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Diatomological Study on Water Bodies in Bengaluru City, India

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Abstract

Context: Unicellular algae called diatoms are typically found in aquatic environments and are frequently used in forensic science as a method to pinpoint the exact moment and place of drowning deaths. The creation of a diatom species database for Bangalore city that may be utilized in forensic investigations is presented in this paper. Light microscopy was used to examine the diatom population in a total of five water samples from diverse aquatic habitats in Bangalore. A database was made utilizing the information used to identify and classify the different diatom species based on their morphology. A list of the diatom species discovered in each water sample may be found in the database. Analyzing the diatom population in five test samples taken from recognisable places in Bangalore served to confirm the database. The findings demonstrate that the database is accurate and trustworthy for classifying diatom species in Bangalore's aquatic settings. Forensic investigators can utilize the diatom species database created in this study to pinpoint the place and timing of drowning fatalities in Bangalore city. Forensic investigators can pinpoint the site of a drowning and offer crucial evidence in court by comparing the diatom species identified in a drowning victim's lungs and other tissues with the diatom species in the database. The database may also be utilized in Bangalore city for ecological research and evaluations of the water quality.

Aims: To examine the diatom population in a total of five water samples from diverse aquatic habitats in Bangalore.

Settings and Design:

Study Location: Bangalore city, India, **Sample Collection:** Five water samples obtained from diverse aquatic habitats.

Methodology: Light microscopy used to examine and classify diatom species based on morphology.

Database Development: Compilation of identified diatom species to create a comprehensive database.

Validation: Analysis of diatom populations in test samples confirms accuracy and reliability of the database for forensic and ecological applications.

Material and Methods: Light microscopy was

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used to examine the diatom population in a total of five water samples from diverse aquatic habitats in Bangalore. A database was made utilizing the information used to identify and classify the different diatom species based on their morphology.

Results: A list of the diatom species discovered in each water sample may be found in the database. Analyzing the diatom population in five test samples taken from recognisable places in Bangalore served to confirm the database.

Conclusion: The findings demonstrate that the database is accurate and trustworthy for classifying diatom species in Bangalore's aquatic settings.

Keywords: Diatoms; Unicellular Algae; Drowning; Forensic Science.

Key Messages: Development of a diatom species database for Bangalore facilitates forensic investigations into drowning deaths, offering precise identification of diatoms from aquatic environments for location and timing determination, alongside applications in ecological research and water quality assessments.

Introduction

Diatoms are unicellular algae. They vary in size and shape. Even though this varies their basic composition remains the same. Diatoms consist of a nucleus, cytoplasm, plasma membrane and cell wall.

The study of diatoms began in the 18th century. The term 'Diatoms' is derived from the genus name *Diatoma.* Since the 18th century there has been a lot of work done in the field of diatoms. Over a century was spent on investigating the morphological and taxonomic features of diatoms. Towards the middle of the 20th century a more in-depth analysis of diatoms was conducted which resulted in additional information regarding Diatoms.

The unicellular algae known as diatoms are found in both freshwater and saltwater habitats. They are vital members of the marine food chain and significant primary producers. With accordance to the amounts of light intensity, nutrients, mineral composition, temperature, and depth, these organisms are established at a site. Variations in seasonality are a significant element influencing changes in the distribution of the diatoms. The variety of diatoms is reduced during winter due to a number of variables, such as short days, cold temperatures, and insufficient light intensity to enter the water column.[1-3]

Given their potential as biological indicators of the water's quality and their biological importance, diatoms have garnered more attention recently in India. With a population of more than 10 million, Bangalore, India is one of India's urban centers with the fastest rate of population growth. Numerous lakes in and near Bangalore have seen major changes in their water quality and biological conditions as a result of the area's growing development and urbanization.

Diatom research in Bangalore city lakes is crucial for a number of reasons. In 10 lakes in Bangalore city, Selvakumar *et al.* (2014) conducted research on the distribution and species diversity of diatoms.[4] The lakes were found to have a wide variety of water quality characteristics, and the composition of the diatom species differed significantly between lakes. Another research by Meera D.S *et al.* (2010) looked at the diatom communities in two urban lakes in Bangalore city.[5] They discovered that Fragilaria construens, Navicula radiosa, and Navicula rhynchocephala were the dominant species in the lakes. The ecological relevance of these species and their potential application as biological indicators of water quality are still largely unknown, despite the fact that these studies offer helpful insights concerning the diatom species diversity in lakes in Bangalore City. More investigation is required to clarify the variables affecting the variety and distribution of diatom species in these lakes as well as to determine the best techniques for controlling and monitoring the effects of human activity on these ecosystems. Additionally, diatoms are also gaining popularity because to their byproduct uses and forensic investigational capabilities.[6] They aid in the forensic resolution of drowning situations. According to Zhao *et al.* (2016), most incidents of drowning are either accidental or suicide.[7] Hypoxemia, a condition when the blood's oxygen level is low, develops after drowning. The body's aerobic metabolism is halted by a hypoxemial condition, which raises acidity and results in mortality. Additionally, a lot of additional things can happen to the body when drowning.[8] Aspiration of water into the lungs causes it to enter the bloodstream through the alveoli. Additionally, minute waterborne particles like silt, microbes, and pollen are delivered to other organs and lodged in their capillaries.

The goal of a forensic investigation in a drowning case is to determine the following: the identity of the victim, an estimate of the postmortem submersion period, the

cause and mechanism of death, and, finally, whether or not the drowning was life-threatening, that is, whether the victim was alive or dead when they entered the water. Diatoms are microscopic creatures that are found in practically all aquatic habitats, and their presence can be taken as a clear indication that someone has drowned.[9,10]

Diatoms spread throughout the body's organs after entering through the water.[11] Diatom species that penetrate into various bodily organs, such as bone marrow, lungs, kidneys, and the brain, aid forensic scientists in investigating drowning cases due to their region-specific diversification.[12]

Due to their siliceous qualities, diatoms are employed in biotechnology to produce biofuel and solar panels.[13,14] This research paper's goals are to present a summary of the current body of information regarding the species composition of diatoms in five freshwater lakes present in Bangalore city and to point out areas that require more study. The paper will cover the body of research on the subject and offer insights into the biological importance of the diatom species present in these lakes as well as their potential application as water quality bioindicators.

Methodology

Sample Collection

The collection of water samples from five (05) different lakes of Bengaluru was carried out from January 2023 and was successfully completed by March 2023. For the purpose of studying the diatom flora, 1 liter of water is randomly selected from each water body, and the water container is labeled with the time, date, and location of that water body. The temperatures for each water body are documented. The samples were collected in sterilized plastic bottles of a capacity of 1 liter with a screw-top closure and were further rinsed with the sample water medium to be collected. The list of chosen Bengaluru water bodies along with the temperature documented during sampling is shown in Table 1.

Table 1: The list of chosen Bengaluru water bodies along with the temperature documented during sampling

Name of the water body	Temperature recorded	Month of collection	Code
Sampangalli Lake	27°C	February 2023	B1
Rachenahalli Lake	26°C	February 2023	B2
Jakkur Lake	27°C	March 2023	B3
Kalikiri Lake	27°C	March 2023	B4
Allalasandra Lake	28 °C	March 2023	B5

Extraction of Diatoms

Some of the common techniques used for extraction of diatoms are

a) Acid digestion by Potassium Per magnet and conc. Hydrochloric acid.

b) Hydrogen Peroxide method.

c) Acid digestion by conc. Nitric acid or sulphuric acid.

In this study, after the collection of water samples from five different sites, 2-3 drops of lugol's Iodine solution was added for the preservation of the samples and left overnight.

Using a dropper, sediments from the settled water sample were transferred to a centrifuge tube, where they were centrifuged at 1500 rpm for 6 to 8 minutes with the use of a centrifuge machine.

After obtaining a centrifugation pellet, the supernatant was discarded. The residual sediments were once more placed in the centrifuged tube, and this procedure was repeated three to four times to produce additional pellets. After the centrifugation process was finished, the resulting pellet was mixed with 2-3 drops of concentrated nitric acid and distilled water in the centrifuge tube. It was then left undisturbed for 8–9 hours. Following that, the pellet was cleaned using distilled water and centrifuged.[15]

Microscopic Examination

The Pellet is diluted with one milliliter of distilled water following the last centrifugation. Microscopic slides were made by pouring the above solution and were allowed to air dry. The microscopic slides are next examined using a compound microscope at 10X and 40X magnifications.

Identification

Based on morphological characteristics such as symmetry, shape, raphe, and striae, the diatoms were identified using two online databases of North America and the United States.

Results & Discussion

In the chosen water body sample of Bengaluru Lakes, the genera *Navicula, Nitzschia, Cyclotella and Synedra* of diatoms are most often found. The distribution of diatoms among the chosen water bodies exhibits a recognizable variance. Nitzschia and Navicula are the two diatom genera that are most frequently found in the lakes of Bengaluru water bodies but in varied amounts. Since the Aquatic samples for the diatom were

collected during February and March when the average temperature was 26°C. These temperatures weren't good for diatom development.[16]

Therefore, fewer diatoms are found in the water samples that were obtained.

Table 2: The specifics of the diatom dispersion in five lakes of Bengaluru water bodies

Genera of Diatom	B1	B2	B3	B4	B5
Navicula	+	+	+	+	+
Nitzchia	+	+	+	+	+
Cyclotella	-	-	-	-	+
Amphipluera	+	-	-	+	+
Skelotenema	-	-	-	+	+
Pinnuleria	+	+	+	+	+
Tabellaria flocculosa	-	-	-	+	+
Cerataulin	+	-	-	-	-
Synedera	+	+	+	+	+
Adalfia	+	+	+	-	-
Nupela	+	+	+	-	+

Many attempts have been undertaken to produce diatom logical data in many South Indian locales, including the lakes of Cochin, Kodaikanal, Mangalore, and Madras. There is currently very less diatom-related data analysis for the Bengaluru area. The diatom genera found in Bengaluru's water bodies include ***Cyclotella, Synedra, Navicula, Nitzschia, Aulacoseira, Pinnularia, Skelotenema, Tabellaria flocculosa, Adalfia and Amphipleura.***

Diatoms from the genera Navicula, Nitzschia, Cyclotella, and Synedra are frequently found in most bodies of water. Some diatom genera, however, are exclusive to a single body of water. ***Tabellaria flocculosa*** in Kalikiri Lake & Allalasandra Lake lake, ***Cerataulina.*** Sampangalli lake, Skeletonema in Kalikiri Lake & Allalasandra Lake, ***Cyclotella*** in Allalasandra Lake and Amphipleura in Sampangalli Lake, Kalikiri Lake, Allalasandra Lake.[16]

Table 3: List of some common genera of diatoms

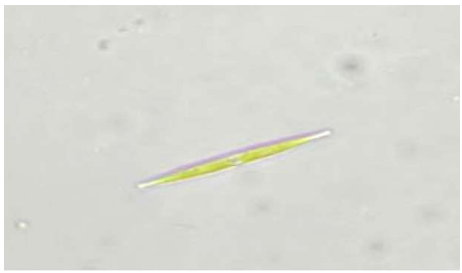
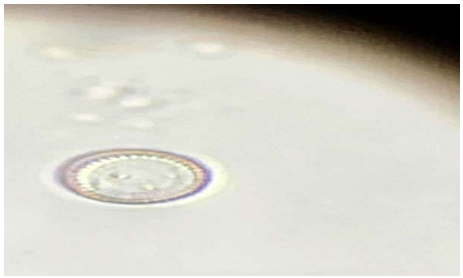
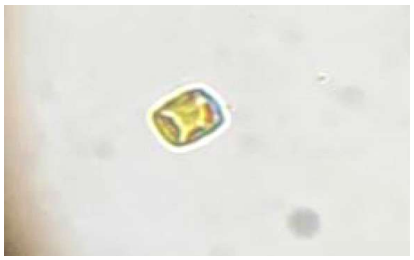
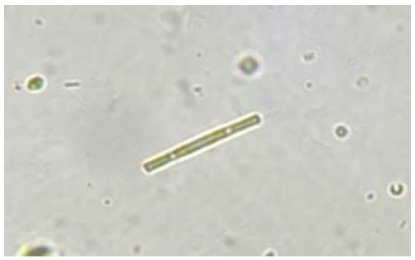
Genera of Diatom	Picture of Diatom
Navicula	
Nitzschia	
Cyclotella	
Nupela	
Pinnuleria	

Table 4: List of pecular genera of diatoms

Tabellaria Sp	
Skeletonema Sp	
Cerataulina Sp	
Aulacoseira Sp	

Diatoms are unicellular, photosynthetic algae that are Microscopic. Their cell membrane is made of silica and is typically found in aquatic habitats. They are especially important in situations where the body is discovered far from the scene of the drowning or body dumping and after an extended period of submersion. Diatoms are detected in the long skeletons of the deceased, particularly in the place of drowning or struggle, which explains why this is the case. Diatom testing is now the most effective method in forensic science; it acts as a benchmark in the investigation of dumping and drowning cases. It could be able to offer an objective ecological evaluation of trace evidence.

A total of 10 diatoms were discovered in the five lakes that were chosen for the analysis. I.e, ***Cyclotella, Synedra, Navicula, Nitzschia, Aulacoseira, Pinnularia and Amphipleura***.

Diatom cells were determined using the Sedgwick Rafter chamber (Bernard, 1971)

and were calculated by using the following formula:

Diatom/Litre (N) = n × v ×1000 V Where,

n = average number of diatom cells in 10 ml of water sample and

v = volume of water sample in concentrated form (ml)

V = volume of total water (liter)

The average no. of diatoms observed in four microscopic slides from all five samples of the chosen Lakes such as Sampangalli Lake, Rachenahalli Lake, Jakkur Lake, Kalikiri Lake, and Allalasandra Lake are listed in Table 3

Table 5: Average no. of diatom observed in five slides of each site in chosen lakes

Genera of Diatom	Average no. of diatom observed in five slides of each site					Orders	Category
	B1	B2	B3	B4	B5		
Navicula	9	6	7	10	11	Naviculales	pennales
Nitzchia	7	7	8	9	10	Bacillariales	pennales
Cyclotella	-	-	-	-	7	Thalassiosirales	Centrales
Nupela	-	-	-	5	5	Naviculales	pennales
Skelotenema	-	-	-	2	3	Thalassiosirales	Centric
Pinnuleria	5	5	5	5	5	Naviculales	pennales
Tabellaria flocculosa	-	-	-	1	1	Tabellariales	pennales
Cerataulina	1	-	-	1	1	Bidduphiales	centrales
Synedera	7	6	5	4	6	Fragilariales	pennales
Adalfia	1	1	1	-	-	Naviculales	Pennales

In the examination of drowning incidents in Bengaluru, the particularly defined genus found in the Upper Lake may be able to aid identify the drowning place. Due to the lack of data on seasonal fluctuation in diatom distribution, this study has certain limitations. The findings can be confirmed by more updates using routine diatomological data monitoring in certain Bengaluru waterbodies.

Conclusion

In this work, an effort is undertaken to create a database of the diatoms found in the Bengaluru region.

The pattern of distribution of the diatoms in the various bodies of water in this area is provided by the diatom logical data. Findings from the research support the notion that the distinctiveness of diatoms in different bodies of water plays a crucial role in drowning case analysis. It is feasible to right away compare the diatoms that were detected in biological specimens of drowning victims against the diatom data received from the research. Therefore, it might assist in accelerating the closure of drowning cases.

Conflict of Interest

The authors declare no conflict of interest for this research study.

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References

1. **Thakar MK, Singh R. (2010)** Diatomological mapping of water bodies for the diagnosis of drowning cases. J Forensic Leg Med. https://doi.org/10.1016/j.jflm.2009.07.016
2. **Falciatore A, Bowler C. (2002)** Revealing the molecular secrets of marine diatoms. Annu Rev Plant Biol. https://doi.org/10.1146/annurev.arplant.53.091701.153921
3. **Horton BP, Boreham S, Hillier C. (2006)** The development and application of a diatom-based quantitative reconstruction technique in forensic science. J Forensic Sci. https://doi.org/10.1111/j.1556-4029.2006.00120.x
4. **Murulidhar VN, Murthy VNY. (2014)** Distribution and ecology of diatom communities in four lakes using Lange-Bertalot method. IntJCurrMicrobiolAppSci 3:539–548
5. **Meera DS, Alakananda B, Ramachandra TV. (2010)** Ecology and Distribution of Diatoms in Bangalore Lakes. 22:
6. **Magrey AH, Raj M. (2014)** Role of diatoms in forensic diagnosis of drowning cases from Jammu & Kashmir, India. Biosci Biotechnol Res Commun 7:
7. **Zhao J, Ma Y, Liu C, Wen J, Hu S, Shi H, Zhu L. (2016)** A quantitative comparison analysis of diatoms in the lung tissues and the drowning medium as an indicator of drowning. J Forensic Leg Med. https://doi.org/10.1016/j.jflm.2016.05.021
8. **Levkov Z, Williams DM, Nikolovska D, Tofilovska S, Cakar Z. (2017)** The use of diatoms in forensic science: advantages and limitations of the diatom test in cases of drowning. The Archaeological and Forensic Applications of Microfossils: A Deeper Understanding of Human History. https://doi.org/10.1144/tms7.14
9. **Lunetta P, Modell JH.** Forensic pathology reviews. 2005. Accessed 12 Jul 2024
10. **Dolinak D, Matshes E, Lew E. (2005)** Forensic pathology: principles and practice.
11. **Uitdehaag S, Dragutinovic A, Kuiper I. (2010)** Extraction of diatoms from (cotton) clothing for forensic comparisons. Forensic Sci Int. https://doi.org/10.1016/j.forsciint.2010.03.039
12. **Seckbach, Joseph; Kociolek JP. (2011)** Cellular Origin, Life in Extreme Habitats and Astrobiology - The Diatom World. Springer
13. **Hildebrand M, Davis AK, Smith SR, Traller JC, Abbriano R. (2012)** The place of diatoms in the biofuels industry. Biofuels. https://doi.org/10.4155/BFS.11.157
14. **Wang JK, Seibert M. (2017)** Prospects for commercial production of diatoms. Biotechnol Biofuels. https://doi.org/10.1186/s13068-017-0699-y
15. **Mishra V, Mishra MK, Gupta AK, Mishra MK. (2017)** Identification of Diatoms on the Basis of Anatomical Pattern of Valve & Girdle View & its Forensic Significance.
16. **Dhariwal A, Mishra PK, Babu S. (2021)** Diatomological Study of Different Water Bodies of Bhopal, The City of Lakes. J Forensic Sci & Criminal Inves. https://doi.org/10.19080/JFSCI.2021.15.555912