TOXIC ALGAE IN ERFENIS AND ALLEMANSKRAAL DAMS - 1999

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1. INTRODUCTION

On 6 April 1999 the Water Control Officer at Erfenis Dam (Mr H. Calitz) reported an algal scum in Erfenis Dam. The dam is situated east of Theunissen on the Klein Vet and the Groot Vet Rivers (Figure 1). The impoundment forms part of the Vaal River Catchment. This algal scum was most probably driven into the area by wind action and Mr. Calitz also mentioned that Allemanskraal Dam is experiencing more algae than usual. Bad odours were experienced when the wind blew in the direction of the water control officer's home, close to the dam wall. Mr. Calitz took scum samples at the boathouse and near the dam wall on 1999-03-29 and 1999-04-01.

2. ACTIONS

IWQS personnel did a once off sampling visit on 1999-04-08 to determine whether the algae were toxic. The results of the visit to Erfenis and Allemanskraal Dams are discussed in this report.

3. RESULTS

The results for the two sites in Erfenis Dam are discussed separately from the Allemanskraal Dam results. The results are shown in Tables 1 and 2.

3.1 Erfenis Dam

Mr. Calitz took scum samples at the boathouse and near the dam wall for toxicity tests.

When IWQS visited Erfenis Dam no algal scum could be found, probably due to the fact that a strong wind started blowing on 1999-04-07 and total mixing of the algae onto the water column occurred. Only a small affected area, on the southern bank of the dam, could be found and was sampled for algal toxin. An algal sample, a major inorganic constituent sample and an algal identification sample were taken at two sites. Site 1 is at the dam wall and Site 2 is on the southern bank of the dam (Figure 1). The results are discussed below.

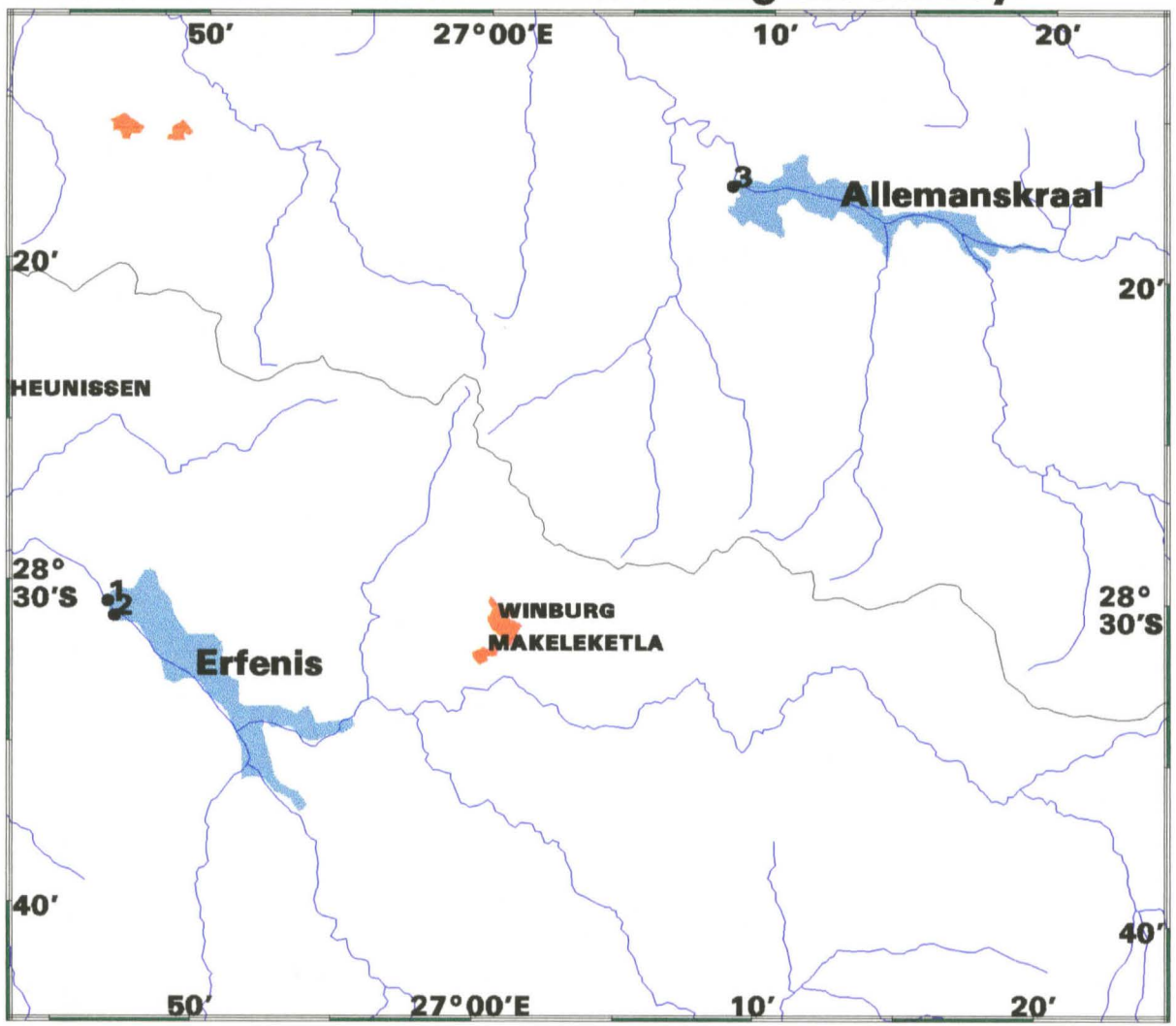
3.1.1 *Toxic Algae*

Toxic algae were implicated in a number of livestock deaths at the Erfenis Dam from April to May 1998. Mr. Calitz, the water Control officer at the Erfenis Dam, was therefore quick to respond to the appearance of algal scum and took scum samples as previously mentioned. The scum taken at the boathouse on 1999-03-29 tested negative for the algal toxin, whereas the samples taken on 1999-04-01 at both the boathouse and at the dam wall were positive for the algal toxin.

The mouse test and the pathological tests done at the toxicology laboratory at Onderstepoort, on the samples at Site 2 in the Erfenis Dam 1999-04-08 were positive for algal toxins. No algal scum was present at Site 1 and, therefore, no toxic algal test was done.

Figure 1.

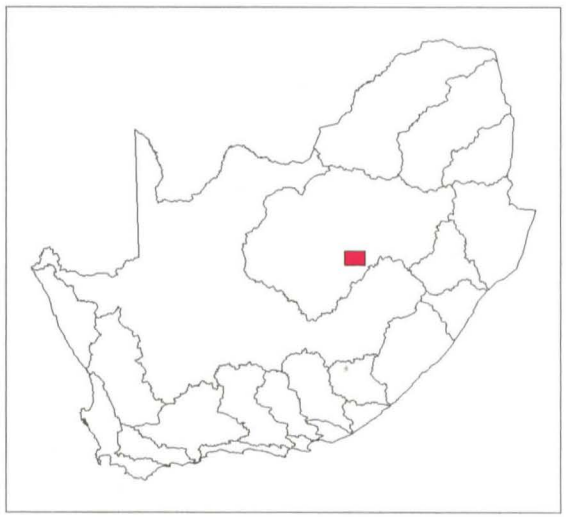
Sampling sites of the Erfenis & Allemanskraal Dams in the Vet & Sandriver catchments during the survey.



LEGEND

- Urban Area
- Dams
- Tertiary Catchments
- Rivers

Location within South Africa



Microcystis and *Anabaena*, algae associated with toxins and odour problems, were present during the sampling exercise at Site 2. *Anabaena* formed 100 % of the algal population in the sample of 1999-04-01 that was taken by Mr. Calitz. The toxicity detected in this sample was, therefore, due to the *Anabaena* specie found.

Table 1. Results at Sites 1 & 2 during the survey at the Erfenis Dam.
AEG = Aquatic Ecosystem Guideline: Target Water Quality Range
AU = Agricultural use: Target Water Quality Range
NG = No Guideline

Variable	AEG	AU	Dam wall Site 1	Southern bank Site 2
Date			1999-04-08	1999-04-08
Time			15:00	10:52
TN:TP ratio	NG	NG	5.4	3.3
Mouse test	NG	NG	No Scum	Positive
Pathology test	NG	NG	No Scum	Positive
pH	NG	6.5-8.4	8.2	9.6
Kjeldahl Nitrogen (mg/l)	NG	NG	0.63	1.28
NH4 (mg/l)	NG	NG	0.03	0.11
NO3 + NO2 (mg/l)	<2.5	110	0.26	0.18
F (mg/l)	≤ 0.75	2	0.3	0.2
Alkalinity as CaCO2 (mg/l)	NG	20-100	84	124
Na (mg/l)	NG	≤70	13	39
Mg (mg/l)	NG	500	7	21
Si (mg/l)	NG	NG	5.4	3.6
Total Phosphorous (mg/l)	0.047 (Walmsley & Butty 1980)	NG	0.166	0.445
PO4 –P (mg/l)	< 0.025	≤0.1	0.086	0.296
SO4 (mg/l)	NG	<1000	14	66
Cl (mg/l)	NG	100	8	73
K (mg/l)	NG	NG	4.6	6.7
Ca (mg/l)	NG	1000	16	42
EC (mS/m)	NG		21.7	59.7
TDS (mg/l)	NG	≤40	167	399
Chlorophyll *a* (µg/l)	15 µg/l	NG	<1	8.85
Anabaena presence (%)	NG	6 colonies/5ml	0	Present
Microcystis presence (%)	NG	6 colonies/5ml	0	Present

3.1.2 *Nutrients*

Kjeldahl nitrogen concentrations were between 0.63 and 1.28 mg/l. This is within acceptable levels. The available nitrogen in the form of NO_3 and NO_2 is low and varies between 0.26 and 0.18 mg/l.

Total phosphorous concentrations varied between 0.166 and 0.445 mg/l. These concentrations classify the Erfenis Dam as a hyper-eutrophic system. The available phosphorous (PO_4-P), 0.086 & 0.296 mg/l, respectively, is also above the Target Water Quality Range (TWQR) of the Aquatic Ecosystem Guideline (AEG) of 0.025 mg/l (DWAF, 1996a) and above the TWQR for Agricultural Use (DWAF, 1996b) of ≤0.1mg/l at Site 2.

The TN:TP ratio varies between 3.3 and 5.4. This is indicative of a hyper-eutrophic system and shows that

To Note!! ?
TN:TP = (∑ Kjeldahl nitrogen and NO3 + NO2)/TP

the system might be nitrogen limited. The high phosphorous concentrations and acceptable nitrogen concentrations might indicate that phosphorous is present in over abundance and that although nitrogen seem to limit the algal growth in the Erfenis Dam it is necessary to control the high influx of phosphorous into the system.

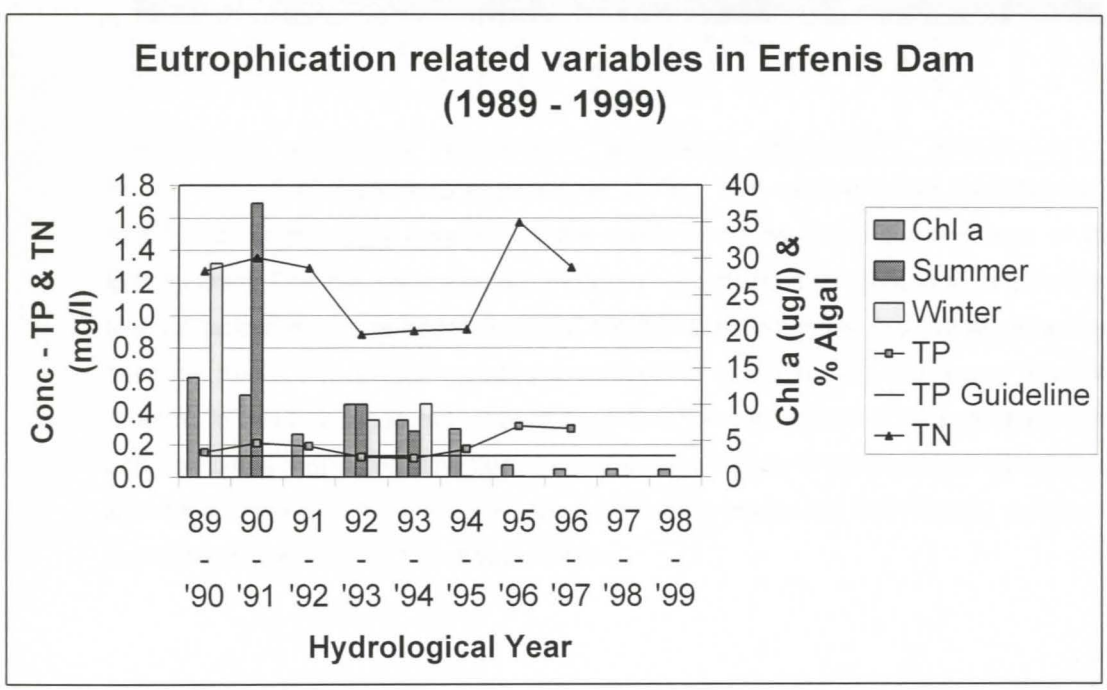
3.1.2 *Physical variables*

The historical pH values for the dam varied between a minimum of 7.1 and a maximum of 8.9. The system is thus alkaline. The pH measured during the survey varied between 8.2 (Site 1) and 9.6 (Site 2). The site where toxic algae occurred has therefore a much higher pH than is usually found in the Erfenis Dam. This is probably due to the photosynthetic utilisation of CO_2, which tends to reduce CO_2 content and to increase pH (Wetzel, 1983).

3.1.3 *Historical limnology of Erfenis Dam*

The Erfenis Dam was one of the impoundments included in the initial Trophic Status Project of the IWQS. Historical information is, therefore, available for Erfenis Dam and is discussed briefly within this section.

Figure 2. Annual means of eutrophication related variables in the Erfenis Dam for the period 1989 to 1999. (Summer = mean summer dominance of Cyanobacteria; winter = winter dominance of Cyanobacteria; TP = total phosphorous; TP Guideline = 0.130 mg/l & TN = total nitrogen)

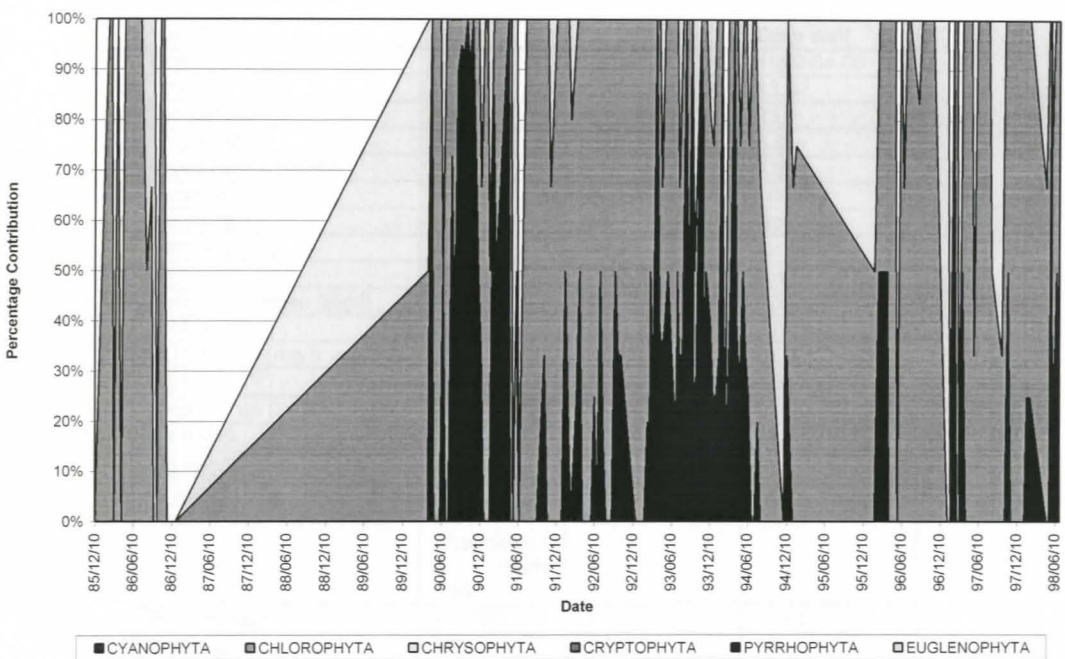


The Erfenis Dam is a turbid, eutrophic system, with a mean Secchi disc depth of 0.2m. The mean chlorophyll *a* concentrations (Fig. 2) do not reflect the eutrophic state of the impoundment due to the fact that light poses a limitation to algal growth.

The influx of nutrients, especially phosphorous, is higher than the acceptable concentration for the phosphorous management objective, which is maintaining mean total phosphorous concentrations in reservoirs at 130 µg/ℓ P or lower (DWA 1988, ANON 1988a, ANON 1988b). Mean nitrogen concentrations are within acceptable limits throughout the historical period of 1989 to 1999 and limit algal growth in Erfenis Dam.

The origin of the influx of nutrients was not determined. It is most probably due to diffuse sources, since there are only small towns in the catchment of the Erfenis Dam.

Figure 3. The succession of algal groups in Erfenis Dam from 1989 to 1999.



From Figure 3 and previous experiences (1998), it is apparent that Cyanobacteria might pose a threat to livestock in the catchment and close surroundings of the Erfenis Dam. The low mean annual chlorophyll *a* concentrations found in Erfenis Dam are not indicative of a eutrophic system, but this does not imply that the algae will not become toxic. The presence of any noticeable algae during the warm summer months, in this impoundment, should, therefore, be considered to be potentially toxic and be closely monitored. The farmers in the close vicinity of the impoundment should also be warned and if possible livestock should be prevented from having access to the impoundment during the critical months.

3.2 Allemanskraal Dam

When IWQS visited the Allemanskraal Dam, no algal scum could be found. This was also possibly due to the strong wind that started blowing on 1999-04-07, resulting in total mixing of the algae in the water column. Samples were taken at the dam wall.

3.2.1 *Toxic Algae*

No algal scum could be found and, therefore, no toxic algal sample was taken.

The chlorophyll *a* concentration (35.95 µg/l) in the Allemanskraal Dam was indicative of a eutrophic system. *Microcystis* formed 100 percent of the algal population in the sample taken. The potential does, therefore, exist for toxic algae to develop in the Allemanskraal Dam.

Table 2. Results of samples taken at Site 3 in the Allemanskraal Dam.
AEG = Aquatic Ecosystem Guideline: Target Water Quality Range
AU = Agricultural use: Target Water Quality Range
NG = No guideline

Variable	AEG		Dam wall
Date			1999-04-08
Time			13:32
Temperature (°C)	NG	NG	23.1
TN:TP ratio	NG	NG	6.8
Dissolved O_2 (mg/l)	NG	6-9	8.8
Dissolved O_2 (%)	NG	NG	103.5
Mouse test	NG	NG	No scum
Pathology test	NG	NG	No scum
pH	NG	6.5-8.4	8.4
Kjeldahl Nitrogen (mg/l)	NG	NG	1.23
NH4 (mg/l)	NG	NG	0.04
NO3 + NO2 (mg/l)	2.5	110	0.04
F (mg/l)	≤ 0.75	2	0.3
Alkalinity as $CaCO_3$ (mg/l)	NG	20-100	93
Na (mg/l)	NG	≤70	18
Mg (mg/l)	NG	500	6
Si (mg/l)	NG	NG	5.1
Total Phosphorous (mg/l)	0.047 (Walmsley & Butty 1980)	NG	0.186
PO_4 –P (mg/l)	< 0.025	≤0.1	0.068
SO_4 (mg/l)	NG	<1000	15
Cl (mg/l)	NG	100	9
K (mg/l)	NG	NG	4.7
Ca (mg/l)	NG	1000	16
EC (mS/m)	NG	NG	23.1
TDS (mg/l)	NG	≤40	182
Chlorophyll *a* (µg/l)	NG	NG	35.95
Microcystis presence (%)	NG	6 colonies/5ml	100

3.2.2 *Nutrients*

Kjeldahl nitrogen concentration was 1.23 mg/l and the available nitrogen in the form of NO_3 and NO_2 was <0.04 mg/l. This is within the TWQR for the Aquatic Ecosystem Guideline (AEG) (DWAF, 1996a).

Total phosphorous concentration was 0.186 mg/l. The available phosphorous (PO_4-P) concentration was 0.068 mg/l. This is above the TWQR for the AEG of 0.025 mg/l (DWAF, 1996a), but is within the TWQR for Agricultural Use (DWAF, 1996b).

The TN:TP ratio was 6.8. This indicates that Allemanskraal Dam is eutrophic and nitrogen limited.

3.2.3 *Physical variables*

The surface temperature at this site was 23.1°C and the sub-surface dissolved oxygen concentration was 8.8 mg/l.

The pH was 8.4 and the Allemanskraal Dam is, therefore, alkaline.

3.2.3 *Inorganic chemical constituents*

None of the inorganic chemical constituents were present in noticeably high concentrations.

3.1.3 *Historical limnology of the Allemanskraal Dam*

The Allemanskraal Dam was also included in the initial Trophic Status Project of IWQS. The historical data for the impoundment can, therefore, be used to compare the present results.

Figure 4. Annual means of eutrophication related variables in Allemanskraal Dam for the period 1989 to 1999. (Summer = mean summer dominance of Cyanobacteria; winter = winter dominance of Cyanobacteria; TP = total phosphorous; TP Guideline = 0.130 mg/l & TN = total nitrogen)

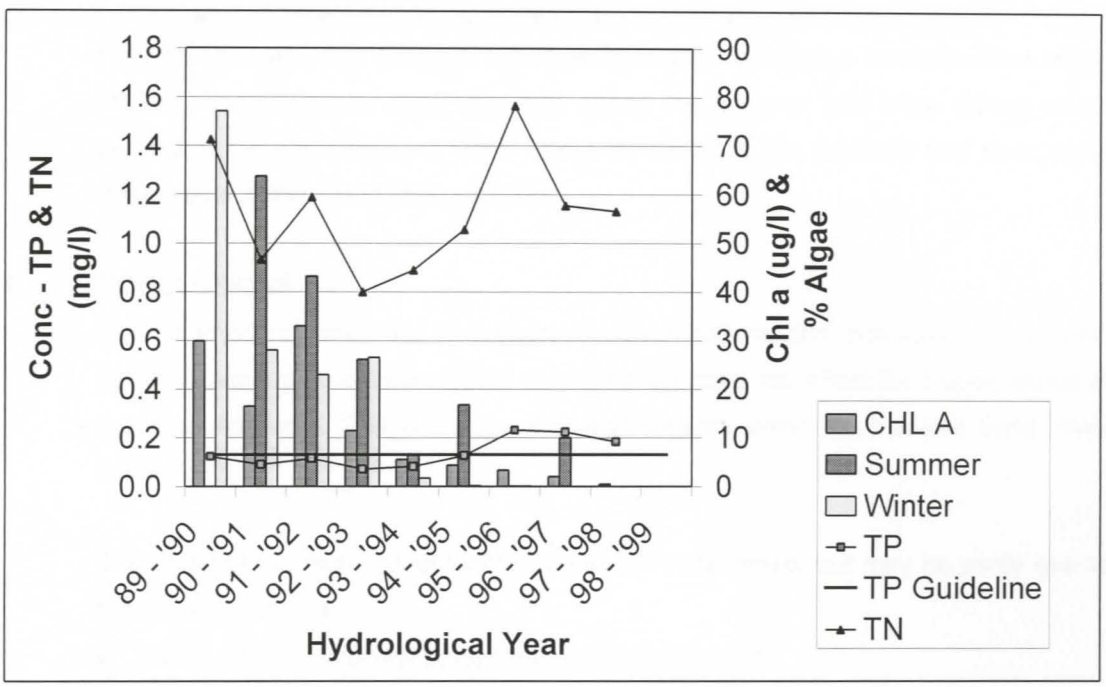


Figure 4 indicates that mean chlorophyll *a* concentrations were higher than 15µg/l with corresponding high dominance of Cyanobacteria during both summer and winter periods. During this period, both nitrogen and phosphorous concentrations were within acceptable limits. There is a distinct increase in the internal phosphorous concentrations during 1995/1996 that might be the result of higher than normal summer rainfall amounts. The same phenomenon occurred in Erfenis Dam during the same period. The phosphorous concentration during the survey was also above the 0.130mg/l level.

Allemanskraal Dam is, therefore, a eutrophic system, but also due to light limitation caused by turbidity (Mean Secchi reading of 0.2m), the mean annual chlorophyll *a* values do not always reflect the trophic status of the system.

Figure 5. The succession of algal groups in Allemanskraal Dam from 1989 to 1999

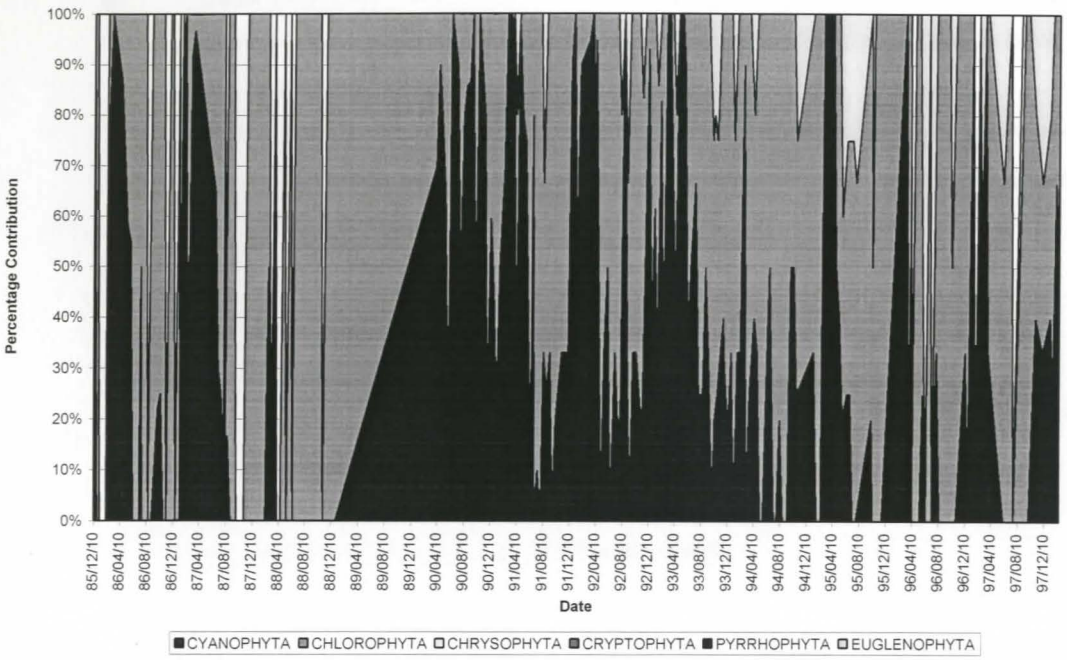


Figure 5 indicates that although the mean annual chlorophyll *a* concentrations might be low, Cyanobacteria occur regularly during the summer and often during winter periods in the Allemanskraal Dam. There is, therefore, the potential that toxic algae might occur in the Allemanskraal Dam.

4. CONCLUSIONS

In both impoundments the phosphorous concentrations are indicative of eutrophic systems, although the chlorophyll *a* concentration does not reflect the trophic status of the impoundments. This is the result of high turbidity within the Vet and Sand River catchments.

The origin of the high nutrient influxes was not determined, but may be partly due to the following factors:

- Wash off from informal settlements in the catchment.
- Nutrient rich effluent from the Water Care Works (WCW) of the small towns in the catchment.
- Excessive use of agricultural fertilisers in the catchment and consequent wash-off during the summer rainfall period
- Natural ground water origin.

In the Erfenis Dam, the presence of the Cyanobacteria, *Anabaena* seems to have been responsible for the positive toxic algal tests. In the Allemanskraal Dam the

dominant algal species was *Microcystis*, which indicates a potential for toxic algae to occur.

5. RECOMMENDATIONS

a) Determine the nutrient contributors in the Vet and the Sand River catchments.

b) Manage the catchment to decrease phosphorous loads into the Erfenis and the Allemanskraal dams.

c) The Water Control Officers at the Erfenis and the Allemanskraal dams should initiate a mechanism to warn livestock farmers as soon as algal biomass is noticed in the impoundments.

6. ACKNOWLEDGEMENTS

- Mr. Calitz for his quick response to the development of algae in the Erfenis Dam and for his help during the sampling trip.
- Kotie Erasmus for producing the cover page.
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