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Original Research Article

Diatomological mapping of water bodies of Delhi region for forensic consideration

Sonali Singh[1], S. K. Pal[2,*], Nitika Bhardwaj[3], Amrik Singh Ahulwalia[4]

[1]*Galgotia University from Basic and Applied Sciences, Uttar Pradesh, India*
[2]*Directorate of Forensics Services, Junga, Shimla Hills, Himachal Pradesh, India*
[3]*Panjab University, Chandigarh, Punjab, India*
[4]*Eternal University, Sirmaur, Himachal Pradesh, India*

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ABSTRACT

Diatoms are photosynthetic algae; having a siliceous cell wall known as 'frustule'. They are abundantly found in every aquatic and terrestrial environment including both fresh and marine water. They are cosmopolitan in nature as these microalgal species are also capable of growing on moist substrates like soil and bark of a plant. The growth of diatoms is very specific to the environmental conditions of a place due to which they are regarded as principal indicators of ecological status of the ecosystem. In forensics also, they play a crucial role in determining the mode and manner of death in cases of drowning. These small entities act as supportive evidence to detect the type of drowning; whether the death of a victim was due to antemortem or postmortem drowning. The diatomological mapping (D-mapping) of water bodies is an essential feature to generate a systematic record of diatom diversity present at a particular site of an aquatic body. The aim of our study is to conduct D-mapping of several regions of Delhi in order to generate a systematic record of diatoms present therein. The results of our study showed about 20 diatom species, some of them were commonly present at all sites, whereas few among them were site specific. The diatom database generated from D-mapping of water bodies can be used as a reference by the forensic pathologists while solving drowning cases, if any, from these aquatic bodies.

1. Introduction

In forensic pathology, solving a drowning case is a huge challenge. Drowning is defined as a submersion or immersion of a victim in any fluid commonly water. The detection of manner and site of drowning becomes a huge challenge for a forensic pathologist to conclude and provide the final cause of death. The manner of death in drowning cases can be suicidal, accidental or homicidal. In fact, there are also situations where body of a victim can be found in a putrefied state due to prolonged overstay in water. Sometimes an aquatic organism may manifest on the organs or tissues of a victim, which can mislead the investigation. Under such complicated circumstances, diatoms play a vital role in solving the case mysteries. Diatoms, popularly known as golden brown algae, are the members of kingdom Protista and class Bacillariophyceae. There are more than 200 genera and 100,0000 species of diatoms Gurung et al. (2012).[1] These small microalgae inhabit almost all types of water bodies and are also found in moist terrestrial substrates such as soil, bark of trees etc. Levkov et al. (2017).[2] They may be planktonic or benthic in nature; as a matter of fact, some of the studies have revealed them to be air-borne also Geissler and Gerloff (1966);[3] Dayan et al. (1978);[4] Romero et al. (1999).[5] The cell of a diatom has a very distinctive feature of an outer wall made up of silica

* *Corresponding author*.
E-mail address: skpal1969@gmail.com (S. K. Pal).

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which is termed as frustule. This siliceous cell wall has a great significance in the morphological characterization of a particular type of diatom. During microscopic observation, these frustules are seen to be composed of beautiful and unique ornamentations which help in recognition of a diatom species. The growth of a particular diatom depends on certain environmental factors such as pH, TDS, temperature, electrical conductivity etc. Hence, they are widely used as principal indicators of determining water quality and ecological status of the ecosystem. In forensics, while solving drowning case mysteries, this special feature makes them suitable for the detection of the site of drowning even in those cases where body gets displaced with the gush of water stream.

Diatom test is based on the principle that when a victim is drowned in an aquatic habitat, these micro algal species enter inside the body due to active respiration till the person dies. During one's struggle in water, diatoms get settled in the organs of a victim through systemic circulation. The quantitative and qualitative analysis of diatoms help in denoting the manner of death. As in ante-mortem drowning, where a person was alive and had struggled for life, the count of diatoms will exceed in the body organs, whereas in post-mortem immersion, this count will remain negligible in the body Timperman (1972).[6] The diatomological mapping (D-mapping) of water bodies can help in forming a systematic record of diatoms distributed at a particular site. While solving a drowning case, these diversity records can be helpful in detecting the site of drowning which further helps in deciphering case mysteries. The main objective of our study is to make a record of some selected water bodies of Delhi region; Haus Khas Reservoir, Sanjay Lake, Bhalswa Lake and Lotus Pond for diatomological mapping. There is no systematic study of diatoms performed on these sites. The continuous mapping of water bodies helps in updating diatom flora with respect to climate change. In cases where body gets displaced by the gush of water stream, this systematic record of diatom helps to characterize the exact place of drowning.

2. Materials and Methods

The water samples were collected from selected sites of Delhi region in 2019. Fresh water bodies of Haus Khas Reservoir, Sanjay Lake, Bhalswa Lake, old fort lake and lotus pond (Lodi Garden) were selected for the diatom analysis. The Sampling of the water bodies was done in early summer and monsoon season, as the growth of microalgae is abundant in both seasons. Approximately, 500 ml of water sample was collected from various sites in sample bottles. For the removal of organic and inorganic components from the diatom, acid digestion was conducted by using modified reverse aqua regia solution Pal et al. (2021).[7] In a clean beaker, 100 ml of water sample was mixed with the strong acidic chemicals, HNO3 and HCl in the ratio of 15 ml: 5 ml respectively. This sample solution mixture was kept on a hot plate under fume hood for simmering at 60°C-70°C for 2 hours. After this process, the sample was left undisturbed to cool under normal room temperature. Once the cooling was complete, then repeated centrifugation of the acid sample mixture was done thrice at 3000 rpm. For the removal of acid from the sample, each round of centrifugation was done by using distilled water under full precautions. After twice washing with the distilled water, the last washing was done with ethanol in order to achieve maximum clarity of the diatoms during microscopic examination. The sample was placed on the glass slide with the help of sterilized dropper. The slide was then heated for few seconds and mounted with DPX for good resolution. Microscopic examination of the samples was done by using Olympus Light Microscope at 40X and 100X. Photographs were captured by the digital camera attached with the microscope for the identification of diatoms (Figures 1 and 2).

2.1. Identification of diatoms

The identification was done by using available literature (Thakar and Singh, 2010; Karthick et al. (2013),[8] Borgohain and Tanti, 2014;[9] and Sane et al. (2018).[10]

3. Results and Discussion

In forensic pathology, deciphering of drowning cases remained a challenging problem. Drowning signs such as froth from nostrils, edematous lungs etc. appear to be the most significant feature to analyze the manner of death. But, in cases where the body is in putrefied or skeletonized stage, it becomes more problematic to determine the accurate cause of death Bhardwaj et al. (2020).[11] In addition, most of the cases don't have eyewitnesses, which further affects the pinpointing the exact site of drowning and it sometimes remains unclear in such situations. To overcome such issues, forensic limnology has been playing an effective role in solving such case mysteries. In more elaborative terms, Diatoms act as supportive evidence to find out the manner and mode of death in drowning cases Sane et al. (2018).[10] Their silica cell wall remains intact and resists all types of changes undergoing in the body of a drowned victim as well as during chemical cleaning in the laboratory. Diatomological mapping of water bodies provides a database of diatom diversity of a particular place. This database can be directly implied while solving drowning cases. Many scientists in India have done D-mapping of water bodies of various regions including Himachal Pradesh, Punjab, Haryana, Jaipur, Assam, Mizoram, Orissa, Southern India (Venkataraman 1939,[12] Jena et al. 2006,[13] Pareek and Singh, 2011,[14] Kumar et al.(2013),[15] Thakar et al. 2011[16] and Saini et al. (2017).[17] But according to literature, many water bodies are

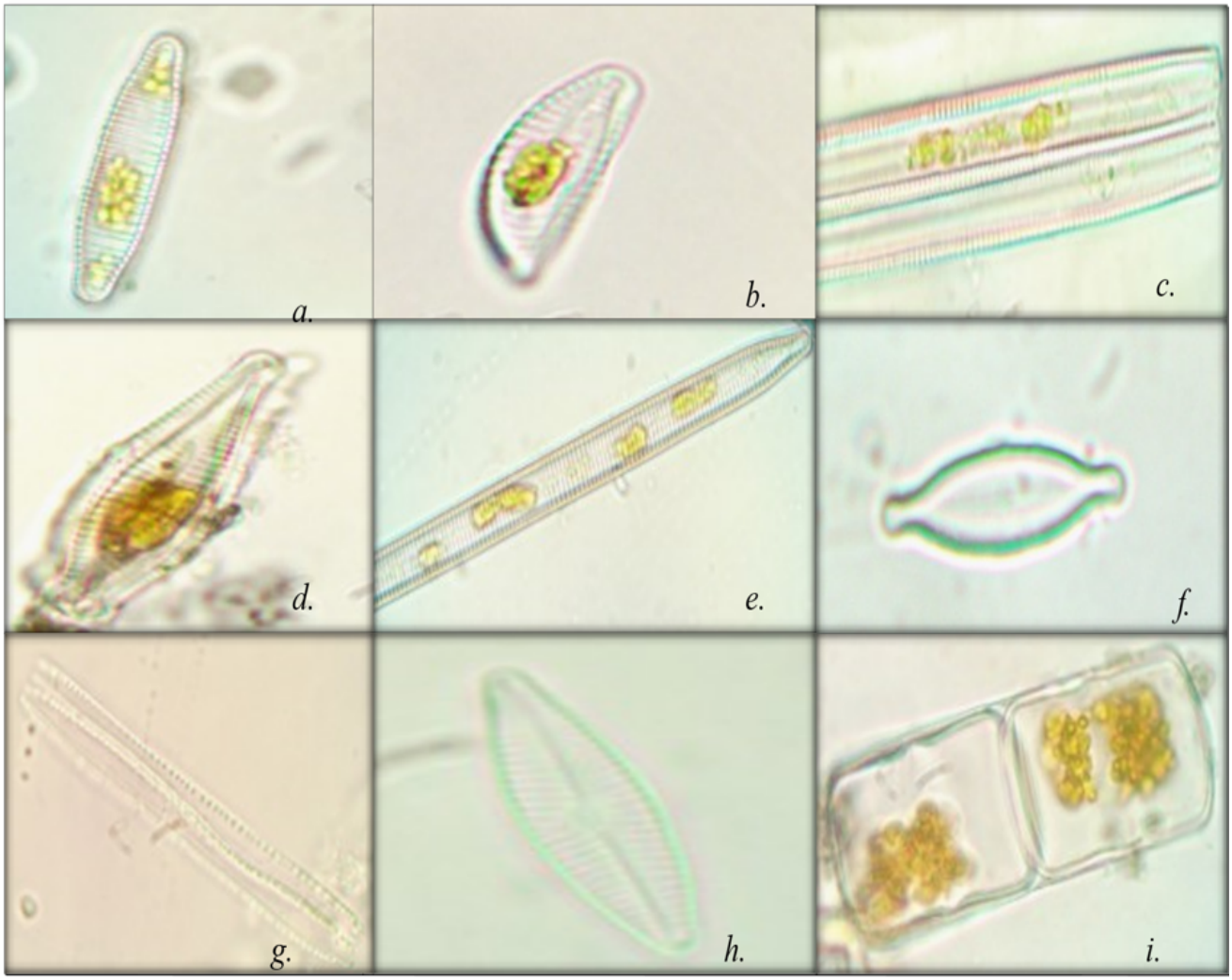

Fig. 1: a: *Diatoma sp*. **b:** *Cymbella sp.;* **c:** *Synedra sp*. **d:** *Gomphonema sp*.; **e:** *Ulnatia sp.*; **f:** *Navicula sp.*; **g:** *Pinnularia sp*.; **h:** *Achnanthes sp*; **i:** *Melosira sp*.

Table 1: Diatoms observed from the selected sites of Delhi region

S.No	Site	Diatom species present	Most abundant	Least abundant
1.	Haus Khas Reservoir	Fragilaria, Synedra, Cocconeis, Achnanthes, Navicula, Diatoma, Cymbella	Navicula	Cocconeis
2.	Sanjay Lake	Amphora, Surirella, Fragilaria, Nitzschia, Pinnularia, Melosira	Nitzschia	Surirella
3.	Bhalswa Lake	Craticula, Cymbella, Nitzschia, Encyonema, Ulnaria, Gomphonema	Encyonema	Craticula
4.	Old fort lake	Amphora, Fragilaria, Navicula, Nitzschia, Cocconeis, Synedra, Afrocymbella	Synedra	Cocconeis
5.	Lotus pond	Pinnularia, Syndera, Achnanthes, Diatoma, Cymella, Gomphoneis, Thalassiosira	Diatoma	Cymbella

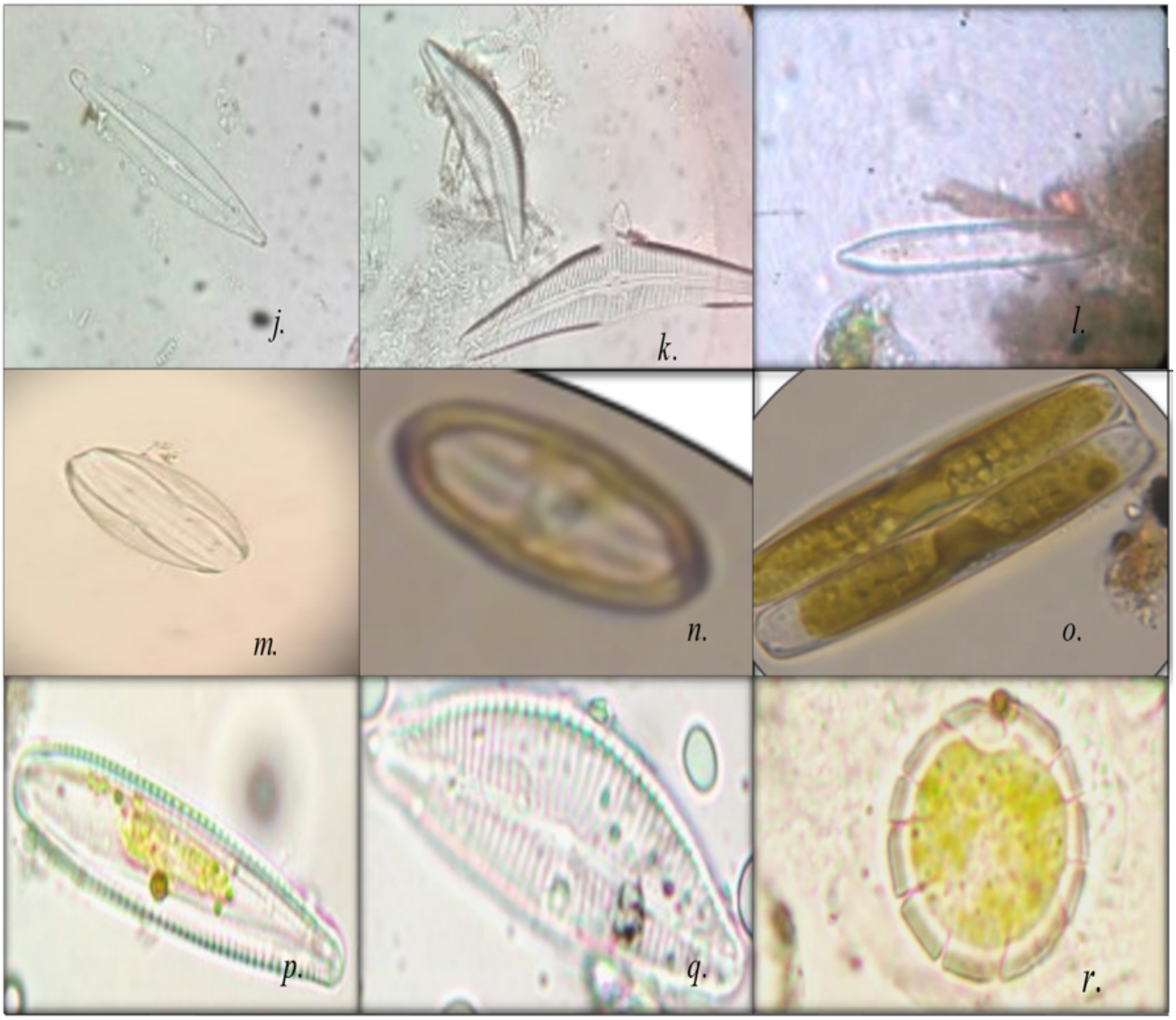

Fig. 2: j: *Craticula sp.*; **k:** *Afrocymbella sp.*; **l:** *Nitzschia sp.*; **m:** *Amphora sp.*; **n:** *Cocconeis sp.*; **o:** *Fragilaria sp.*; **p:** *Gomphoneis sp.*; **q:** Encyonema sp.; **r:** *Thalassiosira sp.*

still unexplored. An attempt has been made to generate a diatom database of several regions of Delhi namely, Haus Khas Reservoir, Sanjay Lake, Bhalswa Lake, Old fort lake and Lotus Pond. The results showed 20 diatom genera found at the selected sites (Table 1; Figures 1 and 2). Out of these 20 diatoms *Fragilaria sp., Synedra sp., Nitzschia sp*. and *Navicula sp* were the most commonly distributed diatoms and observed in almost all sites. Whereas few diatoms were site specific such as *Gomphoneis sp*. and *Thalassiosira, sp*. both of them were only present in lotus pond and showed absence in other water bodies under consideration. However, *Craticula sp., Encyonema sp., Ulnaria sp*. and *Gomphonema sp*. were observed only in Bhalswa Lake. This signifies that diatom's diversity changes with the environmental conditions, and they are site specific organisms. Due to this special property, they act as a standard golden tool in detecting the place of drowning. Hence, the continuous monitoring of water bodies can help in characterization of diatoms with reference to various seasons. The diatom flora of a region can help in recognition of site of drowning in case of absence of eyewitness or body displaced along with the gush of water stream. Thus, diatomological mapping serve as a basis for ecological assessment and monitoring of diversity of a particular water body.

4. Source of Funding

None.

5. Conflict of Interest

None.

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Author biography

Sonali Singh, Student

S. K. Pal, Assistant Director https://orcid.org/0000-0001-8715-267X

Nitika Bhardwaj, Research Scholar

Amrik Singh Ahulwalia, Pro Vice Chancellor

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