TAXONOMIC INVESTIGATION OF EUPLANKTONIC DIATOM COMMUNITIES AS INDICATOR OF COPPER IN THE BANK OF THE SUBARNAREKHA RIVER, GHATSHILA, JHARKHAND, INDIA

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ABSTRACT
The aim of this study was to demonstrate and evaluate the diatom communities in the copper infected areas readily associated with the Hindustan Copper Limited (HCL) at the bank of the Subarnarekha River. This study was based on three sampling sites commonly designated as high copper (>100 μg.L⁻¹), medium copper (≤100 μg.L⁻¹) and low copper (<50 μg.L⁻¹) contaminated area. Results indicated the detailed taxonomic description of 31 species that are dominant or less dominant over these contaminated area. Among the identified taxa, 10 were recorded as new to the Jharkhand state. Water analysis has suggested the presence of 17 species in the high copper contaminated area adjacent to HCL. Nine species was less dominant in the outlet of HCL that belonged to the medium contaminated and only 5 species were dominant over the low copper contaminated area. Physico-chemical parameters like pH, air and water temperature, salinity, conductivity, light extinction coefficient, turbidity, dissolved inorganic salts, dissolved oxygen and carbon-di-oxide, biological oxygen demand and total hardness were also estimated in the present study. The biochemical assessment of the water has indicated the detailed taxonomic description of 31 species that are dominant or less dominant over these contaminated area. A total of 149 taxa, 10 were recorded as new to the Jharkhand state. Water analysis has suggested the presence of 17 species in the high copper contaminated area adjacent to HCL. Nine species was less dominant in the outlet of HCL that belonged to the medium contaminated and only 5 species were dominant over the low copper contaminated area. Physico-chemical parameters like pH, air and water temperature, salinity, conductivity, light extinction coefficient, turbidity, dissolved inorganic salts, dissolved oxygen and carbon-di-oxide, biological oxygen demand and total hardness were also estimated in the present study. The biochemical assessment of the water has indicated the detailed taxonomic description of 31 species that are dominant or less dominant over these contaminated area. A total of 149 taxa, 10 were recorded as new to the Jharkhand state. Water analysis has suggested the presence of 17 species in the high copper contaminated area adjacent to HCL. Nine species was less dominant in the outlet of HCL that belonged to the medium contaminated and only 5 species were dominant over the low copper contaminated area. Physico-chemical parameters like pH, air and water temperature, salinity, conductivity, light extinction coefficient, turbidity, dissolved inorganic salts, dissolved oxygen and carbon-di-oxide, biological oxygen demand and total hardness were also estimated in the present study. The biochemical assessment of the water has indicated the detailed taxonomic description of 31 species that are dominant or less dominant over these contaminated area. A total of 149 taxa, 10 were recorded as new to the Jharkhand state. Water analysis has suggested the presence of 17 species in the high copper contaminated area adjacent to HCL. Nine species was less dominant in the outlet of HCL that belonged to the medium contaminated and only 5 species were dominant over the low copper contaminated area.

Keywords: Diatom, copper, indicator, Ghatshila, HCL, taxonomy, tolerant, new record

INTRODUCTION
Biosorption is a well-known method of phyto remediation, which binds the toxic chemicals or metals and accumulates it in their biological systems especially in cellular structures. The process is widely used to encourage the remediation of heavy metals from the aquatic ecosystems. It also has the potential towards wastewater treatment. Metal toxicity in aquatic ecosystems is commonly triggered by anthropogenic activities including domestic and industrial wastewater, agricultural runoff and dumping of toxic chemicals, e-waste and others (Satpati, 2021). The deposition of toxic elements or trace metals in the aquatic bodies resulting in severe environmental impacts including contamination of surface and ground water and increasing the rate of biomagnification (Shibi et al., 2014; Satpati, 2021). Trace metals like copper (Cu) is a well known aquatic pollutant for its adverse affects on phytoplanktons, especially diatoms (Aboul, Kroon & Wolterbeek, 1994). The heavy presence of Cu in the aquatic food chains may be hazardous to the associated living organisms and to the environment (Nor, 1987). Aquatic living systems may scavenge the trace metals from the water column as well as from the bottom sediments or from both. Recently, algae have served as the most potential aquatic living system or bioindicator for accumulating toxic metals (Zeratkar et al., 2016). Diatoms belong to the group of Bacillariophyta (Guiry in Guiry & Guiry, 2021, AlgaeBase), which are frequently used as bioindicators for heavy metals in aquatic bodies. They are unicellular having silicified cell wall. The cell wall consists of two valves held together by a band of girdle. Most of the studies have been done so far on taxonomic documentation. In India, there are many reports on the freshwater diatom flora with detailed taxonomic account (Gandhi, 1992; Satpati, 1992; Satpati et al., 2017; Arguelles, 2019). The objective of this study was to determine the diversity of diatom flora as indicator of Cu in the adjoining water bodies of HCL and Subarnarekha River. In addition, the abundance of the diatom species in terms of low, medium and high Cu accumulation were also examined. The detailed taxonomic description suggests the proper identification of the euplanktonic diatoms as pollution indicator in aquatic ecosystems. The biochemical assessment of the water has also determined the water quality in the adjacent water bodies of HCL and Ghatshila.

MATERIAL AND METHODS
Sampling sites
For the collection of diatom and water samples, four sites were chosen: canal adjacent to HCL, outlets of HCL, poured into the Subarnarekha River and the
river itself commonly designated as Station 1 (22.5954° N, 86.4519° E), Station 2 (22.5962° N, 86.4522° E) and Station 3 (21.3325° N, 87.2341° E) respectively. All sampling stations are situated in Ghatshila, Jharkhand (Figure 1).

**Figure 1** Google satellite image showing three sampling stations (https://www.google.com/maps/search/ghatshila+hindustan+copper+limited/@2.5911511,86.4454325,4927m/data=!3m1!1e3).

Cu accumulation in water samples were analyzed using an ICP 2070 Sputrophotometer (Baird, USA) and AAS using a Varian Spect AA10 apparatus with Graphite Tube Atomizer GTA-95 (Victoria, Australia). The measurement accuracy was checked by the reference of Chmielewska & Medved (2001).

**RESULTS**

**Water analyses**

Water analysis report is demonstrated in table 1. During the study, all the sampling stations showed a static air temperature but slightly varied in water temperature. Water temperature was recorded minimum in station 1 with 28.35°C whereas highest in Subarnarekha River (station 3) with 30.33°C. pH ranges from slightly acidic (below 7.0) to slightly alkaline (above 7.0). The water pH of the canal adjacent to HCL (station 1) was recorded 6.8. However pH was recorded highest (7.3) in Subarnarekha River. High turbid condition of the water was noticed in station 1 followed by station 2 and 3. Electrical conductivity and light extinction coefficient was significantly decreased in the order station 3 > station 2 > station 1. Highest conductivity recorded in Subarnarekha River was 560.33 μS/cm. Total hardness varied from 260.33 in station 1 to 180.35 in station 3. Salinity was recorded highest (10 ppt) in station 1 and lowest (6 ppt) in station 3. Comparatively DO was highest in station 3 with 3.42 mg.L⁻¹ and lowest in station 1 with 2.21 mg.L⁻¹. However, station 1 recorded highest amount of dissolved CO₂ and BOD instead of station 2 and 3. Interestingly nitrate, sulphate and silicate level in the water was high in station 1, which was highly polluted and found adjacent to HCL. Phosphate level in the water of Subarnarekha River was recorded highest (0.84 mg.L⁻¹) and lowest (0.57 mg.L⁻¹) in the outlet of HCL poured directly into the river. Relatively the concentration of the calcium was high in station 3 and low in station 1. Accumulation of Cu in the water body was recorded highest in station 1 (400 μg.L⁻¹) and lowest in station 3 (47.87 μg.L⁻¹).

**Diatom composition**

In the present study, a total number of 31 species were investigated, which belong to 16 families, 10 orders under the class Bacillariophyceae. The diatom composition has suggested the dominance of *Cymbella* with 6 species followed by 3 species each of *Nitzschia* and *Rhopalodia* in the Cu contaminated area. Two species each from the genus *Navicula*, *Pinnularia*, *Amphora* and *Synedra* were also documented from the study sites. A large number of species were documented as Cu indicator or tolerant in Station 1, closely associated canal of HCL. From Table 2 it can be obtained that, 17 species are rich in Cu in Station 1 of which *Halamphora coffeiformis* was found to be most dominant over the area. Similarly this species was absent in station 2 and 3. Interestingly all species of *Cymbella* and *Navicula* were reported as high Cu tolerant species (Table 2). In station 2, nine diatom species were dominant of which both the species of *Pinnularia*, *P. acrosphaeria* and *P. viridis* showed positive response to Cu accumulation. Two species each of *Rhapalodia* and *Nitzschia* were recommended as Cu tolerant species in Station 2. However in station 3 only 5 species dominated as Cu tolerant upto 50 μg.L⁻¹. Both the species of *Synedra, S. ulna* and *S. ulna var. amphirhynchus* were designated as Cu indicator species in Subarnarekha River. Among the identified diatom species, 10 species viz., *Halamphora coffeiformis*, *Rhopalodia gibberula*, *Mastogloia smithii var. lacustris*, *Nitzschia nana*, *Hinoutidium minus*, *Synedra ulna var. amphirhynchus*, *Fragilaria intermedia var. robusta*, Grammatophora undulata, *Diatoma mesodon* and *Ctenophora palchella* were recommended as new to the Jharkhand State.

**Cu accumulation study**

Table 1 Geospatial and physico-chemical parameters of the Cu contaminated sites

<table>
<thead>
<tr>
<th>Geospatial and physico-chemical parameters</th>
<th>Study sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordinates</td>
<td>Station 1 (High Cu, (&gt;100 μg.L⁻¹)</td>
</tr>
<tr>
<td>pH</td>
<td>6.8</td>
</tr>
<tr>
<td>Air temperature (°C)</td>
<td>32.33</td>
</tr>
<tr>
<td>Water temperature (°C)</td>
<td>28.35</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>32.72</td>
</tr>
<tr>
<td>Electrical conductivity (μS cm⁻¹)</td>
<td>485.31</td>
</tr>
<tr>
<td>Light extinction coefficient (m)</td>
<td>1.39</td>
</tr>
<tr>
<td>Total hardness</td>
<td>260.33</td>
</tr>
<tr>
<td>Salinity (ppt)</td>
<td>10</td>
</tr>
<tr>
<td>Dissolved oxygen (mg.L⁻¹)</td>
<td>2.21</td>
</tr>
<tr>
<td>Dissolved CO₂ (mg.L⁻¹)</td>
<td>10.22</td>
</tr>
<tr>
<td>Biological oxygen demand (mg.L⁻¹)</td>
<td>8.83</td>
</tr>
<tr>
<td>Nitrate (mg.L⁻¹)</td>
<td>1.83</td>
</tr>
<tr>
<td>Phosphate (mg.L⁻¹)</td>
<td>0.76</td>
</tr>
<tr>
<td>Sulphate (mg.L⁻¹)</td>
<td>62.32</td>
</tr>
<tr>
<td>Silicate (mg.L⁻¹)</td>
<td>74.44</td>
</tr>
<tr>
<td>Calcium (mg.L⁻¹)</td>
<td>10.42</td>
</tr>
<tr>
<td>Copper (μg.L⁻¹)</td>
<td>400</td>
</tr>
</tbody>
</table>
Valves 7-8 times longer than broad, 50-70 μm long and 7-10 μm broad, lanceolate with wide central area with rounded apices. 

Voucher no.: CUH/PLANK/DIA- 29/2

Family: Neidiae
Genus: Neidium

**2. Neidium affine var. amphirhynchus (Ehrenberg) Cleve** [Figure 2e]
Hustedt, 1930; Patrick & Reimer, 1966; Eberle, 2008

Valves 7-8 times longer than broad, 50-70 μm long and 7-10 μm broad, lanceolate with wide central area with rounded apices. 

Voucher no.: CUH/PLANK/DIA- 29/2

Family: Neidiae
Genus: Neidium

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**Table 2** List of Cu indicating diatoms in three distinct sites (+++ Most dominant, >70% of the population; ++ Dominant, 40-70% of the population; + Less dominant, <40% of the population; - Absent, No species found)

<table>
<thead>
<tr>
<th>Name of the taxa</th>
<th>Station 1-High Cu (&gt;100 μg L⁻¹)</th>
<th>Station 2- Medium Cu (≤100 μg L⁻¹)</th>
<th>Station 3- Low Cu (≤50 μg L⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Diadesmis confervacea (Kützing)</td>
<td>++</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>2. Neidium affine var. amphirhynchus (Ehrenberg) Cleve</td>
<td>++</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>3. Navicula viridula (Kützing) Ehrenberg</td>
<td>++</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4. Navicula viridula var. rostellata (Kützing) Cleve</td>
<td>++</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>5. Halamphora coffeiformis (C. Agardh) Merechowsky</td>
<td>+++</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6. Pinnularia viridis (Nitzsch) Ehrenberg</td>
<td>-</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>7. Pinnularia viridis var. (Nitzsch) Ehrenberg</td>
<td>-</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>8. Rhopalodia gibba (Ehrenberg) O. Müller</td>
<td>++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>9. Rhopalodia gibberula (Ehrenberg) O. Müller</td>
<td>-</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>10. Rhopalodia operculata (C. Agardh) Håkansson</td>
<td>-</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>11. Achnanthes exigua Grunow</td>
<td>++</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>12. Mastogloia smithii var. lacustris Grunow</td>
<td>+</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>13. Nitzschia obtusa var. scalpelliformis (Grunow) Grunow</td>
<td>+</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>14. Nitzschia nana Grunow</td>
<td>+</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>15. Nitzschia acicularis (Kützing) W. Smith</td>
<td>-</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>16. Amphora elliptica (C. Agardh) Kützing</td>
<td>-</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>17. Amphora ovum Cleve</td>
<td>++</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>18. Himantidium minus Kützing</td>
<td>-</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>19. Synedra ulna (Nitzsch) Ehrenberg</td>
<td>-</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>20. Synedra ulna var. amphirhynchus (Ehrenberg) Grunow</td>
<td>-</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>21. Fragilaria intermedia var. robusta G. S. Venkataraman</td>
<td>+</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>22. Diatomata mesodon (Ehrenberg) Kützing</td>
<td>++</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>23. Cymbella ehrenbergi Kützing</td>
<td>++</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>24. Cymbella affinis Kützing</td>
<td>++</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>25. Cymbella olivii Cholnoky</td>
<td>++</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>26. Cymbella cristula (Ehrenberg) O. Kirchner</td>
<td>++</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>27. Cymbella turgidula Grunow</td>
<td>++</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>28. Cymbella tumida (Brébisson) Van Heurck</td>
<td>++</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>29. Gomphonema lanceolatum Ehrenberg, nom. illeg.</td>
<td>++</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>30. Grammatophora undulata Ehrenberg</td>
<td>++</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>31. Ctenophora pulchella (Ralfs ex Kützing) D. M. Williams &amp; Round</td>
<td>+</td>
<td>++</td>
<td>-</td>
</tr>
</tbody>
</table>
Figure 2 Light micrographs of (a-b) Diadesmis confervacea Kützing. (c) Nitzschia aflatina var. amphibrachys (Ehrenberg) Cleve. (d) Navicula viridula (Kützing) Ehrenberg. (e) Navicula viridula var. robustula (Kützing) Cleve. (f) Halamphora coffeiformis (C. Agardh) Mereschkowsky. (g) Pinnularia acrosphaeria W. Smith. (h) Pinnularia viridis (Nitzsch) Ehrenberg. (i-j) Rhopalodia gibba (Ehrenberg) O. Müller. (k-l) Rhopalodia gibberula (Ehrenberg) O. Müller. (m) Rhopalodia operculata (C. Agardh) Håkanasson. (n) Achnanthes exigua Grunow. (o) Mastogloia smithii var. lacustris Grunow. (p) Nitzschia obtusa var. scalpelliformis (Grunow) Grunow. (Scale bar a-e, g, i-l, o-p: 10 μm; f, n: 5 μm; h, m: 20 μm)

Valves semi-lanceolate, dorsal margins, ventral linear, slightly concave with rostrate or capitata apices, 4-6 times longer than broad, 30-50 μm long and 4-12 μm broad; raphe straight, excentric; striae dorsal, coarse, radiate, 8-12 in 10 μm area.

Voucher no.: CUH/PLANK/DIA- 29/5
Suborder: Sellaphorinae
Family: Pinnariaceae
Genus: Pinnaria

6. Pinnularia acrosphaeria W. Smith [Figure 2g]
Hustedt, 1930; Proschkina-Lavrenko, 1950; Kulikovskiy et al., 2016
Valves linear, gibbose in the middle and at the ends, axial area broad linear and central area punctate, 4.5 to 5.5 times longer than broad, 38-62 μm long and 8-12 μm broad; striations nearly parallel and slightly radial at the ends, striae 9-12 in 10 μm area.

Voucher no.: CUH/PLANK/DIA- 29/6

7. Pinnularia viridis (Nitzsch) Ehrenberg [Figure 2h]
Cleve, 1895; Hu & Wei, 2006; Hofmann, Wurm & Lange-Bertalot, 2013; Synonym and Basionym: Bacillaria viridis Nitzsch
Valves linear with slightly convex margins and rounded ends, axial area narrow and central area is slightly widened, 5-7 times longer than broad, 90-140 μm long and 18-20 μm broad; raphe complex; striations coarse, slightly radial in the middle and convergent at the ends, striae 7-9 in 10 μm area.

Voucher no.: CUH/PLANK/DIA- 30/1
Order: Rhopalodiaceae
Family: Rhopalodiaceae
Genus: Rhopalodia

8. Rhopalodia gibba (Ehrenberg) O. Müller [Figures 2i-j]
Aboal et al., 2003; Jahn & Kusber, 2004; Cocquyt, Kusber & Jahn, 2018
Basionym: Navicula gibba Ehrenberg

Frustules linearly lanceolate with cuneate apices and inflated center, 7-12 times longer than broad, 45-140 μm long and 6-12 μm broad; striae distinct 12-18 in 10 μm.

Voucher no.: CUH/PLANK/DIA- 30/2

9. Rhopalodia gibberula (Ehrenberg) O. Müller [Figures 2k-l]
Hustedt, 1930; Proschkina-Lavrenko, 1950; John, 2018
Basionym: Eunotia gibberula Ehrenberg
Frustules long, elliptical with rounded ends, 1.5 times longer than broad, sometimes as long as broad, 30-42 μm long and 25-30 μm broad, dorsal side highly convex; costae 3-4 in 10 μm area.

Voucher no.: CUH/PLANK/DIA- 30/3

10. Rhopalodia operculata (C. Agardh) Håkanasson [Figure 2m]
Ruck et al., 2016; John, 2018
Basionym: Frustulia operculata C. Agardh
Valve linear, solitary, lanceolate or elliptic with wide rounded apices, 3 times longer than broad, 55-60 μm long and 22-24 μm broad; striae transverse, wide apart from each other.

Voucher no.: CUH/PLANK/DIA- 30/4
Order: Mastogloiales
Family: Achnanthaceae
Genus: Achnanthas

11. Achnanthes exigua Grunow [Figure 2n]
Frustules narrow, rectangular in girdle view, forming short chains; valves narrowly lanceolate with clearly convex margins and rostrate apices; valves 5-15 μm long and 3-5 μm broad; striae is not clearly visible under compound microscope.

Voucher no.: CUH/PLANK/DIA- 30/5
Order: Bacillariaceae
Family: Bacillariaceae
Genus: Nitzschia

12. Mastogloia smithii var. lacustris Grunow [Figure 2o]
Proschkina-Lavrenko, 1950; Lee et al., 2014
Valve linear, elliptical and constricted, two narrow ends with central broad area, 4 times longer than broad, 31-32 μm long and 7.5-8.5 μm broad; striations are not clearly visible under compound microscope.

Voucher no.: CUH/PLANK/DIA- 30/6
Order: Bacillariaceae
Family: Bacillariaceae
Genus: Mastogloia

13. Nitzschia obtusa var. scalpelliformis (Grunow) Grunow [Figure 2p]
Hustedt, 1930; Proschkina-Lavrenko, 1950
Basionym: Nitzschia scalpelliformis Grunow
Valves linear, 10-14 times longer than broad, 80-100 μm long and 6-10 μm broad, apices bend in opposite direction, margins parallel; striae fine 25-30 in 10 μm.

Voucher no.: CUH/PLANK/DIA- 31/1

14. Nitzschia nana Grunow [Figure 3a]
Hofmann, Wurm & Lange-Bertalot, 2013; Miscoe et al., 2016; John, 2018
Valves linear, 10-15 times longer than broad, 100-200 μm long and 8-12 μm broad, apices sharp midille like, striae is not clear under compound microscope.

Voucher no.: CUH/PLANK/DIA- 31/2

15. Nitzschia acicularis (Kützing) W. Smith [Figure 3b]
Hustedt, 1930; Aboal et al., 2003; John, 2018
Basionym: Syndra acicularis Kützing
Valves are spindle shaped, slightly silicified, both side of the valves are slightly tapering with sharp narrow apices; valves 15-20 times longer than broad, 35-135 μm long and 2-6 μm broad; striae is not clear under compound microscope.

Voucher no.: CUH/PLANK/DIA- 31/3
Order: Thalassiosirales
Family: Catenulidae
Genus: Amphora
19. Synedra ulna (Nitzsch) Ehrenberg [Figure 3f]

Frustules are oval to elliptical with large central chloroplast, 3-4 times longer than broad, 40-50 μm long and 12-14 μm broad, clear transverse striae present, 8-10 in 10 μm area.

Voucher no.: CUH/PLANK/DIA- 33/1

20. Synedra ulna var. amphirhynchus (Ehrenberg) Grunow [Figure 3g]

Valves are broadly lanceolate with obtuse apices, 3-5 times longer than broad, 35-36 μm long and 12.5-13 μm broad; transverse raphe located at the middle; central nodule present; distinct transverse striations present and radial towards the center, striae 5-10 in 10 μm area.

Voucher no.: CUH/PLANK/DIA- 32/5

21. Fragilaria intermedia var. robusta G. S. Venkataraman [Figure 3h]

Venkataraman, 1939

Frustules are linear, rectangular in girdle view, 14-18 times longer than broad, 70-140 μm long and 5-8 μm broad; valves linear with parallel sides and gradually tapering capitulate ends; striae coarse and distinct, 11-12 in 10 μm area.

Voucher no.: CUH/PLANK/DIA- 32/3

Order: Tabellariae

Family: Tabellariae

Genus: Fragilaria

22. Diatoma mesodon (Ehrenberg) Kützing [Figure 3i]

Aboal et al., 2003; Hofmann, Werum & Lange-Bertalot, 2013; Lange-Bertalot et al. 2017

Synonym: Odontidium mesodon (Kützing) Kützing

Basionym: Fragilaria mesodon Ehrenberg

Valves are rectangular arranged in chains, 10-20 μm long and 7-10 μm broad; striae are not clearly visible under compound microscope but usually 20 in 10 μm area.

Voucher no.: CUH/PLANK/DIA- 32/4

Order: Cymbellales

Family: Cymbellaceae

Genus: Cymbella

23. Cymbella ehrenbergii Kützing [Figure 3j]

Proschkina-Lavrinenko, 1950; Hu & Wei, 2006

Asymmetrical, biraphid, lanceolate frustules with obtuse end, 2.5 to 3 times longer than broad, 28-40 μm long and 11-12 μm broad; striae radial and lineate, 10 in 10 μm area.

Voucher no.: CUH/PLANK/DIA- 32/1

24. Cymbella affinis Kützing [Figure 3k]

Aboal et al., 2003; Hofmann, Werum & Lange-Bertalot, 2013

Valves 5 times longer than broad, 20-30 μm long and 4-6 μm broad, strongly dorsiventral with rostrate apices; central stigma present; 8-12 striations in 10 μm area.

Voucher no.: CUH/PLANK/DIA- 32/6

25. Cymbella oliffii Cholnoky [Figure 3l]

Cholnoky, 1956

Frustules are oval to elliptical with large central chloroplast, 3-4 times longer than broad, 35-80 μm long and 10-15 μm broad, ventral convex and median inflated; raphe central, proximal, straight; stigma present, 2-3; striae coarse, 8-12 in 10 μm area.

Voucher no.: CUH/PLANK/DIA- 32/3

26. Cymbella cistula (Ehrenberg) O. Kirchner [Figure 3m]

Hustedt, 1930; Hu & Wei, 2006

Basionym: Bacillaria cistula Ehrenberg

Valve strongly dorsiventral with rounded apices, 3-5 times longer than broad, 35-80 μm long and 10-15 μm broad, ventral convex and median inflated; raphe central, proximal, straight; stigma present, 2-3; striae coarse, 8-12 in 10 μm area.

Voucher no.: CUH/PLANK/DIA- 33/2

27. Cymbella tumida (Brébisson) Van Heurck [Figure 3n]

Aboal et al., 2003; Hu & Wei, 2006; John, 2018

Valves dorsiventral, broadly lanceolate, 3 times longer than broad, 30-45 μm long and 10-15 μm broad, apices blunt, rostrate to truncate; proximal striae 10-12 and distal striae 12-15 in 10 μm area.

Voucher no.: CUH/PLANK/DIA- 33/3

28. Cymbella capitata (Brébisson) Van Heurck [Figure 3o]

Aboal et al., 2003; Hu & Wei, 2006; Hofmann, Werum & Lange-Bertalot, 2013

Valves broadly lanceolate with obtuse ends, 3-5 times longer than broad, 50-70 μm long and 10-20 μm broad; dorsal and ventral margins of the valve bent in opposite direction; striations radial, 8-10 in 10 μm area.

Voucher no.: CUH/PLANK/DIA- 33/4

Family: Gomphonemataceae

Genus: Gomphonema

29. Gomphonema lanceolatum Ehrenberg, nom. illeg. [Figure 3p]

Hustedt, 1930; Eberle, 2008

Valves dorsiventral to clavate in shape with distinctly rounded apex and base, 4-4.5 times longer than broad, 50-55 μm long and 12-14 μm broad; raphe slightly thick and straight; Striae radial and lineate, 10 in 10 μm area.
Nymphaea pubescens
Dwivedi & Misra, 2015

condition of the water bodies of the
Dixit
imary
Petrou
2014

suggests the low pH. Total hardness and turbidity values in all stations suggest
production in diatoms (pollution (which is slightly acidic suggesting the starting point of acidification due to
reduces water quality (Limnological parameter greatly influences the assemblage of diatoms and
present study sites correspond closely to shifts in other living communities such
rapidly to any environmental changes. Changes in diatom assemblage in the
abnormalities and ecological fluc
Himantidium minus
1992

1
2
3

1. Diatom diversity was highest in all three sampling stations that were
studied 19 periphytic diatom taxa from the river Ganges polluted
with Cu, Pb and Zn.

Dowd and Zhang (2002).

2. Station 1, 17 species were found to be domi
station 3 vanished
of species composition and species richness (Cattaneo et al., 2011). From the study it can be concluded that the diatom assemblages of Ghatshila can serve as best bioindicator of Cu.

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