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Effect of organic pollution on the development of diatom communities in the alpine streams Finstertaler Bach and Gurgler Ache (Northern Tyrol, Austria)

by

Barbara KAWECKA*)

(Laboratory of Water Biology, Polish Academy of Sciences, Kraków)

Auswirkungen organischer Verunreinigung auf die Entwicklung von Diatomeen-Gemeinschaften in den Hochgebirgsbächen Finstertaler Bach und Gurgler Ache (Nordtirol, Österreich)

Zusammenfassung:

Die Entwicklung von Diatomeen-Aufwuchs war in zwei Hochgebirgsbächen an der Grenze zur subalpinen Höhenstufe von November 1970 bis Mai 1971 verfolgt worden. Die Entnahmestellen lagen oberhalb und unterhalb der Wintersportorte Kühtai und Obergurgl, deren Abwässer den Finstertaler Bach bzw. die Gurgler Ache zur Zeit geringer Wasserführung stark belasten.

Im nicht verunreinigten Abschnitt des Finstertaler Baches dominierten *Tabellaria flocculosa, Achnanthes minutissima, Ceratoneis arcus* und *Diatoma hiemale* in einer sehr artenreichen Gesellschaft. Die Besiedlung der Gurgler Ache erwies sich oberhalb Obergurgl als spärlich, ohne auffallendes Hervortreten bestimmter Arten.

Unterhalb der Beileitung häuslicher Abwässer änderte sich die Struktur der Diatomeen-Gesellschaften drastisch: Zur Zeit geringer organischer Verunreinigung entwickelte sich in beiden Bächen *Cymbella ventricosa,* daneben im Finstertaler Bach *Fragilaria capucina, Diatoma hiemale* und *Ceratoneis arcus,* in der Gurgler Ache *Gomphonema angustatum, Navicula crytocephala* und *Pinnularia mesolepta.* Zur Zeit starker Abwasserzufuhr kam es zu einer Massenentwicklung von *Cymbella ventricosa* und zu einer Abnahme der Artenvielfalt.

Die Ähnlichkeit dieser Befunde mit Beobachtungen an Diatomeengesellschaften des Baches Rybi Potok (Hohe Tatra, Polen), den Abwässer des Touristenhauses "Morskie Oko" belasten, wird diskutiert.

*) Anschrift der Verfasserin: Dr. B. Kawecka, Laboratory of Water Biology, Polish Academy of Sciences, 31-016 Kraków, Sławkowska 17, Poland.

Abstract:

The development of diatom communities in the streams Finstertaler Bach and Gurgler Ache (Austrian Alps) was observed in winter 1970/71 in the natural environment and in the environment polluted with domestic sewage discharged from the villages Kühtai and Obergurgl. Changes in the number and in the qualitative composition of the communities under the influence of sewage are shown.

Introductions

The present paper aims at examining the succession of diatom communities in the Finstertaler and Gurgler streams during the increase of pollution coming from the villages Kühtai and Obergurgl, in comparison with their development in natural conditions above these settlements.

Both villages Kühtai and Obergurgl are winter sport centres, and therefore the streams are polluted periodically, during early spring and in autumn their waters being considerably clean. Summer tourism causes minor pollution: PESCHEK (1968) classified the water of the Finstertaler stream in summer as I - II class of purity, and that of the Gurgler stream as II. Winter tourism starts in mid-December and reaches its climax in March. The pollution of the strems icreases at the same rate. At that time the waters of the Finstertaler stream belong to the IInd class of purity and those of the Gurgler stream to the IIIrd and IVth (PESCHECK, 1968). Above the settlements the waters of the streams are clean and oligotrophic.

Terrain description, material and methods

The Finstertaler and Gurgler streams are situated in the central part of the Austrian Alps, south-west from Innsbruck. Both fall into the stream Ötztaler Ache, which is a main tributary of the river Inn. The Inn is the main tributary of the Danube from Austrian territory. The Finstertaler stream flows in the range of the Stubaier Alps. It dewaters the lake Vorderer Finstertaler See, situated at an altitude of 2237 m above sea level. The stream flows down a rocky gully into a large terrace where at an altitude of 1976 m above sea level it passes by the settlement Kühtai. Then it turns westwards towards the valley Ötztal.

The stream Gurgler Ache rises in a strongly iced part of the Ötztaler Alpen. 5 km below Obergurgl it meets with the Venter Ache to form the big stream Ötztaler Ache, which runs north towards the river Inn.

The main source of the Gurgler stream are the snow and ice fields of the "Gurgler Ferner", but there are many more glaciers in the catchment area of this stream. The Gurgler stream is a typical "Gletscherabfluß" in the sense of KRESSER (1961), with peak discharge in July, and little water during the winter months. It passes the village of Obergurgl at an elevation of about 1950 m a.s.l. Maximum discharge at this point frequently surpasses 10 m^3/sec, but the winter minimum is far below 1 m^3/sec.

In late autumn, winter and early spring the Gurgler stream is fed with water seeping mainly from the moraine under the glaciers. At this time the Gurgler stream is narrow, carries very clear water and flows at a rather constant rate. In summer however it is a foaming water course, with turbid water due to silt, sand and organic debris mainly of glacial origin, with considerable daily fluctuations of discharge, and with a high degree of mobility even of big boulders in its bed. BRETSCHKO (1969) describes both environmental conditions and fauna of this stream and stresses the fundamental differences between the summer and winter situations. The present paper refers to this winter aspect only.

The investigated material was collected three times in the period from November 1970 till March 1971. Thanks to the kindness of Prof. R. Pechlaner, Dr. W. Moser and H. Pfeifer we also got additional material from April and May. The samples were taken at two points in each stream above (station No.1) and below (station No.2) the point of sewage discharge (fig.1, 2). The water temperature at that time was 0,2 – 0,8°C in the Finstertaler stream, and 0,1 – 0,5°C in the Gurgler stream. The material was preserved in a 4 percent solution of formalin. Part of the material was treated with a mixture of sulfuric acid and saturated solution of potassium bichromate in the ratio of 3:1 in order to remove the inner content of diatoms. Afterwards it was washed and centrifuged using distilled water. The cleaned diatom frustules were maintained in distilled water. A fixed preparation of diatoms was embedded in the synthetic resin "pleurax".

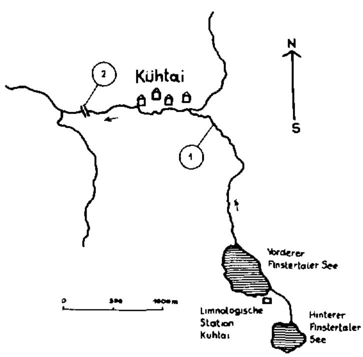

Fig. 1: Localisation of the sampling stations above and below Kühtai (Finstertaler Bach).

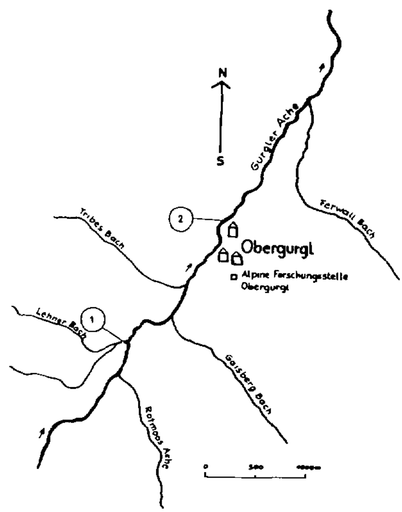

Fig. 2: Sampling stations near Obergurgl (Gurgler Ache).

In quantitative elaboration, the method for diatoms as indicators of water evaluation (STARMACH, 1969 a,b) was applied. The following calculations were used:

The quantity was obtained by counting the specimens of each species in 10 fields of view on 2 microscopic slides under the objektive 40x and ocular 12,5x with a mounted Zeiss net micrometer.

The size was determined by use of a net micrometer, adopting a small square of 100 μ^2 area as a standard unit. The size of the cell was expressed according to how many squares of what part of it it covered. The assimilation area was obtained conventionally by multiplying the size of the cell by two.

The coefficient of coverage or quantity was calculated by multiplying the average size of the specimens by their numbers.

The index of diatom biomass of each station was obtained after adding up the total numbers of quantity of all species.

Table 1 shows the species of diatoms of a higher coefficient of coverage than 5, assuming all other species as accidental (Tab. 2). In calculations of the coefficient of coverage the mean number of the species from 5 samples was given.

Results

Remarks on species

In the examined material 146 species and varieties of diatoms were determined; 127 occurred in the Finstertaler stream and 94 in the Gurgler stream. There were 75 taxons common to both streams. The great majority were forms occuring in single specimens.

In this group of accidental species several forms have been found with cell sizes differing from the average, some of them being narrower, shorter or in general smaller than given in the description of HUSTEDT (1930), PROŠKINA-LAVRENKO (1949/50), SIEMIŃSKA (1964). They suited, however, the diagnosis of species for Sweden and Finland (CLEVE-EULER, 1952-1955). *Cymbella gracilis* (RABH.) CL., fig.6 (33–38,5μ x 5,5 μ, 10–12 striae in 10 μ) and *Pinnularia subcapitata* GREG., fig.18 (22–27,5 μ x 4,5–5 μ, 9-13 striae in 10 μ) had narrower cells. Small cells were observed in *Cymbella Cesatii* (RABH.) GRUN., fig.4 (27,5–41,8 μ x 5,5 μ, 18–20 striae in 10 μ). *Nitzschia Hantzschiana* RABH., fig.17 (16,5–35 μ x 3,3–4,4 μ, 9 keelpunctae in 10 μ, about 25 striae in 10 μ) had short cells. In that case the length of cells was also in agreement with the description of PROŠKINA-LAVRENKO (1949/50). Departures from the size of cells of some species of diatoms were observed in forms originating from the streams of the High Tatra and the Rila Mountains (KAWECKA, 1971, 1974).

The taxa encountered in the examined material are classified according to HUSTEDT (1942), KRASSKE (1932, 1949) and SIEMIŃSKA (1964) as belonging to the boreo-montan type. A great majority of them were also encountered in the High Tatra and in the Rila Mts. in Bulgaria (KAWECKA, 1965, 1971, 1974). These were: *Anomoeoneis exilis* (KÜTZ.) CL. (fig.3), *Cymbella hebridica* (GREG.) GRUN. (fig.5), *Eunotia bigibba* KÜTZ. (fig.8), *E.triodon* EHR. (fig.11), *E.robusta* RALFS var. *tetraodon* (EHR.) RALFS., (fig.10), *Melosira distans* (EHR.) KÜTZ. var. *alpigena* GRUN. (fig.12), *Pinnularia lata* (BRÉB.) W.SM. (fig.19). Some of the observed forms belong to the rare species (SIEMIŃSKA, 1964), such as:

Navicula densestriata HUST. (fig.13): 15,4–19,9 μ x 4,5–5 μ, in the middle of the cell about 25 striae in 10 μ, and in a lower part they are so numerous and fine that they cannot be distinguished.

Navicula levanderi HUST. var. *tatrensis* BILÝ et MARVAN (fig.14): 25,3–36,3 μ x 5,5 μ,20–24 striae in 10 μ.

Other interesting forms were:

Cymbella imitans GUTW. var. *striator* KALBE (fig.7), 16,5 μ x 4,4 μ, striae 16 in 10 μ. This was reported for the first time in the Slovak Tatra Mts. (KALBE, 1963).

Eunotia diodon forma? (fig.9), 18,7 μ–28,7 μ x 6,6–7,7 μ, striae 12 in 10 μ. The similar specimens were found in Rila Mts. and in the Tatra Mts. (KAWECKA, 1971, 1974).

Nitzschia communis RABH. var. *hyalina* LUND (fig.16): 18,75–19,8 μx 3,3–4,4μ, 14–15 striae in 10 μ. It was found in the soil environment (LUND, 1946).

FIG. 3-19

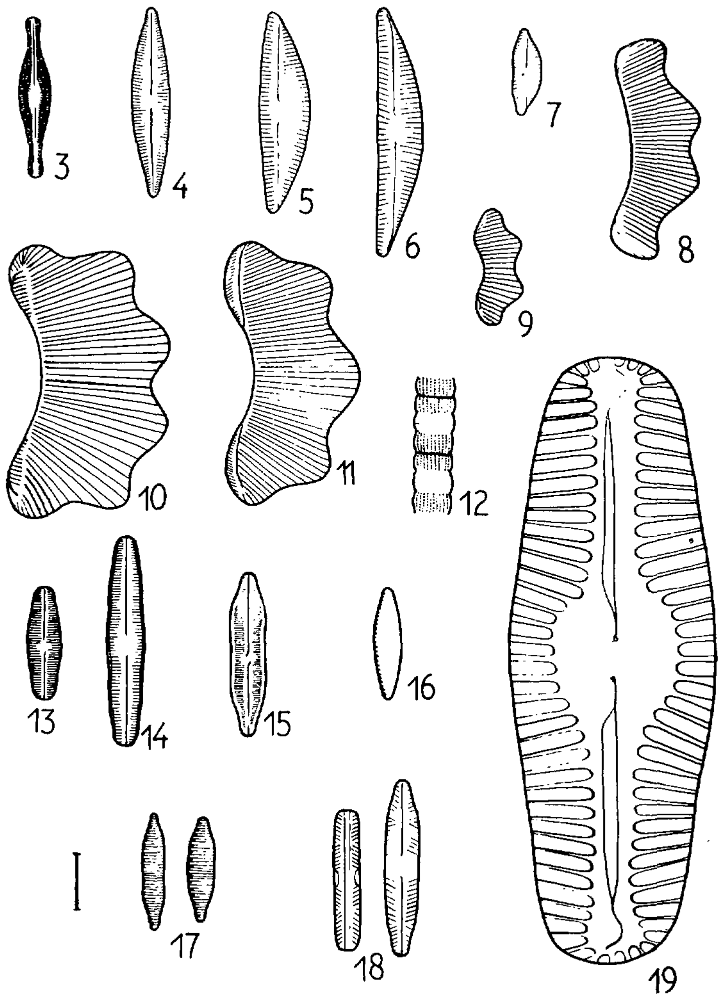

Fig. 3 - 19: Fig. 3: *Anomoeoneis exilis* (Kütz.) Cl. - Fig. 4: *Cymbella Cesatii* (Rabh.) Grun. - Fig. 5: *Cymbella hebridica* (Greg.) Grun. - Fig. 6: *Cymbella gracilis* (Rabh.) Cl. - Fig. 7: *Cymbella imitans* Gutw. var.*striatior* Kalbe - Fig. 8: *Eunotia bigibba* Kütz. Fig. 9: *Eunotia diodon* forma ? - Fig. 10: *Eunotia robusta* Ralfs var. *tetraodon* (Ehr.) Ralfs - Fig. 11: *Eunotia triodon* Ehr. - Fig. 12: *Melosira distans* (Ehr.) Kütz. var. *alpigena* Grun. - Fig. 13: *Navicula densestriata* Hust. - Fig. 14: *Navicula levanderi* Hust. var. *tatrensis* Bily et Marvan - Fig. 15: *Neidium affine* (Ehr.) Cl. var. *longiceps* (Greg.) Cl. - Fig. 16: *Nitzschia communis* Rabh. var. *hyalina* Lund - Fig. 17: *Nitzschia Hantzschiana* Rabh. - Fig. 18: *Pinnularis subcapitata* Greg. - Fig. 19: *Pinnularia lata* (Breb.) W. Sm.

Diatom communities

Finstertaler streams

The diatom community of the clean part of the Finstertaler stream was characterized during the whole period of investigation by a great variety of species. A relatively low index of the diatom biomass at a simultanously great differentiation of taxonomic units indicated this fact. Prelevant in the community were: *Ceratoneis arcus, Achnanthes minutissima* with the variety *cryptocephala, Diatoma hiemale, Tabellaria flocculosa, Eunotia pectinalis, Synedra rumpens.* The community did not show any larger quantitative variations in our period of observations (tab. 1, fig. 20A).

Under the influence of organic matter the number of *Achnanthes minutissima* with the variety *cryptocephala, Tabellaria flocculosa, Eunotia pectinalis* and *Synedra rumpens* decreased. On the other hand there developed numerously: *Cymbella ventricosa, Ceratoneis arcus, Diatoma hiemale* with the variety *mesodon, Fragilaria capucina,* which caused a continuous increase of the biomass index. A mass development of *Cymbella ventricosa* took place additionally with the increase of pollution, and this caused the peak of the biomass index in March. Simultaneously, the number of taxonomic units in the community decreased during the quantitative development of particular species (tabl. 1, fig. 20A).

Gurgler streams

The unpolluted part of the Gurgler stream was characterized by the scarcity of diatom species and individuals. Cells of *Ceratoneis arcus, Cymbella ventricosa, Gomphonema angustatum, Diatoma hiemale* with the variety *mesodon* were mostly encountered (tabl. 1, fig. 20B).

In the part of the stream charged with sewage the situation changed entirely. Initially (November) a quantitative increase of *Cymbella ventricosa* and *Gomphonema angustatum* with the variety *productum, Navicula cryptocephala, Pinnularia mesolepta* was observed. In consequence the index of diatom biomass increased about ten times in comparison with the unpolluted environment and reached the maximum state.

At that time the highest number of taxonomic units was also recorded. At a further increase of pollution the index of diatom biomass was rapidly reduced because the numbers of the majority of the above mentioned species of diatom decreased. Only *Cymbella ventricosa* developed well, and in January it was entirely dominant in the environment. In the phase of culmination of the sewage effect in the end of February it decreased in number. At the same time the number of species in the community decreased permanently. The raised water level in April and May caused the destruction of diatom communities in both streams (tab. 1, fig. 20B).

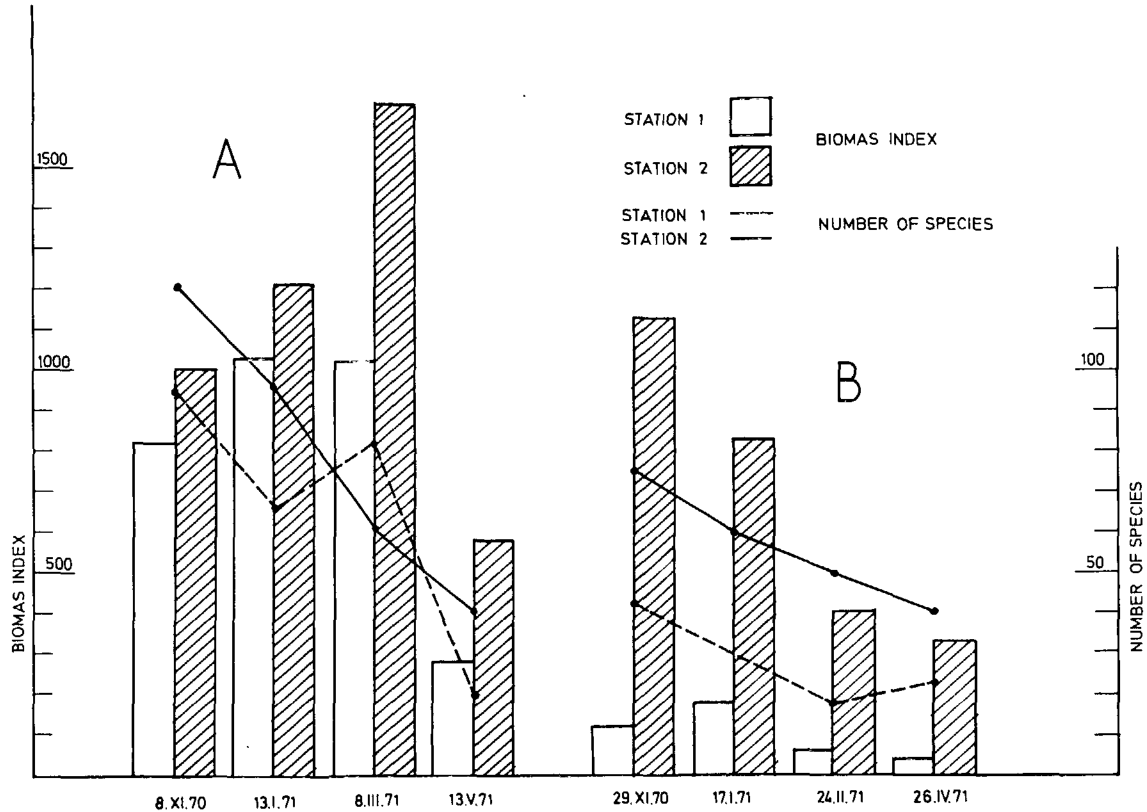

Fig. 20: Changes of diatoms biomas index and of the total number of species in a stream before (Station 1) and after pollution with organic material: A = Finstertaler Bach; B = Gurgler Ache.

Discussion

Similar investigations were carried out in the High Tatra Mts. The effect of domestic sewage escaping from the tourist house at "Morskie Oko" on the biocenosis of the Rybi Potok stream was examined (BOMBOWNA, 1973, KAWECKA, STARZECKA, 1974). Comparing the results of investigations much analogy is observed in the development of the communities of algae. In the case of the Finstertaler and the Rybi Potok streams, both being lake outflows, analogous diatom communities corresponding to the determined developmental conditions were found.

In the clean environment above the point of sewage inflow (Rybi Potok: pH 6,6 – 7, temperature of water 4 – 12,4° C; Finstertaler stream: pH 6,4 – 6,5, water temperature 0,2 – 0,8° C) *Tabellaria flocculosa* and *Achnanthes minutissima* were common for the two streams, attaining very great numbers, and disappearing below the point of sewage discharge. *Achnanthes minutissima* reappeared in the cleaned part of the stream, but *Tabellaria flocculosa* did not. *Tabellaria flocculosa* reached greater numbers in Rybi Potok than in Finstertaler stream, for *Achnanthes minutissima* the reverse was observed.

According to CHOLNOCKY (1968) *Tabellaria flocculosa* is an acidiphilous species, finding optimum conditions at about pH 5, whereas *Achnanthes minutissima* prefers well oxygenated and slightly alkaline waters (CHOLNOCKY, 1968, VENKATESWARLU, 1970, BESCH et al. 1972).

In the presence of small amounts of organic matter in the Finstertaler stream at the beginning of winter, and in Rybi Potok about 500 m below the discharge of sewage (content of $N\text{-}NH_4$ about 0,1 mg/l, $P\text{-}PO_4$ about 0,01 mg/l, pH 7 – 7,8, water temperature 4 – 12,7° C), the number of heterotrophic bacteria (proteolitic, aminoficative and denitrificating forms) was of the order $10^2 - 10^3$) another group of algae developed: *Cymbella ventricosa, Fragilaria capucina, Diatoma hiemale* with the variety *mesodon, Ceratoneis arcus.* Moreover in all the examined streams an increase of differentiation of forms in the community was observed.

Fragilaria capucina found optimal conditions at pH 7,4 – 7,8, *Ceratoneis arcus* probably at pH 7,2 – 7,3, and *Diatoma hiemale* at pH below 7 (CHOLNOCKY, 1968). Moreover, *Diatoma hiemale* is regarded by many authors as an indicator for oligosaprobic waters and its variety *mesodon* for xenosaprobic waters.

At a great cumulation of organic matter in all the examined streams a reduction of organisms took place, *Cymbella ventricosa* remaining the dominating form. In Rybi Potok *Nitzschia palea* developed simultaneously. The general relationship between the quantity of species and the number of taxonomic units in a community under the effect of such an extreme factor (complex of factors) as the sewage inflow, was largely confirmed. This type of community occurred in the Alpine streams in February and March, and in Rybi Potok immediately below the point of sewage discharge at a high content of $N\text{-}NH_4$ (0,7 mg/l) and $P\text{-}PO_4$ (0,15 mg/l), pH 6,6 – 6,9 and counts of all bacteria examined being of the order of $10^5 - 10^6$.

A mass development of *Cymbella ventricosa* was evidently correlated with the decomposition of the organic matter in the community. EICHENBERGER (1967) found experimentally that maximum development of this species took place in winter when *Cladophora* died and in spring when colonial agglomeration of diatoms disappeared.

According to CHOLNOCKY (1968) the optimum development of this species takes place at pH 7,7 - 7,8; it stands, however, great variations of water reaction and is a species characteristic of acidic waters. *Nitzschia palea* is known to be positively correlated with high contents of organic matter in the environment. According to CHOLNOCKY (1968) this species stands great variations of pH from 4,3 to 8,65, its optimum development being observed at pH 8,4. In the Alpine streams the moment of mass development was not recorded. VENTZ (1964) stated that this species develops when the organic matter undergoes oxygenic decomposition.

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Summary

The development of diatom communities during the winter 1970/71 in the alpine Austrian streams Finstertaler Bach and Gurgler Ache, polluted with domestic sewage from the winter sport centres at Obergurgl and Kühtai, has been studied. In the unpolluted environment of the Finstertaler stream the species *Tabellaria flocculosa, Achnanthes minutissima, Ceratoneis arcus, Diatoma hiemale* were dominating, whereas in the Gurgler stream the community was very evenly developed.

Sewage input caused drastic changes in the structure of diatom communities. In the presence of a small dose of sewage in both streams *Cymbella ventricosa*, in the Finstertaler stream besides this *Fragilaria capucina, Diatoma hiemale, Ceratoneis arcus*, and in the Gurgler stream *Gomphonema angustatum, Navicula cryptocephala, Pinnularia mesolepta* were developed.

At a high degree of pollution *Cymbella ventricosa* was developed in mass, simultaneously the total number of species in the respective communities decreased.

The development of diatom communities along the stream Rybi Potok (High Tatra Mts.) polluted with domestic sewage flowing from the tourist house at "Morskie Oko" proceeded in a similar manner.

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Tab. 1: The diatom communities in the streams Finstertaler Bach and Gurgler Ache.

COEFICIENT OF COVERAGE: • 5-10; •• 10-20; ••• 20-50; •••• 50-100; ••••• 100-200; •••••• 200-400; •••••••• 400-700; ••••••••• 700-1000

STREAM	FINSTERTALER								GURGLER							
STATION	1				2				1				2			
DATA OF SAMPLING	8 XI	13 I	8 III	13 V	8 XI	13 I	8 III	13 V	29 XI	17 I	24 II	26 V	29 XI	17 I	24 II	26 IV
Achnanthes minutissima Kütz. / A. minutissima Kütz. var. cryptocephala Grun.	•••••	•••••	••••••	••	••	•••	••	•••						•		
Tabellaria flocculosa (Roth) Kütz.	••••	••••	••••	••	•••	•••	•			••		•	•			
Eunotia pectinalis (Dillw.? Kütz.) Rabh.	••••	•••	•••••	••	•		•									
Synedra rumpens Kütz.	••••	•••••	••••		••	••	•	•								
Gomphonema lanceolatum Ehr. var. insigne (Greg. Cl.)	•••	•••	••••	•••												
Cymbella Cesatii (Rabh.) Grun	•	•	•••													
Synedra minuscula Grun.	••	••••	•••		•••	•••	•••									
Anomoeoneis exilis (Kütz.) Cl.			••													
Amphora ovalis Kütz		••														
Fragilaria crotonensis Kitt.	•															
Eunotia praerupta Ehr.	•	••	••				••									
Navicula Rotaena (Rabh.) Grun.		•	•		•	•	•	•								
Cymbella sinuata Greg.					•	•	•									
Synedra ulna (Nitzsch) Ehr.								••								
Navicula cryptocephala Kütz. var intermedia Grun.			•											•		
Fragilaria capucina Desm.	•••		•••		•••••	•••••	•••									
Diatoma hiemale (Lyngb.) Heib.	•••••	•••••	••••	•••••	•••	•••••	•••••	••••	•	••	•	•	••	•••	••	
D. hiemale (Lyngb.) Heib. var. mesodon (Ehr.) Grun.	•••	•••	••	••••	••••	•••••	•••••			••	•	•	•	•••	•	
Cymbella ventricosa Kütz.	•••	•••	•••		••••••	••••••	•••••••••	••••••	•••	•••	••	••	••••••••	•••••••••	••••••	••••••
Ceratoneis arcus (Ehr.) Kütz.	••••••	••••••	••••	••••	••••••	••••••	••••••	•••••	•••	••••	•••	•	•••	•••	••••	••
Gomphonema angustatum (Kütz) Rabh.	••	••	••	••				••	••	••			••••••			
G. angustatus (Kütz.) Rabh. var. productum Grun.													••••			
Navicula cryptocephala Kütz.													••••			
Pinnularia mesolepta (Ehr.) W. Sm.													••••			
Nitzschia palea (Kütz.) W. Sm.														•••	•	
Achnanthes lanceolata (Breb.) Grun.													•••			
Pinnularia subcapitata Greg.													•••			
Nitzschia communis Rabh. var. hyalina Lund													•••			
Gomphonema intricatum Kütz. var. pumilum Grun.															•••	
Stauroneis phoenicentron Ehr.										•••			•			
Nitzschia Hantzschiana Rabh.											••					
Navicula pelliculosa (Breb.) Kütz.													•			

Tab. 2: Accidental species. Those occuring in Finstertaler stream are marked by *, species from Gurgler stream are marked by ● and the rest is common for both streams:

Achnanthes lanceolata (Breb.) Grun., * *A. lanceolata* (Breb.) Grun. var. *capitata* O. Müll., * A. lanceolata (Breb.) Grun. var. *rostrata* (ϕ str.) Hust., *A. lanceolata* (Breb.) Grun. var. *ventricosa* Hust., *A. lapidosa* Krasske, *A. lapponica* Hust., ● *Amphora ovalis* Kütz., ● *Anomoeoneis exilis* (Kütz.) Cl., * *A. serians* (Breb.) Cl., *A. serians* (Breb.) Cl. var. *brachysira* (Breb.) Hust., * *A. serians* (Breb.) Cl. var. *brachysira* (Breb.) Hust f. *thermalis* (Grun.) Hust., * *Caloneis silicula* (Ehr.) Cl. *Ceratoneis arcus* (Ehr.) Kütz. var. *amphioxys* (Rabh.) Grun., * *Cocconeis pediculus* Ehr., * *C. placentula* Ehr., ● *C. placentula* Ehr. var. *euglypta* (Ehr.) Cl., * *C. placentula* Ehr. var. *klinoraphis* Geitl., * *Cymbella aegualis* W. Sm., *C. affinis* Kütz., * *C. aspera* (Ehr.) Cl., ● *C. Cesatii* (Rabh.) Grun., ● *C. cuspidata* Kütz., *C. cymbiformis* (Ag. ? Kütz.) V. H., * *C. gracilis* (Rabh.) Cl. , * *C. hebridica* (greg.) Grun., * *C. helvetica* Kütz., * *C. imitans* Gutw. var. *striatior* Kalbe, *C. lanceolata* (Ehr.) V. H., * *C. microcephala* Grun., *C. naviculiformis* Auersw., * *C. perpusilla* Cl., ● *C. sinuata* Greg., * *C. turgida* (Greg.) Cl., *Denticula tenuis* Kütz. var. *crassula* (Näg.) Hust., *Diatoma anceps* (Ehr.) Kirch., ● *D. elongatum* (Lyngb.) Ag. var. *tenue* (Ag.) V. H., *D. vulgare* Bory., * *Epithemia zebra* (Ehr.) Kütz., * *Eunotia arcus* Ehr., * *E. bigibba* Kütz., * *E. biggiba* Kütz. var. *pumila* Grun., *E. diodon* Ehr., * *diodon* forma ? , *E. exigua* (Breb.) Rabh., * *E. lunaris* (Ehr.) Grun., ● *E. pectinalis* (Dillw. ? Kütz.) Rabh., *E. pectinalis* (Dillw. ? Kütz.) Rabh. var *minor* (Kütz.) Rabh., * *E. polydentula* Brun. var. *perpusilla* Grun., * *E. polyglyphis* Grun., ● *E. praerupta* Ehr., var. *muscicola* Petersen, *E. robusta* Ralfs var. *tetraodon* (Ehr.) Ralfs, * *E. triodon* Ehr., ● *Fragilaria capucina* Desm., *F. construens* (Ehr.) Grun., * *F. construens* (Ehr.) Grun. var. *binodis* (Ehr.) Grun., ● *F. crotonensis* Kitt., * *F. leptostauron* (Ehr.) Hust., * *F. pinnata* Ehr., *F. pinnata* (Ehr.) Hust. var. *lancettula* (Schum.) Hust., * *Frustulia rhomboides* (Ehr.) De Toni, *F. rhomboides* (Ehr.) De Toni var. *saxonica* (Rabh.) De Toni, * *F. rhomboides* (Ehr.) De Toni var. *saxonica* (Rabh.) De Toni f. *undulata* Hust., *F. vulgaris* (Thw.) De Toni, ● *Gomphonema acuminatum* Ahr. var. *coronatum* (Ehr.) W. Sm., * *G. angustatum* (Kütz.) Rabh. var. *productum* Grun., * *G. constrictum* Ehr., *G. gracile* Ehr., * *G. intricatum* Kütz. var. *pumilum* Grun., ● *G. lanceolatum* Ehr. var. *insigne* (Greg.) Cl., ● *G. longiceps* Ehr., * *G. longiceps* Ehr. var. *mintanum* (Schum.) Cl., * *G. olivaceum* (Lyngb.) Kütz., *G. parvulum* (Kütz.) Grun., * *G. parvulum* (Kütz.) Grun. var. *micropus* (Kütz.) Cl., *Hantzschia amphioxys* (Ehr.) Grun., *M. distans* (Ehr.) Kütz. var. *alpigena* Grun., * *Melosira islandica* O. Mull. var. *helvetica* O. Mull., * *M. italica* (Ehr.) Kütz. subsp. *subarctica* O. Mull., * *M. Roseana* Rabh. *Meridion circulare* Ag., *M. circulare* Ag. var. *constricta* (Ralfs) V. H., *Navicula contenta* Grun., * *N. contenta* Grun. f. *biceps* Arn., * *N. cryptocephala* Kütz., *N. cryptocephala* Kütz. var. *veneta* (Kütz.) Grun., * *N. densestriata* Hust., ● *N. dicephala* (Ehr.) W. Sm., ● *N. gracilis* Ehr., ● *N. graciloides* Mayer, *N. menisculus* Schum., *N. minima* Grun., *N. levanderi* Hust. var. *tatrensis* Bily et Marvan, *N. perpusilla* Grun., * *N. pseudoscutiformis* Hust., *N. pupula* Kütz., * *N. pupula* Kütz. var. *elliptica* Hust., ● *N. Rotaena* (Rabh.) Grun., * *N. scutelloides* W. Sm., ● *N. viridula* Kütz., *Neidium affine* (Ehr.) Cl. *N. affine* (Ehr.) Cl. var. *longiceps* (Greg.) Cl., *N. bisulcatum* Lagerst.) Cl., * *N. dubium* (Ehr.) Cl., *N. iridis* (Ehr.) Cl., ● *Nitzschia acicularis* W. Sm., * *N. amphibia* Grun., *N. dissipata* (Kütz.) Grun., * *N. fonticola* Grun., * *N. Hantzschiana* Rabh., * *N. palea* (Kütz.) W. Sm., *N. sublinearis* Hust., *Pinnularia borealis* Ehr., ● *P. dactylus* Ehr., * *P. episcopalis* Cl., * *P. gibba* Ehr., * *P. interrupta* W. Sm., * *P. mesolepta* (Ehr.) W. Sm., *P. microstauron* (Ehr.) Cl., *P. subcapitata* Greg. var. *Hilseana* (Janisch) O. Mull., *P. viridis* (Nitzsch) Ehr., *P. viridis* (Nitzsch) Ehr. var. *sudetica* (Hilse) Hust., *Stauroneis anceps* Ehr., * *S. phoenicentron* Ehr., *Surirella angustata* Kütz., *S. ovata* Kütz., ● *Synedra minuscula* Grun., ● *S. rumpens* Kütz., ● *S. ulna* (Nitzsch) Ehr.