ACTA HYDROBIOL.	28	3/4	371—378	KRAKÓW 1986

Sessile algae of the River Nida (Southern Poland) in the area of experimentally fertilized bankside soils*

Barbara Kawecka

Polish Academy of Sciences, Institute of Freshwater Biology
ul. Sławkowska 17, 31-026 Kraków, Poland

Manuscript submitted December 3, 1985, accepted April 8, 1986

Abstract — No great differences were found in the structure of algal communities developing at control stations, and those affected by the run-off from experimentally fertilized fields. Cells of *Fragilaria pinnata*, *Nitzschia palea*, *Achnanthes lanceolata* with varieties, and *Cocconeis placentula* var. *euglypta* were most frequently observed: the biomass index of diatoms reached maximum values in the summer-autumn period and minimum ones in winter. At the station below a fertilized field the number of *Navicula pupula*, *Nitzschia kützingiana*, and green algae increased in the summer-autumn period.

Key words: rivers, sessile algae, ecology of algae, seasonality, agricultural wastes.

1. Introduction

Contrary to point pollution (domestic and industrial sewage) whose effects are distinctly manifested, surface run-off from the arable land, though difficult to record, also contributes to the eutrophication of surface waters. In recent years the effect of pastoral and agricultural economy on water biocenoses was investigated by numerous workers (Bombówna 1982, Dumnicka 1982, Grabacka 1982, Kawecka 1982,

* The work was carried out within Project No MR.II.17.

Kownacki 1982a, 1982b, Kurek, Pawlik-Dobrowolski 1982, Niesiołowski 1982, Reczyńska-Dutka 1982, Starmach 1982, Starzecka, Trela 1982, Klapwijk et al. 1983).

The aim of the present work was to study the development of communities of sessile algae in the River Nida, which flowed through experimentally fertilized areas. The paper is a part of a complex investigation on microbiological processes occurring in the area of experimentally fertilized bankside soils, and on the effect of this fertilization on river biocenoses (Bednarz unpubl., Bombówna unpubl., Grabacka unpubl., Starzecka unpubl., Starzecka, Mazurkiewicz 1987, Zygmuntowa unpubl.).

2. Study area

The River Nida, 179 km in length, is a left-side tributary of the upper Vistula. It flows out at an altitude of 269 m, originating from the confluence of the Rivers Biała and Czarna Nida which drain the Świętokrzyskie Mts (with a maximum absolute altitude of 612 m). In its upper course the river has a natural character while in the middle and lower course it flows through towns which pollute it to a great degree. The town of

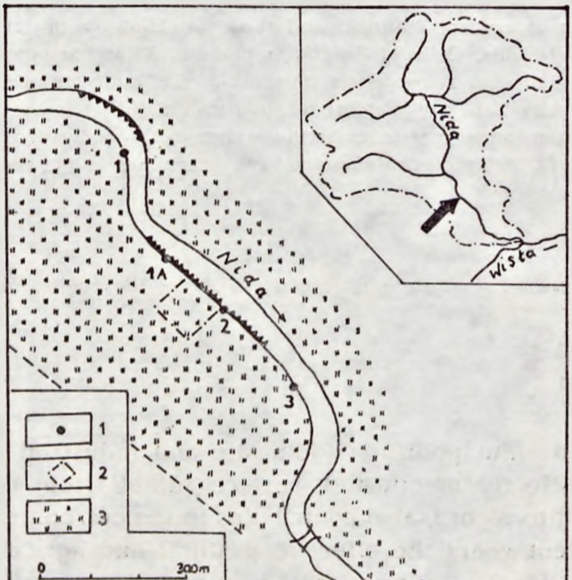

Fig. 1. Map of the River Nida (after Starzecka, Mazurkiewicz 1987). 1, 1A, 2, 3 — stations

Pińczów is particularly important in this respect. The investigation was carried out in the locality of Chroberz in the lower river course (fig. 1). The river, flowing in meanders, has a typically lowland character here. It is 20—40 m wide and 10—150 cm deep. The bottom is sandy with mud at the banks. The waters of the river are of calcium-hydrocarbonate type and markedly eutrophicated in the whole length of the investigated section, this above all being manifested by a large content of phosphates (B o m b ó w n a unpubl.).

The investigation was carried out in the region of a 0.6 — kilometre section of the river, where 4 stations, — 1, 1A, 2, and 3 — were established (fig. 1, 2). Owing to habitat differences between the control Station 1 and Stations 2 and 3, an additional control Station 1A was appointed. Both control Stations lay above the fertilized field but while Station 1 lay near a flat bank on a sand shoal with shallow water, Station 1A was situated near a high bank. Station 2 was by the end of the field and Station 3 below the fertilized area. They were both situated near a high steep bank in deep water. The bankside field of 1 ha was fertilized 3 times a year (in April, July, and September) with 80 kg ha^{-1} of ammonium nitrate. The fertilized field reached right to the edge of the riverbed. In the section of river affected by the applied doses of fertilizers the content of biogenes slightly increased (fig. 2).

3. Material and method

The investigation was carried out throughout 1984. In winter months (January and February) sampling was prevented by a thick layer of ice at Stations 1A and 2. Algae were sampled from the bottom in the zone of the river near the bank at the side of the fertilized field. The material was preserved in a 4% solution of formalin. Preparation of diatoms and the quantitative elaboration of the material were carried out according to methods described in detail by the author (K a w e c k a 1980).

4. Results

Diatoms prevailed in the communities of algae (144 taxa, this constituting 93.5% of all species and varieties recorded).

In general, the structure of algal communities was similar at all stations. The numbers of taxa and biomass indices of diatoms were maintained at an average level (fig. 2). Species of the genera *Fragilaria* (chiefly *F. pinnata* with varieties), *Nitzschia palea, Achnanthes lanceolata* with varieties, *Cocconeis placentula* var. *euglypta* accompanied by

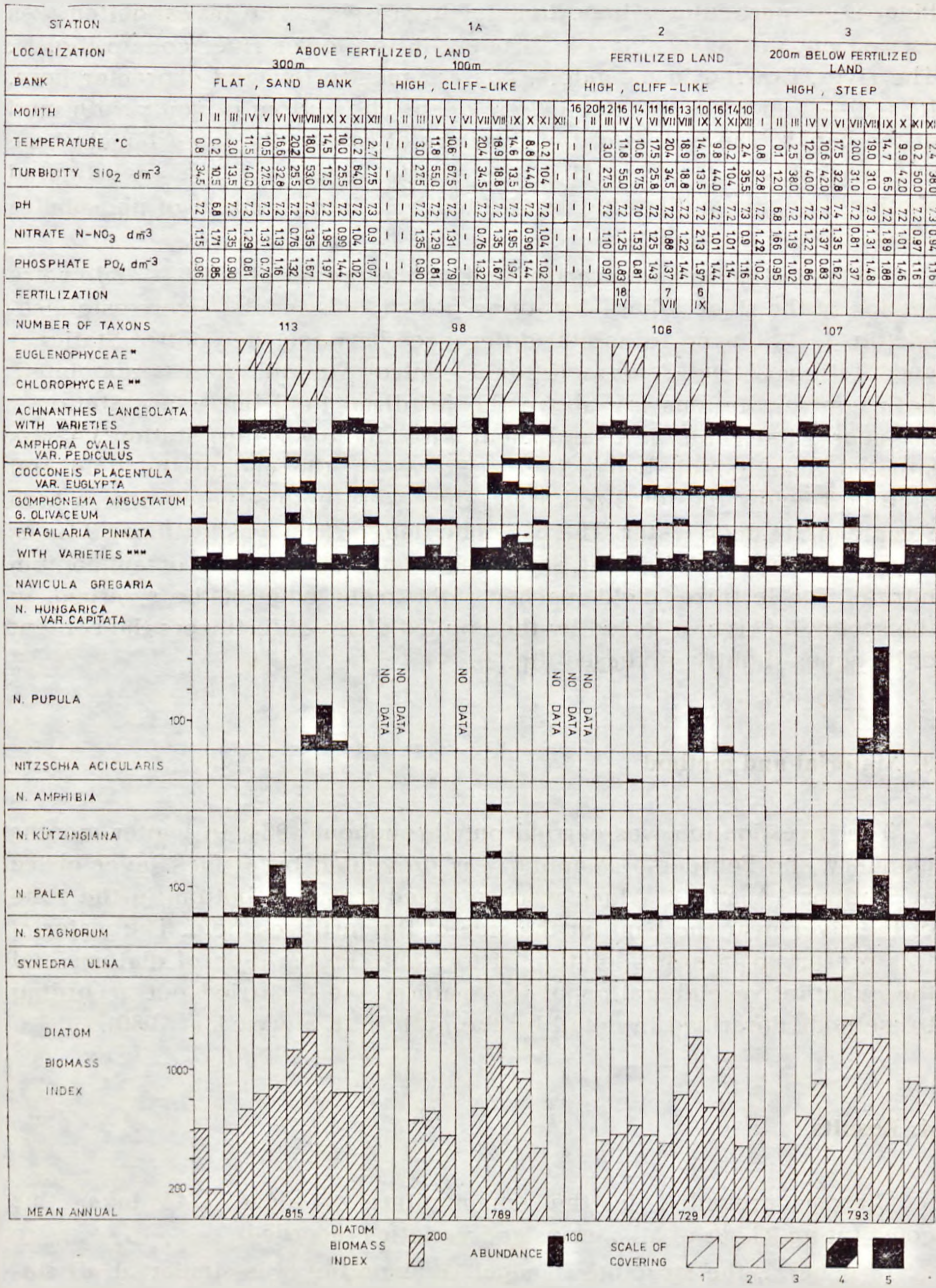

Fig. 2. Communities of sessile algae in the River Nida, dominating diatom species and algae forming macroscopic aggregations. * — *Euglena geniculata, E. viridis, E. fusca, E. intermedia;* ** — *Cladophora* sp., *Oedogonium* sp., *Spirogyra* sp., *Vaucheria* sp.

C. pediculus, and species of the genus *Gomphonema* developed abundantly at all stations.

At all stations the pattern of development of algal communities throughout the year was similar. In winter the development of algae was poor and the index of biomass of diatoms showed low values. In spring diatoms and in May also euglenoids developed. In summer and autumn the abundant development of diatoms was manifested by the maximum values of their biomass index.

At the control stations, which differed in habitat conditions since one lay at the low bank (Station 1) and the other at a high one (Station 1A), there appeared differences in the number of taxa and abundance of species. At Station 1 the development of diatoms was more intense and the species in the community were more varied. *Nitzschia palea* formed larger populations here and in autumn *Navicula pupula* developed profusely. The biomass index of diatoms reached higher values, not only exceeding the level noted at Station 1A but also that at the experimentally fertilized Stations 2 and 3.

At Stations 2 and 3 affected by the experimentally fertilized the number of taxa was slightly larger than that at the control Station 1A but smaller than at Station 1. In spring *Nitzschia acicularis* and *Navicula gregaria* and in summer *N. hungarica* var. *capitata* appeared in the group of dominants. In the summer-autumn period the development of *Navicula pupula, Nitzschia kützingiana*, and of green algae, chiefly with *Cladophora* sp., became more intensive. The biomass index of diatoms reached a level similar to that noted at the control Station 1A but lower than that at Station 1 (fig. 2).

5. Discussion

In the entire studied section the waters of the River Nida were eutrophicated to a fairly high degree and the organisms developing there were adapted to these living conditions. Therefore, an insignificant increase in the fertility of the water in the experimentally fertilized area did not significantly change the structure of algal communities. Along the whole length of the investigated stretch of the river there occurred large numbers of the following species: *Nitzschia palea*, a species characteristic for strongly eutrophicated waters, an obligatory nitrogen heterotroph (Cholnoky 1968), living in the pH range 4.2—9 (Lowe 1968); *Fragilaria pinnata*, an organism determined as mesotrophic, β-me-

(at Station 3 in April only *Vaucheria* sp. and *Spirogyra* sp.); *** — *Fragilaria construens* var. *binodis*, *F. construens* var. *subsalina* (chemical data according to Bombówna unpubl.)

sosaprobic, or oligosaprobic, living in the pH range 5.7—9 (L o w e 1974); *Achnanthes lanceolata* encountered in the natural environment of high-mountain streams but also in those polluted by domestic sewage, at pH 6.3—8.5 (K a w e c k a 1981); *Cocconeis placentula* var. *euglypta*, which lives both in oligotrophic and mesotrophic waters at pH 6.2—8.5 (K a w e c k a 1981), resistant to pollution (W e h r l e 1942).

The following species occurred in smaller numbers; *Nitzschia stagnorum*, an organism of mesotrophic waters, living within the pH range 6.6—7.7 (L o w e 1974); *Gomphonema angustatum* and *G. olivaceum* determined as oligosaprobic organisms and also living in eutrophicated waters at pH 6.4—9 (*G. olivaceum*) and 6—9 (*G. angustatum*) (L o w e 1974); *Amphora ovalis* var. *pediculus*, an organism of mesosaprobic to oligosaprobic waters, found at pH 4.5—9 (L o w e 1974), and *Synedra ulna* which lives both in oligotrophic and eutrophic waters (K a w e c k a 1981) at pH 5.7—9 (L o w e 1974). In May euglenoids occurred abundantly at all stations, chiefly *E. geniculata*, an organism very well tolerating pollution (S l á d e č e k, P e r m a n 1978).

In the part of the river neighbouring upon the experimentally fertilized field there appeared in the group of dominants small numbers of *Nietzschia acicularis*, a species of strongly eutrophicated waters (C h o l n o k y 1968), and *Navicula hungarica* var. *capitata*, a halophilous diatom which occurs in polluted waters at a content of $N—NH_4$ in the range 0.31—1.15 mg dm^{-3} and pH 6.4—7.6 (T u r o b o y s k i 1979) and is frequently found in the polluted waters of Upper Silesia (B u c k a 1985).

At the station below the fertilized field the numbers of *Navicula pupula* and *Nitzschia kützingiana* increased. These two species live in eutrophicated waters, the latter being classified among obligatory nitrogen heterotrophs (C h o l n o k y 1968). *Navicula pupula* is neutral with regard to pH while *Nitzschia kützingiana* appears in the pH range 6.4—8.4 (L o w e 1974). *Navicula gregaria*, an organism of brackish waters and a facultative nitrogen heterotroph (C h o l n o k y 1968), also appeared here but its numbers were small. Besides, green algae, chiefly *Cladophora* sp., developed at this station. In general, the species mentioned above found suitable development also at the stations above the experimentally fertilized field. For example, in September fairly large populations of *Navicula pupula* were observed at the control station as well (fig. 2). Therefore, the quantitative growth of algal communities in the discussed area cannot be associated with the fertilization of the bankside field alone. This may be the result of fertilization but local factors not connected with the experiment might have played some role here.

Differences in the communities of algae at the control Stations 1 and 1A were most probably associated with the micro-habitat conditions. At Station 1, which was a sandy shoal, the zone of water near the bank was shallow, hence the light and thermal conditions were much better, this stimulating the development of algae. The algal community here was richer in species and the biomass index of diatoms reached higher values than those at Station 1A which lay near a high and steep bank. It is worth noting that at Station 1 also the biomass index of diatoms was higher than that at Stations 2 and 3, which were affected by experimental fertilization but were situated near a high bank similarly as Station 1A (fig. 2). This suggests that the habitat conditions play an important role in the development of algae and should be taken into consideration in evaluating water productivity.

Acknowledgements — The author wishes to thank Dr Halina Bucka for identifying the species of euglenoids.

6. Polish summary

Glony osiadłe rzeki Nidy (Polska Południowa) na obszarze eksperymentalnie użyźnianych przybrzeżnych gleb

Badania prowadzono w 1984 r. na około 0,6 km odcinku rzeki Nidy, w miejscowości Chroberz (ryc. 1). Łan eksperymentalny o powierzchni 1 ha był nawożony trzy razy w roku (IV, VII, IX) saletrą amonową o łącznej ilości 240 kg ha^{-1}. Wyznaczono cztery stanowiska (ryc. 2): kontrolne, usytuowane powyżej użyźnianego łanu (1, 1A), przy końcu użyźnianego łanu (2) oraz poniżej niego (3). Stanowisko 1A wyznaczono dodatkowo ze względu na różnice siedliskowe; stanowisko 1 usytuowane było przy brzegu płaskim na piaszczystej ławicy, woda była tu płytka i w związku z tym panowały dużo lepsze warunki świetlne i termiczne w stosunku do stanowiska 1A, położonego podobnie jak stanowiska 2 i 3, przy wysokim brzegu, stromo opadającym i wodzie głębokiej. Rzeka na badanym odcinku posiadała charakter wodoro-węglanowo-wapniowy i była znacznie zeutrofizowana.

Zbadano glony osiadłe w przybrzeżnej strefie rzeki (ryc. 2). Stwierdzono duże znaczenie warunków siedliskowych dla rozwoju glonów, na stanowisku bowiem kontrolnym 1 rozwój okrzemek był intensywniejszy niż na stanowisku 1A, przewyższał nawet ich rozwój na stanowiskach eksperymentalnie użyźnionych. Badania nie wykazały większych różnic w strukturze dominacji na stanowiskach kontrolnych i nawożonych. W ciągu roku najczęściej spotykano *Nitzschia palea*, gatunki z rodzaju *Fragilaria* (głównie *F. pinnata* z odmianami), *Achnanthes lanceolata* z odmianami, *Cocconeis placentula* var. *euglypta*. Przebieg rozwoju zbiorowisk glonów był w ciągu roku podobny na wszystkich stanowiskach. W zimie rozwój był słaby, na wiosnę nastąpił wzrost ilościowy okrzemek, a także euglen. Najlepszy rozwój glonów notowano w okresie letnio-jesiennym. W tym czasie na stanowisku 3, położonym poniżej użyźnianego pola, dość znacznie wzrosła liczebność *Navicula pupula*, *Nitzschia kützingiana* oraz zielenic (głównie *Cladophora* sp.). Organizmy te, częste w wodach eutroficznych, w zasadzie posiadały dogodne warunki rozwoju także i na stanowiskach kontrolnych, dlatego trudno powiedzieć co wpłynęło na ich rozwój: spływ z terenów użyźnianych czy też inne czynniki nie związane z prowadzonym eksperymentem.

7. References

B o m b ó w n a M., 1982. Stream ecosystems in mountain grassland (West Carpathians). 3. Chemical composition of water. Acta Hydrobiol., 24, 321—335.

B u c k a H., 1985. Ecology of some waters in the forest-agricultural basin of the River Brynica near the Upper Silesian Industrial Region. 6. Communities of plankton algae. Acta Hydrobiol., 27, 493—508.

C h o l n o k y B. J., 1968. Die Oekologie der Diatomeen in Binnengewässern. Weinheim, J. Cramer Verl., 699 pp.

D u m n i c k a E., 1982. Stream ecosystems in mountain grassland (West Carpathians). 9. *Oligochaeta*. Acta Hydrobiol., 24, 391—398.

G r a b a c k a E., 1982. Stream ecosystems in mountain grassland (West Carpathians). 7. *Ciliata*. Acta Hydrobiol., 24, 367—375.

K a w e c k a B., 1980. Sessile algae in European mountain streems. 1. The ecological characteristics of communities. Acta Hydrobiol., 22, 361—420.

K a w e c k a B., 1981. Sessile algae in European mountain streams. 2. Taxonomy and autecology. Acta Hydrobiol., 23, 17—46.

K a w e c k a B., 1982. Stream ecosystems in mountain grassland (West Carpathians). 6. Sessile algae communities. Acta Hydrobiol., 24, 357—365.

K o w n a c k i A., 1982a. Stream ecosystems in mountain grassland (West Carpathians). 8. Benthic invertebrates. Acta Hydrobiol., 24, 375—390.

K o w n a c k i A., 1982b. Stream ecosystems in mountain grassland (West Carpathians). 12. General conclusion. Acta Hydrobiol., 24, 413—432.

K l a p w i j k S. P., T. F. B o e r, M. J. R i j s, 1983. Effects of agricultural wastewater on bethic algae in ditches in the Netherlands. In: R. G. Wetzel (Ed.): Periphyton of freshwater ecosystems. Hague, W. Junk Publ., 311—319

K u r e k S., J. P a w l i k - D o b r o w o l s k i, 1982. Stream ecosystems in mountain grassland (West Carpathians). 2. Hydrological characteristics. Acta Hydrobiol., 24, 307—320.

L o w e R. J., 1974. Environmental requirements and pollution tolerance of freshwater diatoms. Envir. Monit. Series, Nat. Envir. Res. Center Office Res. Develop., Cincinnati, Ohio, U.S. Envir. Protect. Agency, 334 pp.

N i e s i o ł o w s k i S., 1982. Stream ecosystems in mountain grassland (West Carpathians). 10. *Simuliidae* and *Empididae* (*Diptera*). Acta Hydrobiol., 24, 399—403.

R e c z y ń s k a - D u t k a M., 1982. Stream ecosystems in mountain grassland (West Carpathians). 4. Heavy metals. Acta Hydrobiol., 24, 337—341.

S l á d e č e k V., J. P a r m a n, 1978. Saprobic sequence within the genus *Euglena*. Hydrobiol., 57, 57—58.

S t a r m a c h J., 1982. Stream ecosystems in mountain grassland (West Carpathians). 11. Fish. Acta Hydrobiol., 24, 405—412.

S t a r z e c k a A., K. T r e l a, 1982. Stream ecosystems in mountain grassland (West Carpathians). 5. *Bacteria*. Acta Hydrobiol., 24, 343—355.

S t a r z e c k a A., G. M a z u r k i e w i c z, 1986. The activity of bacterial flora in the River Nida, in stretches differing in geological substratum and soils near the banks (Southern Poland). Acta Hydrobiol., 28, 317—328.

T u r o b o y s k i L., 1979. Hydrobiologia techniczna [Technical hydrobiology]. PWN, Warszawa, 444 pp.

W e h r l e E., 1942. Algae in Gebirgsbächen am Südostrende des Schwarzwaldes. Beitr. naturk. Forsch. Oberrheingeb., 7, 128—286.