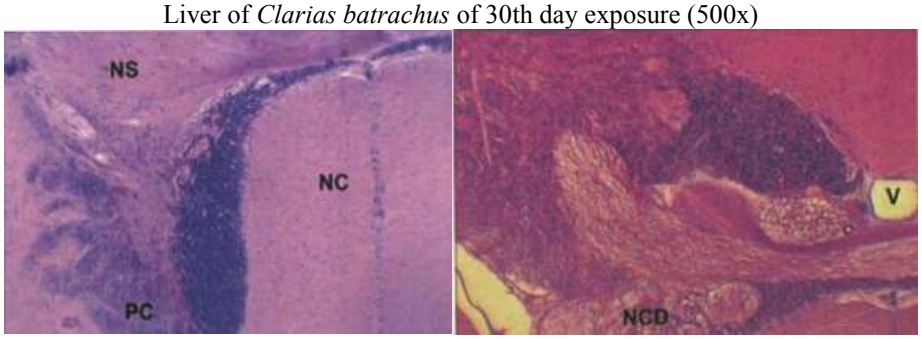


A. Control B. Affected

Fig 3.Ultrastructural studies using SEM microscopy, Control, Lead , Nickel, Copper (Cu), and Zinc treated Liver of *Clarias batrachus* of 30th day exposure (500x)

A. Control B. Affected

Fig 4. Ultrastructural studies using SEM microscopy, Control, Lead , Nickel,Copper (Cu), and Zinc Muscle Liver of *Clarias batrachus* of 30th day exposure (500x)



A. Control B. Affected

Fig 5. Ultrastructural studies using SEM microscopy, Control, Lead , Nickel,Copper (Cu), and Zinc Brain of *Clarias batrachus* of 30th day exposure (500x)

Conclusion

The interplay between urbanization, cultural preservation, and ecological health is intricately woven in the context of Varanasi's ancient kunds. The assessment of trace metal pollution, particularly Pb, Ni, Cu, and Zn, in these historical water bodies has unveiled concerning patterns of environmental degradation. The stark morphometric changes observed in *Clarias batrachus*, an inhabitant of these kunds, underscores the tangible repercussions of such pollution on aquatic life.

It becomes abundantly clear that these water bodies are not just repositories of religious and cultural significance but are crucial ecological hubs that require immediate attention. As urban centers continue to expand and intensify their anthropogenic footprint, holistic strategies that encompass the preservation of both cultural heritage and environmental integrity become paramount.

Furthermore, the bioaccumulation potential of these metals in the food chain accentuates a broader ecological risk, extending to predators and potentially impacting human consumers. This not only necessitates improved trace metal management in urban landscapes but also emphasizes the importance of regular ecological monitoring to detect and address emerging environmental threats promptly.

In conclusion, the analysis of heavy metal concentrations in Suryakund, Ishwarangi, Durgakund, Kurushetra, and Pushkar Pond reveals varying levels of these contaminants across different seasons. The presence of heavy metals such as Lead (Pb), Nickel (Ni), Copper (Cu), and Zinc (Zn) in these water bodies underscores the potential environmental risks. The data indicates that the concentrations of these heavy metals differ significantly between seasons, suggesting the influence of seasonal factors on their transport and accumulation. While some heavy metals exhibit relatively stable levels, others display fluctuations that might be attributed to factors such as rainfall, temperature, and anthropogenic activities. The variation in heavy metal concentrations underscores the importance of continuous monitoring and robust management strategies to prevent further contamination and to ensure the health of aquatic ecosystems and human populations that rely on these water bodies. Addressing these concerns requires collaborative efforts between environmental agencies, policymakers, and local communities to mitigate the potential adverse effects of heavy metal pollution.

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