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Application of Diatom Analysis in the Forensic Differentiation Between Drowning and Postmortem Immersion: A Case Series from the Yamuna River, India

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ABSTRACT

Keywords:

Diatoms
Drowning
Forensic diatomology
Bone Marrow
Postmortem immersion

Background: Diatom analysis is considered one of the most important forensic techniques for the diagnosis of drowning. The present study aimed to evaluate the reliability of diatom testing in differentiating true drowning from postmortem immersion through comparative analysis of environmental water samples and biological tissues. **Methods:** Thirty bodies recovered from three sites along the Yamuna River at Prayagraj, India, in 2013, were examined. Water samples were processed by sedimentation and centrifugation, and biological specimens (femoral bone marrow, clavicular bone marrow or cardiac blood) by nitric acid digestion and centrifugation, followed by light-microscopic identification of diatoms. **Results:** Diatoms were present in all water samples. Twenty-three of the 30 cases (77%) were diatom-positive in tissue and were interpreted as consistent with drowning; seven (23%) were diatom-negative despite diatoms in the water and were interpreted as consistent with postmortem immersion. The same taxon was found in water and tissue in only 2 of the 23 positive cases. Several diatom genera, including *Cyclotella*, *Navicula*, *Craticula*, *Aulacoseira*, *Fragilaria*, *Ulnaria* and *Synedra*, were identified. **Conclusions:** The findings support diatom analysis as a valuable supportive forensic tool for distinguishing drowning from postmortem immersion in aquatic environments, although neither a positive nor a negative result is diagnostic on its own. Results should be interpreted alongside autopsy findings, environmental investigation, and other medico-legal evidence.

تطبيق تحليل الدياتومات في التمييز الطبي الشرعي بين الغرق والغمر في الماء بعد الوفاة: سلسلة حالات من نهريامونا، الهند

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المخلص

الكلمات المفتاحية:

الدياتومات
الغرق
علم الدياتومات الجنائي
نخاع العظم
الغمر بعد الوفاة

الخلفية: يُعد تحليل الدياتومات من أهم التقنيات الطبية الشرعية لتشخيص الغرق. هدفت هذه الدراسة إلى تقييم موثوقية اختبار الدياتومات في التفريق بين الغرق الحقيقي والغمر في الماء بعد الوفاة بالتحليل المقارن لعينات المياه البيئية والأنسجة الحيوية. **الطرائق:** فُحصت 30 جثة انتُشلت من ثلاثة مواقع على نهر يامونا في براياغراج بالهند خلال عام 2013. عُولجت عينات المياه بالترسيب والطرْد المركزي، وعُولجت العينات الحيوية (نخاع عظم الفخذ أو نخاع عظم الترقوة أو دم القلب) بالهضم بحمض النيتريك والطرْد المركزي، ثم حُدِّدت الدياتومات بالمجهر الضوئي. **النتائج:** وُجدت الدياتومات في جميع عينات المياه. كانت 23 حالة من 30 (77%) إيجابية للدياتومات في الأنسجة وفُسِّرت بأنها متوافقة مع الغرق، وكانت 7 حالات (23%) سلبية رغم وجود الدياتومات في المياه وفُسِّرت بأنها متوافقة مع الغمر بعد الوفاة. ولم يتطابق النوع نفسه في المياه والأنسجة إلا في حالتين من الحالات الإيجابية الثلاث والعشرين. وحُدِّدت عدة أجناس من الدياتومات، منها *Cyclotella* و *Navicula* و *Craticula* و *Aulacoseira* و *Fragilaria* و *Ulnaria* و *Synedra*. **الاستنتاجات:** تدعم النتائج أن تحليل الدياتومات أداة طبية شرعية مساندة لقيمة التمييز بين الغرق والغمر في الماء بعد الوفاة في البيئات المائية، مع أن النتيجة الإيجابية أو السلبية وحدها ليست تشخيصية، على أن تُفسَّر نتائج مع نتائج التشريح والمعاينة البيئية وسائر الأدلة الطبية الشرعية لضمان دقة التشخيص.

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1. Introduction

Drowning remains one of the major causes of accidental and unnatural deaths worldwide, with an estimated 300,000 deaths in 2021, nine in ten of them in low- and middle-income countries [1]. It represents a significant challenge in forensic investigations. Determining whether death occurred as a result of true drowning or whether the body was disposed of in water after death is often difficult, particularly in decomposed or highly deteriorated corpses. Conventional autopsy findings may sometimes be inconclusive due to overlapping pathological features, thereby increasing the importance of supportive forensic techniques capable of improving diagnostic accuracy [2–4].

Among the various forensic approaches used in drowning investigations, diatom analysis has gained considerable importance because of its scientific reliability and broad medico-legal applications. Diatoms are unicellular photosynthetic algae characterized by highly resistant siliceous cell walls known as frustules. These microorganisms are ubiquitous in aquatic ecosystems, including freshwater, seawater, rivers, lakes, and ponds. Due to the durability of their silica-based structures, diatoms can persist in environmental and biological samples for long periods without significant degradation, making them useful indicators in forensic examinations [5,6].

The forensic significance of diatoms is based on the hypothesis that during active drowning, inhaled water carrying microscopic diatoms enters the lungs and subsequently passes through the alveolar-capillary barrier into the bloodstream. From there, diatoms may circulate and become deposited in distant organs and tissues such as bone marrow, liver, kidney, brain, and cardiac blood. In contrast, in cases of postmortem immersion, the absence of active circulation prevents the systemic distribution of diatoms into internal organs. Therefore, the detection of diatoms within internal tissues is considered an important supportive indicator of antemortem drowning [7,8].

Several analytical techniques have been developed for the extraction and identification of diatoms from biological tissues and environmental water samples. Acid digestion methods using nitric acid remain among the most commonly employed procedures because they effectively digest organic tissues while preserving the

siliceous structure of diatom frustules. Following digestion, centrifugation and microscopic examination are generally performed to isolate and identify diatom species based on their morphological characteristics. Despite its widespread application, the diatom test still faces certain limitations, including contamination risks, environmental variability, and false-negative findings in some drowning cases [9,10]. More recent work has introduced quantitative criteria based on the number of diatoms per gram of tissue [11], microwave digestion with vacuum filtration and scanning electron microscopy [12], molecular detection of diatom DNA [13] and automated identification by deep learning [14]. Nevertheless, a recent systematic review concluded that the evidentiary value of the test remains uncertain, because methods and reporting differ widely between studies [15].

Previous forensic investigations have demonstrated the diagnostic value of diatom analysis in differentiating drowning from postmortem immersion or body disposal. Pollanen et al. [3] reported that diatom examination of bone marrow provides significant supportive evidence in drowning diagnosis, while Gruspier and Pollanen [16] highlighted the importance of femoral bone marrow analysis in decomposed bodies recovered from aquatic environments. Furthermore, comparative analysis between environmental water samples and biological tissues has been shown to improve the reliability of forensic interpretation by correlating specific diatom species with the suspected drowning site [17–19]. In India, diatom mapping of rivers, lakes and reservoirs has been undertaken to support such comparisons [20–22], and bone-marrow diatom testing has been applied in medico-legal casework [23].

The present study aims to evaluate the forensic applicability of diatom analysis in distinguishing drowning cases from cases of postmortem immersion through comparative examination of water samples and biological tissues collected from different locations along the Yamuna River. The study further seeks to assess the reliability of acid digestion and microscopic identification methods in detecting diatoms in suspected drowning victims and to emphasize the medico-legal importance of combining diatom testing with autopsy findings and environmental investigations.

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2. Materials and Methods

2.1. Study design and cases

This was a case series of 30 bodies recovered from the Yamuna River at Prayagraj (formerly Allahabad), Uttar Pradesh, India, in 2013. All bodies underwent medico-legal autopsy at the mortuary in Prayagraj, and cases were included when both a water sample from the probable site of recovery and a biological sample were available for diatom analysis.

2.2. Collection of samples

Water samples were collected in clean containers, sealed with evidentiary tags and labelled with the decedent's name, sampling site, date, time and the name of the person sampling. Each sample was 1000 mL. Samples were taken at three sites on the Yamuna River at Prayagraj where bodies are commonly recovered: under the old bridge (site A1), at the Boat Club (A2) and under the new bridge (A3), with three samples per site. Water samples were collected in 2013 at the probable site of body recovery, and each case was compared with the water sample from that site.

Biological samples (femoral bone marrow, clavicular bone marrow or cardiac blood from the left side of the heart) were collected at autopsy at the mortuary in Prayagraj and provided by the Department of Forensic Science, SHUATS (formerly SHIATS). One tissue was examined per case. For bone marrow, the bone surface was washed with distilled water, the bone was opened with a clean saw, and about 2 g of marrow was removed with a clean spatula; for cardiac blood, about 10 mL was collected from the left side of the heart.

2.3. Extraction of diatoms from water samples

Half of the volume of each water sample was discarded, and the remainder was shaken thoroughly and poured into a beaker. Two to three drops of Lugol's iodine were added, and the beaker was covered with aluminium foil and left overnight for sedimentation. The next day, a small volume of sediment was taken from the bottom of the beaker into a polypropylene centrifuge tube (Tarsons) and centrifuged at 1500 rpm (approximately $250 \times g$) for 5–7 min to pellet particulate matter, including diatoms, and the supernatant was discarded. A drop of the diluted pellet was placed on a microscope slide, dried on a hot plate and covered with a coverslip. Water samples were not acid-digested.

2.4. Extraction of diatoms from biological samples

Each biological sample was placed in a glass tray, washed with distilled water and transferred to a beaker. Distilled water (400 mL) and concentrated nitric acid (50 mL) were added, and the mixture was heated to boiling over a flame in a fume hood until the tissue was completely digested (approximately 1–2 h). The beaker was then covered with aluminium foil and left overnight for the sediment to settle. The next day, the sediment was collected from the bottom with a dropper, transferred to a polypropylene centrifuge tube and

centrifuged at 1500 rpm for 5–7 min, and the supernatant was discarded. This step was repeated three to four times. The pellet was then washed with distilled water to remove residual nitric acid and resuspended in about 1 mL of distilled water. One to two drops of the suspension were placed on clean glass slides with a micropipette or dropper, dried on a hot plate, mounted in DPX and covered with a coverslip.

2.5. Contamination control and criteria for a positive result

Contamination during sampling and processing is the main source of false-positive diatom findings [24,25]. To reduce contamination, all glassware was cleaned with nitric acid and rinsed with distilled water before use, and samples were kept in covered containers throughout processing. A tissue sample was considered diatom-positive when at least one intact diatom frustule identifiable to genus level was observed on the examined slides. Results were recorded as presence or absence of diatoms.

2.6. Microscopic examination and identification

Slides from water and tissue samples were examined with a compound light microscope at $100\times$ to $1000\times$ total magnification ($10\times$ to $100\times$ objectives), with species-level identification at $1000\times$ under oil immersion. Diatoms were identified from frustule morphology using standard identification keys [26], and species names follow current nomenclature in AlgaeBase [27]. Identifications were checked against the reference illustrations in these keys. Slides were mounted in DPX; because this mountant has a lower refractive index than media designed for diatoms, fine ornamentation may have been less visible.

3. Results

3.1. Detection of diatoms in water and biological samples

A total of 30 bodies recovered from three sites along the Yamuna River were examined. The tissue examined was femoral bone marrow in 18 cases, clavicular bone marrow in 6 and cardiac blood in 2; the tissue was not recorded for cases 1, 9, 16 and 30. Water samples were processed by sedimentation and centrifugation, and tissues by nitric acid digestion and centrifugation, before microscopic examination (Section 2).

Diatoms were detected in all water samples, confirming the abundance of these microorganisms within the investigated aquatic environment. Among the 30 examined cases, 23 (77%) showed the presence of diatoms in both water and biological samples and were classified as diatom-positive, consistent with drowning. In contrast, 7 cases (23%) exhibited the presence of diatoms only in water samples, while biological tissues were negative for diatom detection; these cases were classified as diatom-negative, consistent with postmortem immersion.

Several diatom genera were identified during microscopic

examination, including *Cyclotella*, *Navicula*, *Craticula*, *Aulacoseira*, *Fragilaria*, *Ulnaria* and *Synedra* (Table 1). Only one taxon was recorded per sample. The same taxon was found in water and tissue in only 2 of the 23 diatom-positive cases (cases 5 and 24). In the other 21, the tissue taxon differed from the taxon recorded in the corresponding water sample, and in six cases (2, 4, 9, 14, 15 and 21) the tissue taxon (*Synedra dorsiventralis*, *Ulnaria ulna* or *Navicula chandolensis*) was not recorded in any water sample in the study. This variation may be attributed to the heterogeneous distribution of diatom populations in river ecosystems and differences in water circulation patterns; other explanations are considered in the Discussion.

The results for each case are summarised in Table 1, and the micrographs for each case are shown in Figs. 1–30.

4. Discussion

In this series, diatoms were found in the bone marrow or cardiac blood of 23 of 30 bodies (77%) recovered from the Yamuna River, and these cases were interpreted as consistent with drowning; the remaining seven bodies were diatom-negative despite diatoms in the river water. Because diatoms reach distant organs only through an active circulation, their presence in closed tissues supports antemortem drowning, whereas their absence is compatible with, but does not prove, postmortem immersion [7,15].

The present findings are consistent with previous forensic studies reported by Pollanen et al. [3], who emphasized the diagnostic significance of bone marrow diatom analysis in drowning investigations. Similarly, Gruspier and Pollanen [16] showed that femoral bone marrow examination is valuable in the investigation of limbs and remains recovered from water. Furthermore, Ludes et al. [18] reported that comparative analysis between environmental water samples and biological tissues enhances the reliability of forensic interpretation and assists in identifying the probable drowning site. The positivity rate in this series (77%) is, however, considerably higher than the 28% reported for femoral bone marrow in 738 freshwater drownings in Ontario [3]. Differences in diatom density between water bodies and seasons may explain part of this difference [3,20], but contamination should also be considered (see limitations below).

Pollanen [28] described six illustrative cases of homicidal drowning and concluded that the diatom test was a useful adjunct to the medico-legal investigation of death.

Gruspier and Pollanen [16] examined nitric acid extracts of femoral bone marrow from five cases of limbs recovered from water in which drowning was doubtful. Diatom frustules were recovered from the marrow in all instances, indicating that drowning was the cause of death.

An important finding of this study is the low concordance between water and tissue taxa: the same taxon was found in both in only 2 of the 23 positive cases. By contrast, Pollanen found the same diatom types in bone marrow and drowning medium in 90% of freshwater drownings [8]. Several explanations are possible. First, only one taxon was recorded per sample, whereas river water typically contains many taxa; more than 100 taxa were recorded in a single Indian reservoir [22], and diatom assemblages vary with site and season [20,21]. Second, nitric acid digestion can damage or lose some taxa, including *Navicula* [29]. Third, even in controlled drowning experiments, tissue and water assemblages do not match perfectly [30]. Finally, the water may have been sampled away from the actual drowning site, or tissue diatoms may reflect contamination. For these reasons, the present data do not allow the drowning site to be inferred.

The classification used here should be interpreted with caution. Diatoms are absent in a proportion of true drownings: in one series, they were not detected in 13 of 94 confirmed drowning deaths [31], and in the Ontario series most freshwater drownings had diatom-negative bone marrow [3]. Conversely, small numbers of diatoms have been found in the bone marrow of non-drowned bodies [24]. A negative test therefore does not prove postmortem immersion, and a positive test alone does not prove drowning; both should be weighed together with the autopsy findings and the circumstances of death [11,15,25]. This caution matters because the diatom finding reaches the court as part of a medical expert opinion, and medico-legal disputes are commonly resolved by weighing the views of independent medical experts against each other [32].

Although diatom analysis remains one of the most widely used supportive forensic techniques for drowning diagnosis, certain limitations should be considered. False-negative findings may occur due to low diatom concentration in water, delayed recovery of the body, decomposition processes, or methodological limitations during extraction and identification procedures [3,31]. Therefore, diatom testing should not be used as a standalone diagnostic criterion but rather interpreted alongside autopsy findings, toxicological analysis, and environmental investigations.

This study has further limitations. The sample was small (30 cases), no non-drowned control bodies were examined, and no reagent-blank results are reported. Air and settled dust in hospital environments carry environmental microorganisms, including fungi and Gram-negative bacilli [33,34]; samples left loosely covered overnight in a laboratory could collect airborne particles in the same way, so reagent and air blanks processed with each batch would be needed to exclude contamination. Only one tissue was examined per case, lung tissue was not analyzed, and results were recorded qualitatively as presence or absence rather than as diatoms per gram of tissue [11]. Water was sampled once per site, and only one taxon

was recorded per sample. Identification relied on light microscopy with a DPX mountant. In other laboratory diagnoses, light microscopy has proved less sensitive than antigen-based detection [35] and is treated as a screening step to be confirmed by a reference method rather than as a diagnosis in itself [36]; diatom identification by light microscopy shares this limitation. Finally, there was no independent reference standard for the cause of death against which the diatom test could be evaluated. Quantitative methods such as microwave digestion with vacuum filtration and automated scanning electron microscopy [12], molecular detection of diatom DNA [13] and deep-learning identification [6,14] may address several of these limitations in future work. Overall, the present study supports the use of diatom analysis as an adjunct in distinguishing drowning from postmortem immersion in aquatic death investigations, provided that the results are interpreted with the limitations above in mind.

5. Conclusions

In this series of 30 bodies recovered from the Yamuna River, diatoms were found in the tissues of 23 (77%), consistent with drowning, and were absent in 7 (23%) despite their presence in the river water, consistent with postmortem immersion. Water and tissue taxa matched in only two positive cases, so the results do not support inference of the drowning site.

Diatom analysis is a useful adjunct in the investigation of bodies recovered from water. It should be interpreted together with autopsy findings, the circumstances of death and other medico-legal evidence, using standardised, contamination-controlled and quantitative methods.

Declarations

Author contributions: Fakhri Omar Issa: Methodology, Writing – original draft, Writing – review and editing. A.K. Gupta and Munish Mishra: Supervision, Proofreading of the manuscript. All authors read and approved the final manuscript.

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Conflicts of interest: The authors declare no competing interests.

Ethics approval and consent to participate: The study used anonymized biological samples obtained during routine medico-legal autopsies performed at the mortuary in Prayagraj under the authority of the investigating police officer; no additional procedures were performed on the bodies for the purpose of this study.

Data availability: The data supporting the findings of this study are available from the corresponding author, Fakhri Omar Issa, upon reasonable request.

Use of generative AI: An AI assistant (Claude, Anthropic) was used during revision for language editing, updating references and restructuring the text. The authors reviewed all changes and take full

responsibility for the content.

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Tables

Table 1. Tissue examined, diatom taxa identified in water and tissue, and interpretation for each case

Case	Tissue	Taxon in water	Taxon in tissue	Tissue diatom test
1	NS	<i>Aulacoseira granulata</i>	<i>Cyclotella operculata</i>	Positive
2	FBM	<i>Aulacoseira distans</i>	<i>Synedra dorsiventralis</i>	Positive
3	CBM	<i>Aulacoseira distans</i>	—	Negative
4	FBM	<i>Aulacoseira granulata</i>	<i>Ulnaria ulna</i>	Positive
5	CBM	<i>Cyclotella operculata</i>	<i>Cyclotella operculata</i>	Positive
6	FBM	<i>Cyclotella kuetzingiana</i>	—	Negative
7	CB	<i>Cyclotella meneghiniana</i>	<i>Aulacoseira distans</i>	Positive
8	FBM	<i>Navicula cryptocephala</i>	<i>Synedra affinis</i>	Positive
9	NS	<i>Aulacoseira granulata</i>	<i>Synedra dorsiventralis</i>	Positive
10	FBM	<i>Aulacoseira distans</i>	<i>Aulacoseira granulata</i>	Positive
11	CBM	<i>Synedra affinis</i>	—	Negative
12	FBM	<i>Fragilaria rumpens</i>	<i>Aulacoseira granulata</i>	Positive
13	FBM	<i>Craticula cuspidata</i>	<i>Fragilaria rumpens</i>	Positive
14	FBM	<i>Navicula rostellata</i>	<i>Navicula chandolensis</i>	Positive
15	FBM	<i>Cyclotella meneghiniana</i>	<i>Ulnaria ulna</i>	Positive
16	NS	<i>Aulacoseira granulata</i>	<i>Aulacoseira distans</i>	Positive
17	FBM	<i>Navicula grimeii</i>	—	Negative
18	FBM	<i>Navicula cryptocephala</i>	<i>Craticula cuspidata</i>	Positive
19	CB	<i>Fragilaria rumpens</i>	—	Negative
20	FBM	<i>Cyclotella meneghiniana</i>	<i>Cyclotella kuetzingiana</i>	Positive
21	FBM	<i>Aulacoseira granulata</i>	<i>Ulnaria ulna</i>	Positive
22	FBM	<i>Cyclotella kuetzingiana</i>	<i>Navicula rostellata</i>	Positive
23	FBM	<i>Craticula cuspidata</i>	<i>Navicula grimeii</i>	Positive
24	FBM	<i>Craticula cuspidata</i>	<i>Craticula cuspidata</i>	Positive
25	FBM	<i>Navicula cryptocephala</i>	<i>Synedra affinis</i>	Positive
26	CBM	<i>Craticula cuspidata</i>	<i>Cyclotella kuetzingiana</i>	Positive
27	CBM	<i>Craticula cuspidata</i>	—	Negative
28	CBM	<i>Aulacoseira granulata</i>	—	Negative
29	FBM	<i>Aulacoseira distans</i>	<i>Navicula rostellata</i>	Positive
30	NS	<i>Cyclotella kuetzingiana</i>	<i>Cyclotella meneghiniana</i>	Positive

FBM, femoral bone marrow; CBM, clavicular bone marrow; CB, cardiac blood (left side of heart); NS, not specified. Positive, diatoms present in tissue (consistent with drowning); Negative, no diatoms in tissue (consistent with postmortem immersion). Diatoms were present in all water samples. Names follow current nomenclature (AlgaeBase).

Figures



(a) *Aulacoseira granulata* (b) *Cyclotella operculata*

Fig. 1. Diatoms in case 1: (a) water sample; (b) biological sample.



(a) *Aulacoseira distans* (b) *Synedra dorsiventralis*

Fig. 2. Diatoms in case 2: (a) water sample; (b) biological sample.



(a) *Aulacoseira distans* (b) Diatom absent

Fig. 3. Diatoms in case 3: (a) water sample; (b) biological sample.



(a) *Aulacoseira granulata* (b) *Ulnaria ulna*

Fig. 4. Diatoms in case 4: (a) water sample; (b) biological sample.



(a) *Cyclotella operculata* (b) *Cyclotella operculata*

Fig. 5. Diatoms in case 5: (a) water sample; (b) biological sample.



(a) *Cyclotella kuetzingiana* (b) Diatom absent

Fig. 6. Diatoms in case 6: (a) water sample; (b) biological sample.



(a) *Cyclotella meneghiniana* (b) *Aulacoseira distans*

Fig. 7. Diatoms in case 7: (a) water sample; (b) biological sample.



(a) *Navicula cryptocephala* (b) *Synedra affinis*

Fig. 8. Diatoms in case 8: (a) water sample; (b) biological sample.



(a) *Aulacoseira granulata* (b) *Synedra dorsiventralis*

Fig. 9. Diatoms in case 9: (a) water sample; (b) biological sample.



(a) *Aulacoseira distans* (b) *Aulacoseira granulata*

Fig. 10. Diatoms in case 10: (a) water sample; (b) biological sample.



(a) *Synedra affinis* (b) Diatom absent

Fig. 11. Diatoms in case 11: (a) water sample; (b) biological sample.



(a) *Fragilaria rumpens* (b) *Aulacoseira granulata*

Fig. 12. Diatoms in case 12: (a) water sample; (b) biological sample.



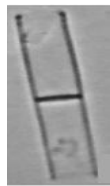
(a) *Craticula cuspidata* (b) *Fragilaria rumpens*

Fig. 13. Diatoms in case 13: (a) water sample; (b) biological sample.

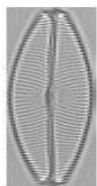
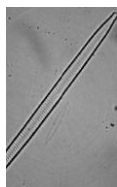


(a) *Navicula rostellata* (b) *Navicula chandolensis*

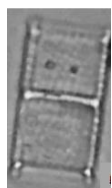
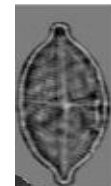
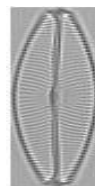
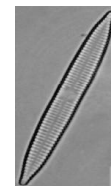
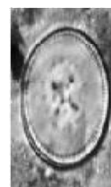
Fig. 14. Diatoms in case 14: (a) water sample; (b) biological sample.

(a) *Cyclotella meneghiniana*(b) *Ulnaria ulna***Fig. 15.** Diatoms in case 15: (a) water sample; (b) biological sample.(a) *Aulacoseira granulata*(b) *Aulacoseira distans***Fig. 16.** Diatoms in case 16: (a) water sample; (b) biological sample.(a) *Navicula grimmei*

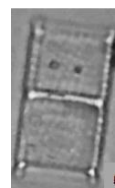
(b) Diatom absent

Fig. 17. Diatoms in case 17: (a) water sample; (b) biological sample.(a) *Navicula cryptocephala*(b) *Craticula cuspidata***Fig. 18.** Diatoms in case 18: (a) water sample; (b) biological sample.(a) *Fragilaria rumpens*

(b) Diatom absent

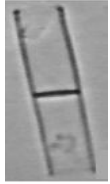
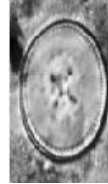
Fig. 19. Diatoms in case 19: (a) water sample; (b) biological sample.(a) *Cyclotella meneghiniana*(b) *Cyclotella kuetzingiana***Fig. 20.** Diatoms in case 20: (a) water sample; (b) biological sample.(a) *Aulacoseira granulata*(b) *Ulnaria ulna***Fig. 21.** Diatoms in case 21: (a) water sample; (b) biological sample.(a) *Cyclotella kuetzingiana*(b) *Navicula rostellata***Fig. 22.** Diatoms in case 22: (a) water sample; (b) biological sample.(a) *Craticula cuspidata*(b) *Navicula grimmei***Fig. 23.** Diatoms in case 23: (a) water sample; (b) biological sample.(a) *Craticula cuspidata*(b) *Craticula cuspidata***Fig. 24.** Diatoms in case 24: (a) water sample; (b) biological sample.(a) *Navicula cryptocephala*(b) *Synedra affinis***Fig. 25.** Diatoms in case 25: (a) water sample; (b) biological sample.(a) *Craticula cuspidata*(b) *Cyclotella kuetzingiana***Fig. 26.** Diatoms in case 26: (a) water sample; (b) biological sample.(a) *Craticula cuspidata*

(b) Diatom absent

Fig. 27. Diatoms in case 27: (a) water sample; (b) biological sample.(a) *Aulacoseira granulata*

(b) Diatom absent

Fig. 28. Diatoms in case 28: (a) water sample; (b) biological sample.

(a) *Aulacoseira distans*(b) *Navicula rostellata***Fig. 29.** Diatoms in case 29: (a) water sample; (b) biological sample.(a) *Cyclotella kuetzingiana*(b) *Cyclotella meneghiniana***Fig. 30.** Diatoms in case 30: (a) water sample; (b) biological sample.