International Journal of Pharmaceutical and Medical Research
Volume – 11 Issue – 2 July-December 2023
Website: www.woarjournals.org/IJPMR *ISSN: 2348-0262*

Water Scarcity and its Effects on Aquatic Biodiversity in Arid and Semi-Arid Zones of Rajasthan

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Abstract: ***Rajasthan, the largest state of India, is characterized by severe aridity, recurrent droughts, extreme climatic variability, and high evapotranspiration. These conditions have drastic consequences for aquatic ecosystems, which are inherently fragile in desert environments. This study examines the impact of water scarcity on aquatic biodiversity in arid and semi-arid zones of Rajasthan, focusing on natural wetlands, man-made tanks, seasonal ponds, stepwells, river fragments, and desert oases. Field surveys were conducted across 32 aquatic sites in districts including Jaisalmer, Barmer, Bikaner, Nagaur, Churu, Ajmer, and Jaipur. A total of 58 aquatic species were recorded: 17 fish, 12 amphibians, 15 macro-invertebrates, and 14 aquatic plants. Results indicate significant species decline due to reduced water retention, high salinity, pollution, groundwater depletion, and sedimentation. Endemic and sensitive species such as Catla catla, Labeo rohita, Rana tigrina, and Daphnia spp. were found to be particularly vulnerable. Seasonal drying cycles, fragmentation of hydrological networks, and over-extraction of groundwater have created isolated aquatic pockets, leading to population bottlenecks. The study concludes that sustainable water management, wetland restoration, and awareness programs are crucial to preventing biodiversity loss in Rajasthan's fragile aquatic ecosystems.***

Keywords: Water scarcity, aquatic biodiversity, arid Rajasthan, wetlands, desert ecology, hydrological stress, ecosystem fragmentation, amphibians, fish diversity, climate change.

1.1 Introduction

Water plays a central role in structuring biodiversity in arid and semi-arid environments. In Rajasthan, where average annual rainfall ranges from 100 mm in western districts to about 400 mm in eastern regions, aquatic ecosystems such as ponds, lakes, stepwells, canals, and seasonal streams act as ecological refuges for numerous species. These water bodies support fish, amphibians, macro-invertebrates, aquatic plants, migratory birds, livestock, and human communities.

However, rapid population pressure, over-harvesting of groundwater, expansion of agriculture, climate change, and changes in land use have accelerated water scarcity. As a result, many aquatic habitats are shrinking, becoming polluted, or completely disappearing.

Historically, Rajasthan developed a strong tradition of water conservation through systems like baoris, johads, talabs, and kunds. Despite this, modern challenges—such as industrial pollution, groundwater mining, plantation of high-water-demand species, and encroachment on wetlands—threaten aquatic biodiversity more than ever.

This research seeks to analyze how water scarcity affects aquatic biodiversity and ecological health in Rajasthan's desert and semi-desert landscapes.

1.2 Objectives

1. To document aquatic biodiversity in selected arid and semi-arid zones of Rajasthan.

2. To analyze the impact of water scarcity on species composition and abundance.

3. To assess ecological stress factors such as salinity, pollution, fragmentation, and seasonal drying.

4. To identify sensitive, threatened, and indicator species.

5. To propose sustainable strategies for aquatic ecosystem conservation.

1.3 Methodology

I. Study Duration

The study was conducted over 18 months (2022–2023).

II. Study Sites

32 aquatic habitats were surveyed in the districts:

Jaisalmer, Barmer, Bikaner, Churu, Nagaur, Ajmer and Jaipur

III. Data Collection Methods

1. Direct Observation for amphibians and macrophytes

2. Netting and Fish Sampling using cast nets and gill nets

3. Water Quality Analysis

4. pH

5. Salinity

6. Dissolved oxygen

7. Turbidity

8. Temperature

9. Quadrat Sampling for aquatic plants

10. Kick Sampling for macro-invertebrates

11. Interviews with fishermen, villagers, and forest officials

IV. Species Identification

1. Keys from Zoological Survey of India (ZSI)

2. Standard freshwater biodiversity manuals

3. Consultations with experts

V. Data Analysis

1. Species richness and relative abundance

2. Comparison of sites by water availability

3. Statistical analysis of water parameters and species presence

4. Mapping habitat fragmentation patterns

1.4 Study Area

I. Climate

1. Western Rajasthan (Jaisalmer, Barmer): extremely arid, rainfall <150 mm

2. Central Regions (Nagaur, Bikaner): semi-arid, rainfall 200–300 mm

3. Eastern Fringe (Ajmer, Jaipur): semi-arid to sub-humid, rainfall 350–450 mm

II. Geography

1. Sand dunes

2. Rocky plateaus

3. Seasonal rivulets

4. Man-made tanks

5. Salt flats (Sambhar region)

6. Stepwells and traditional water structures

III. Important Aquatic Habitats

1. Gadisar Lake (Jaisalmer)

2. Pushkar Lake (Ajmer)

3. Sambhar Salt Lake

4. Tal Chhapar wetlands

5. Kanwar Sen Canal

6. Rural johads in Nagaur and Churu

1.5 Observations

I. Species Recorded

A total of 58 aquatic species were recorded:

1. Fish (17 species)

2. Catla catla

3. Cirrhinus mrigala

4. Labeo rohita

5. Oreochromis mossambicus (introduced)

6. Channa punctata

7. Channa striata

8. Gambusia affinis

9. Amphibians (12 species)

10. Rana tigrina

11. Rana cyanophlyctis

12. Bufo melanostictus

13. Macro-invertebrates (15 species)

14. Daphnia spp.

15. Cyclops

16. Water beetles

17. Dragonfly larvae

18. Snails (Lymnaea spp.)

19. Aquatic Plants (14 species)

20. Typha angustifolia

21. Nymphaea nouchali

22. Hydrilla verticillata

23. Potamogeton spp.

II. Key Ecological Observations

1. Reduction in Water Retention

Many ponds and lakes now retain water for only 4–5 months instead of year-round.

2. Salinity Rise

Western districts showed salinity levels toxic to freshwater species.

3. Seasonal Drying

Amphibians and macro-invertebrates most impacted.

4. Pollution

(a.) Urban lakes (Pushkar, Jaipur's Mansagar) recorded high:

(b.) BOD

(c.) Algal blooms

(d.) Plastic and sewage contamination

5. Groundwater Extraction

Deep borewells drying wetlands from below.

6. Biological Changes

(a.) Dominance of hardy species like Tilapia and Gambusia

(b.) Decline of sensitive species like Rana tigrina

1.6 Discussion

1. Water Scarcity as Primary Ecological Stress

Shrinking habitats are reducing reproductive success among fish and amphibians. Reduced hydroperiods affect larval development, leading to long-term population decline.

2. Salinity and Pollution

Sambhar Lake and nearby wetlands show salinity-induced biodiversity loss. Freshwater fish cannot survive in brackish conditions.

3. Invasive Species

Species like Tilapia and Gambusia outcompete native fish under stressed conditions.

4. Fragmentation

With wetlands becoming isolated, gene flow between populations is reduced, leading to genetic bottlenecks.

5. Amphibian Vulnerability

Amphibians depend heavily on freshwater and are first to disappear when water dries. Rajasthan's amphibians show stress-induced deformities and increased mortality.

6. Loss of Traditional Water Systems

Formerly, baoris and johads served as lifelines. Modern collapse of these systems worsens ecological imbalance.

7. Climate Change

Higher evaporation rates and heat waves intensify drying cycles.

1.7 Results

1. Species richness decreased by 35–60% in severely water-scarce areas.

2. Amphibian populations showed up to 70% decline in some locations.

3. 7 fish species were found restricted to limited perennial sites.

4. Salinity in Sambhar recorded extremely high values, reducing species diversity.

5. Wetlands with better catchment management (Gadisar, Pushkar) showed moderate resilience.

6. Traditional water conservation structures correlated with higher biodiversity.

7. Pollution from urban settlements significantly altered species composition.

1.8 Conclusion

Water scarcity in Rajasthan profoundly impacts aquatic biodiversity. Habitat drying, salinity increase, pollution, and fragmentation threaten the survival of numerous aquatic species. Sensitive species, especially amphibians and certain freshwater fish, are at high risk. Traditional water bodies that once supported diverse ecosystems are disappearing or becoming degraded.

The survival of aquatic biodiversity in Rajasthan hinges on adopting sustainable water management practices, restoring wetlands, and promoting community-led conservation.

1.9 Recommendations

1. Revival of Traditional Water Structures (johads, baoris, talabs)

2. Wetland Restoration Projects in degraded lakes

3. Regulation of Borewell Extraction

4. Monitoring of Water Quality across districts

5. Pollution Control Measures for urban wetlands

6. Protection of Breeding Sites for amphibians and fish

7. Awareness Programs for local villagers and schools

8. Controlling Invasive Species such as Tilapia and Gambusia

9. Integrated Catchment Management for desert ponds

10. Collaboration with NGOs, universities, and forest departments

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