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Popular Article

Environmental DNA - As a Technology for Assessment of Biodiversity

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Introduction

- **Environmental DNA** or **eDNA** is DNA that is collected from a variety of environmental samples such as soil, seawater, snow or air, rather than directly sampled from an individual organism.
- As various organisms interact with the environment, DNA is expelled and accumulates in their surroundings from various sources.

A brief history of eDNA

- Over the last few decades, the development of eDNA and sequencing techniques have resulted in an increasing interest in its use as a tool for both targeted species detection and assessments of the biodiversity of any ecosystem.
- The term "Environmental DNA" was first coined in microbiology to describe a technique for collecting DNA from a soil environmental sample without first isolating the target microorganisms.

eDNA:

- Environmental DNA (eDNA) is an effective conservation tool that allows scientists to discover the presence or absence of specific species in an ecosystem.
- Ecologists, geneticists, and data scientists work together to improve this new technique. Environmental DNA (eDNA) is mitochondrial or nuclear DNA that was discharged into the environment by animals.

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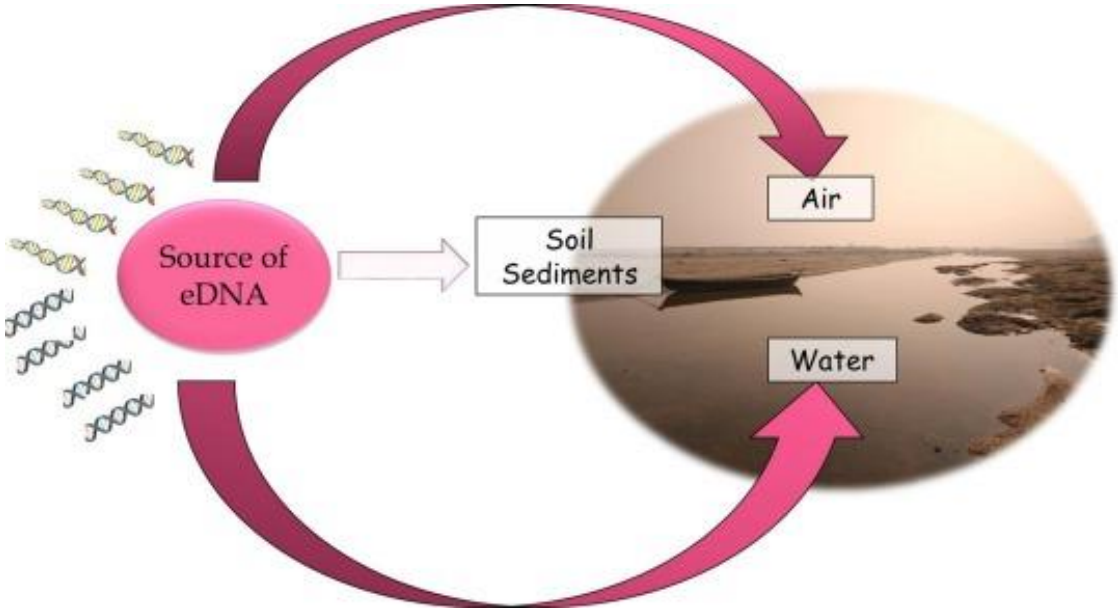
Source of eDNA

- The cells and waste that they shed and excrete, such as faeces (poops), urine, mucus, gametes, shed skin, hair, blood, epidermal cells, and corpses, are the source of eDNA in soil, organic sediments, and water.
- In this precise meaning, eDNA is thought to be a combination of trace amounts of intact cells (intracellular DNA) and DNA fragments (extracellular DNA) released into the environment by animals that are no longer present, and may be detected by sampling the environment alone.
- Extracellular DNA from injured tissues frequently degrades into smaller fragments, while intracellular DNA is obtained from cells or organisms present in the sample and is more likely to be of excellent quality.



The major sources of eDNA in aquatic environment.

eDNA WORKFLOW

Environmental DNA assessment of aquatic microorganisms (referred to as "eDNA analysis" from this point forward) from water samples involves some basic steps are:

- sample collection,
- eDNA capture,
- eDNA extraction,
- PCR and sequencing,
- Sequence analysis

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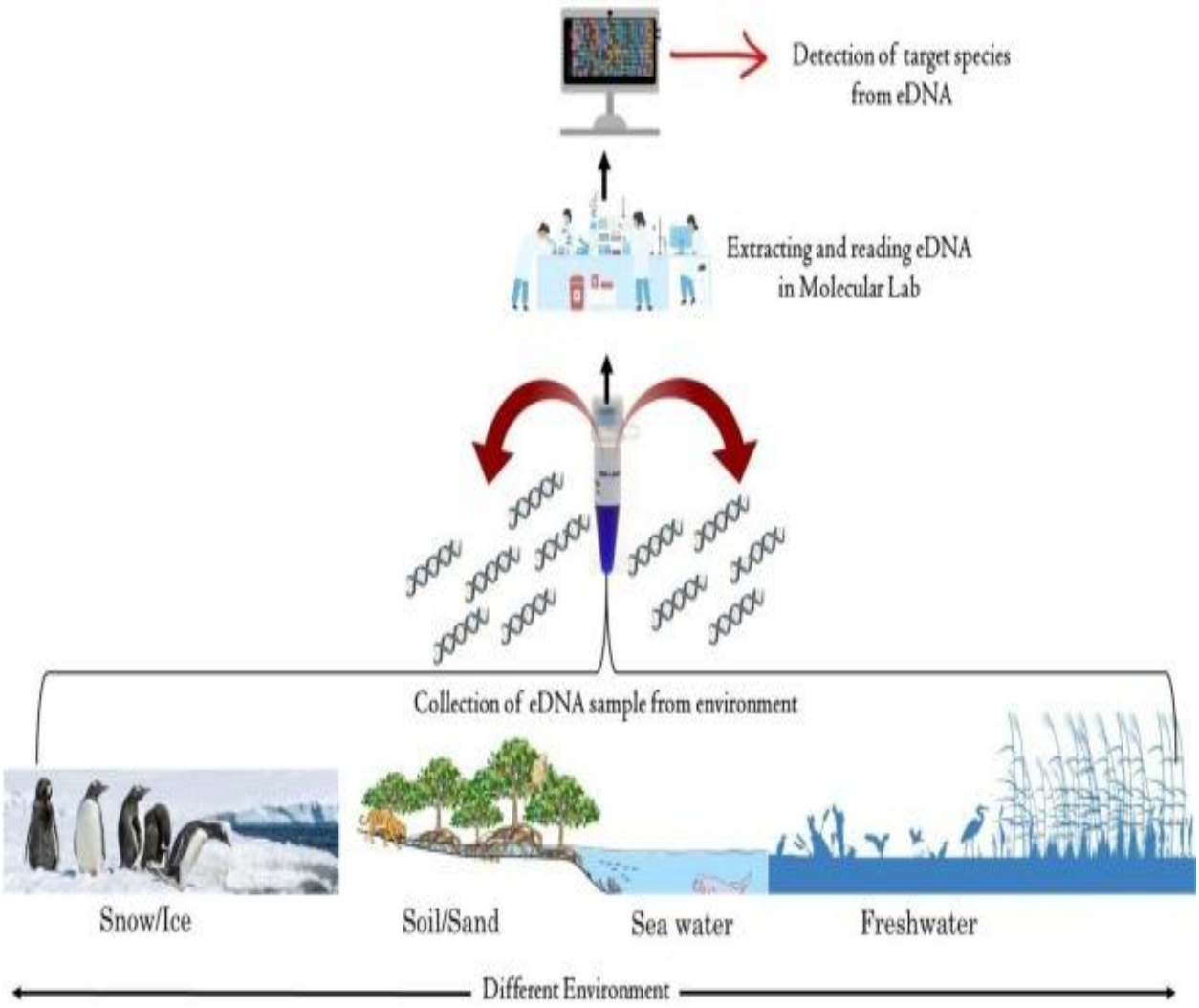

eDNA workflow

Abundance estimates using eDNA

- The quantitative study of eDNA provides a substantial opportunity to measure a species presence–absence in natural ecosystems and its relative abundance (Jerde et al., 2011).
- eDNA has the ability to record not only the number of species present, but also the number of individuals living within any given environment, allowing ecological inquiries to change from species richness to species diversity.
- According to one study, electrofishing took 93 days to identify a single example of a rare species of fish, while eDNA took only 4 h to detect the species (Jerde et al., 2011).
- This provides advanced data for biodiversity and ecosystem monitoring, allowing for the tracking of changes in ecosystems over time, the observation of variations between habitats and ecosystems, and the understanding of ecosystem health.

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- Recent studies positively correlated eDNA concentration from qPCR with broad categorical variables of high/low density of like frogs in ponds (Ficetola et al., 2008), and Asian carp in different waterways (Jerde et al., 2011).

Uses of eDNA methods

➢ **Biomass estimation:**

- Species distribution and biomass estimation are essential components for the conservation of populations. Species distribution can be determined by absence/presence data.
- This novel method has ability to detect single species to the targeting of many species from ecosystem.

Advantages of eDNA as an assessment tool

- **High sensitivity:** The eDNA analysis is sensitive enough to detect low-abundance or low-detection rate species.
- **Non-invasive:** No organism handling, capturing or distribution is required.
- **Cheap:** The present technique is cheaper than the conventional environmental sampling technique as it requires the least field work or equipment.
- **Time-saving:** eDNA sampling and analysis is a fast and rapid method that gives us results within a day or two.
- **Universal:** The present technique is universally accepted in the study of ecosystems, wildlife conservation and other fields.

Disadvantages of eDNA as an assessment tool

- The eDNA approach only gathers information on the presence or absence of the target species. It does not provide any information on factors such as a species' life stage, reproduction, or fitness.
- Based on eDNA, hybrids cannot be identified from their maternal species because most eDNA studies focus on mitochondrial DNA, which is transmitted only from the mother.

Type 1 and type 2 errors:

- There are two types of error which are false positive (type 1) and false negative (type 2) error rates.
- Traditional methods used to sample species in aquatic habitats are prone to type 1 error (i.e., recording a species when it is absent; generally, through misidentification of observation or possible cross-contamination)
- Type 2 errors (i.e., failing to detect a species when it is actually present). Environmental DNA approaches are also subject to these potential errors; however, eDNA methods have a reduced likelihood for type 2 errors as PCR analysis methods are highly sensitive.

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Factors affecting eDNA and survey

- Various abiotic and biotic factors affect fish eDNA and their surveys. eDNA degrades during transport, either through abiotic or biotic processes such as sedimentation and Biofilm.

Conclusion

- Environmental DNA analysis has been used in targeted species detection studies with PCR and qPCR assays, and in community (i.e., multi-species) studies using metabarcoding.
- The eDNA has the potential to make significant contributions to the detection of rare or threatened species as well as invasive species, community and ecosystem biodiversity, functional diversity, wildlife, and conservation biology.
- Since 2012, there has been a wide range of research on eDNA metabarcoding which is used in biodiversity conservation, fish community identification, fisheries management, the target of invasive species, and fish biomass/abundance estimations.
- The use of eDNA is escalating, and it is currently being used to monitor biodiversity and improve environmental probabilities to possibilities, as well as to monitor benthic organic enrichment, community assessment in microcosm research to detect anthropogenic contamination, coastal sediment structure, and to study the most diverse ecosystems.

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