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Impact of Agrochemical Runoff on Amphibian Diversity in Semi-Arid Karnataka

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Abstract:

Amphibians are sensitive bioindicators vulnerable to habitat contamination. This study investigates the impact of agrochemical runoff on amphibian diversity in the agricultural landscapes of Chintamani Taluk, Karnataka. Data were collected from five wetlands, analyzed for chemical presence (nitrates, phosphates, chlorpyrifos), and correlated with amphibian population trends. Findings reveal a decline in both abundance and species richness in areas adjacent to farmlands. Recommendations are made for integrated pesticide management and habitat buffer zones.

Keywords:

Amphibians, agrochemicals, biodiversity, runoff, Karnataka, pesticides, habitat loss, bioindicators

2. Introduction

- Amphibians are crucial components of ecosystems, acting as predators, prey, and biological indicators.
- The Western and Eastern Ghats are home to a high number of endemic amphibian species, many of which are poorly studied in dry semi-arid inland zones like Chintamani.
- Increasing pesticide use in paddy, tomato, and ragi cultivation in Karnataka has led to leaching of substances like urea, phosphates, glyphosate, and chlorpyrifos into surface waters.
- Amphibians are uniquely sensitive to these chemicals due to their semi-permeable skin and aquatic larval stages.
- This study investigates the amphibian diversity in areas adjacent to intensive farming and evaluates the presence of agrochemicals in wetland systems.
- **Objectives:**
  a) Identify the diversity of amphibian species in agrochemical-affected vs. unaffected areas
  b) Measure concentrations of agrochemicals in water samples
  c) Evaluate relationships between chemical levels and species richness

3. Materials and Methods

Study Area

- Chintamani Taluk in Chikkaballapur District, Karnataka
- Five wetlands selected (3 near agricultural fields, 2 protected)
- GPS coordinates and mapped layouts included in original field study

Data Collection

- Visual Encounter Surveys (VES) at dawn and dusk (March–May 2017)
- Pitfall traps with drift fences installed
- Nighttime call surveys conducted to detect calling males

Chemical Testing

- Water samples taken from each site biweekly
- Laboratory analysis using spectrophotometry for:
  - **Nitrates**
  - **Phosphates**
  - **Chlorpyrifos**
  - **pH, Dissolved Oxygen, Conductivity**

Statistical Analysis

- Species richness and evenness calculated using Shannon-Weiner and Simpson indices
- ANOVA used to test for differences in chemical concentrations
- Pearson correlation coefficient to analyze amphibian richness vs. chemical load

4. Results and Discussion

Field surveys across the five wetland sites yielded a total of **18 amphibian species** belonging to six families. Sites adjacent to intensive agricultural activity exhibited significantly lower species richness (average: 6 species) compared to relatively undisturbed wetlands (average: 14 species). Statistical analysis using the **Shannon-Weiner Diversity Index** revealed a drop from **H' = 2.61** in control sites to **H' = 1.24** in contaminated zones.

Water quality assessments confirmed the presence of agrochemicals at concerning levels. Chlorpyrifos concentrations ranged from **0.12 mg/L to 0.46 mg/L**, exceeding safe ecotoxicological thresholds for amphibians (as per USEPA guidelines). **Nitrate** and **phosphate** concentrations also peaked post-irrigation cycles, correlating with seasonal pesticide applications.

Pearson correlation analysis demonstrated a strong negative relationship between chlorpyrifos concentration and amphibian abundance ($r = -0.84$, $p < 0.01$). Sites with higher chemical loads exhibited behavioral anomalies in amphibians, such as irregular calling patterns and reduced mobility. Species like *Polypedates maculatus* and *Fejervarya limnocharis* were present at all sites but in reduced numbers, whereas sensitive species such as *Euphlyctis cyanophlyctis* were completely absent from chemically exposed wetlands.

Histopathological studies (conducted on salvaged specimens under ethical clearance) revealed epithelial thinning, edema, and early-stage liver necrosis in specimens collected from high-chemical-load sites — indicating chronic exposure effects.

The results are consistent with earlier studies (Hayes et al., 2006; Relyea, 2005) on endocrine disruption and neural toxicity due to pesticides. Moreover, the findings support the notion that even **non-lethal subchronic exposure** can drive population-level declines through reproductive inhibition and developmental abnormalities.

Notably, **buffered wetlands** surrounded by native vegetation had markedly better water quality and amphibian diversity, underscoring the protective role of landscape elements.

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5. Conclusion

This study provides compelling evidence that agrochemical runoff — particularly from pesticides like chlorpyrifos and high levels of nitrogenous fertilizers — is a significant driver of amphibian diversity loss in the semi-arid agricultural zones of Karnataka.

Findings underscore a **clear link between chemical exposure and reduced amphibian species richness**, behavioral disruptions, and early pathological effects in resident populations. These patterns mirror global amphibian decline trends but highlight the urgent need for **localized policy and habitat protection measures** in India’s dryland ecosystems.

To mitigate further biodiversity loss, it is imperative that local agricultural practices adopt:

- **Integrated Pest Management (IPM)** strategies
- Establishment of **30–50 meter vegetation buffer zones** around wetlands
- **Farmer education programs** on ecotoxicology
- Periodic biodiversity and water quality monitoring under **state-level conservation programs**

Protecting amphibians not only supports ecological balance but serves as a safeguard for human health, given their sentinel role in environmental monitoring. Future research should explore molecular biomarkers of exposure and integrate GIS-based habitat modelling to inform regional conservation planning.

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8. Endnotes

1. Amphibians' permeable skin increases sensitivity to pollutants.
2. Chlorpyrifos is a neurotoxic organophosphate used widely in tomato and paddy farming.
3. The dry season sees higher pesticide concentrations due to evaporation and low dilution.
4. Wetland biodiversity declines can serve as early ecological warnings.
5. Amphibians in Karnataka show breeding activity mainly post-March pre-monsoon.
6. Spectrophotometry allows reliable detection of phosphates down to 0.01 ppm.
7. Farmers reported increasing pesticide use due to pest resistance.
8. Soil runoff is accelerated by absence of grass or hedgerows around farms.
9. Statistical correlation does not imply causation but supports hypothesis formation.
10. Similar patterns were reported in Andhra Pradesh (Rao et al., 2015).