REPORT OF THE ALGAE ODOUR CONTROL WORKING GROUP

DEPARTMENT OF CONSERVATION AND ENVIRONMENT
Western Australia

FOREWORD

The community enjoys the scenic vistas and wildlife associated with lakes and wetlands.

Often, however, factors such as mosquitoes and midges may reduce such enjoyment.

The same can be true of odours. The Department of Conservation and Environment therefore convened a multidisciplinary group to assess algal-odour factors associated with wetlands in the Perth metropolitan area.

This report serves as a baseline study against which specific odour complaints about wetlands can be assessed, accurately and scientifically as well as by their effects on the community.

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PREFACE

This report is a synopsis of the activities of the Algae Odour Control Working Group which was established following reports and complaints of pesticide-like odours which emanated from certain fresh-water lakes in the Perth metropolitan area.

The Working Group set out to:

1. Characterise the pesticide-like odours and relate them to a source;
2. Determine factors related to the production of the odours, in an attempt to find means to prognosticate the onset of the odours;
3. Suggest possible remedial methods, bearing in mind the ecology of the lakes.

The time limit set for the study was 12 months. In that period certain physical and chemical attributes in three lakes in the Perth metropolitan area were studied by the Group and attempts were made to relate these factors to the productivity and species composition of planktonic algae in the lakes. The Group established that the pesticide-like odours emanated from heavy water-blooms of certain species of blue-green algae.

The Working Group recognised that algae water blooms (and subsequent odour) problems were manifestations of the effects of a number of pressures, related to urban development, on the unconfined ground water systems of the Swan Coastal Plain.
It therefore recommended that studies into the taxonomy, physiology and ecology of aquatic life (plants, animals and micro-organisms) be undertaken under some multi-disciplinary authority set up to study and/or advise on ground water resources of the Swan Coastal Plain.

T.E.H. Aplin
CHAIRMAN

REPORT OF THE ALGAE ODOUR CONTROL WORKING GROUP

SUMMARY

Pesticide-like odours emanating from some metropolitan lakes were attributed to water-blooms of certain species of blue green algae.

The relationship between any of several factors that were measured and the appearance of a water-bloom could not be demonstrated in a study that was conducted.

Several remedial methods for overcoming the odour problem were suggested. They involved the prevention of the control of algal water-blooms.

The problems associated with algal water blooms are, in all probability, manifestations of the degrading effects of urban development pressures on the unconfined ground water systems of the Swan Coastal Plain. Thus, any long term solution to these problems must lie in scientifically based management programmes for these wetland resources.

INTRODUCTION

In September 1974, the Department of Public Health was made aware of odours, resembling those of pesticides of the mixed isomers of benzene hexachloride type, which emanated from certain lakes in and adjacent to the City of Melville.

These pesticide-like odours were attributed to water-blooms of certain species of blue-green algae which developed in certain lakes at the time the odours were apparent.

There is to date, inadequate information to give precise recommendations for the control of odours or other nuisance physical factors in lakes.

Following a meeting of representatives of the Department of Public Health, Department of Conservation and Environment, Department of Agriculture and the City of Melville a technical working group was convened by the Department of Conservation and Environment, in November 1974, to commence a study into the control of pesticide-like odours attributable to algae.

The Working Group comprised the following members:

Mr. T.E.H. Aplin (Chairman)	Department of Agriculture
Mr. N. Orr	Department of Conservation and Environment
Mr. G.A. Pearce	Department of Agriculture
Mr. J. Goodsell	Department of Fisheries and Wildlife
Mr. N. Platell	Government Chemical Laboratories
Mr. K.R. Partridge	Metropolitan Water Supply Board
Mr. A. Van Leeuwen	City of Perth
Mr. L.H. Wills	City of Melville
Mr. J.M. Jeffery	City of Melville
Mr. A.J. Smith	City of Melville
Mr. B.A. Carbon	CSIRO Division of Land Resources Management
Mrs. J. Harris	Minute Secretary, City of Melville

The ready help and advice given to the Group by the following persons during the course of its study is gratefully acknowledged:

Dr. A.D. Allen	Department of Mines
Dr. P. Wycherley	Director, Kings Park & Botanic Gardens
Mrs. G. Fash	Minute Secretary, City of Melville

The contributions made in the preparation of this report by Messrs. Platell and Partridge are acknowledged with gratitude. Also acknowledged with gratitude is the helpful advice given by Dr. J.W. Green, Department of Agriculture, in the presentation of the report.

OBJECTIVES

The Working Group sought:

1. To characterise certain pesticide-like odours attributable to algae;
2. To determine factors related to the production of these odours, in order to prognosticate the onset of the odours; and
3. To suggest possible remedial methods to overcome the odours, bearing in mind the ecology of the aquatic environment.

METHODS

The Working Group sought to characterise the odours by conducting a survey amongst householders within the City of Melville, at a time when the odours were apparent.

To determine the relevant factors related to the production of the odours, the Working Group set out to measure algal populations and a number of physical and chemical attributes of the water in three lakes in the metropolitan area.

Blue Gum Lake and Booragoon Lake, in the City of Melville, were selected because, besides the initial involvement of the City of Melville, the former was known to develop water-blooms; the latter was selected because it did not develop water-blooms. The third lake that was selected for study was Lake Monger, in the City of Perth. This lake had, in the past, a history of water-blooms but, in more recent years, had apparently been free of this phenomenon.

Blue Gum and Booragoon as they are known today were originally heavily overgrown swamps which dried up periodically. With the raising of the water-table through urban development the vegetation fringing Blue Gum was killed off. At the present time there is very little natural vegetation around the lake.

Booragoon is still almost in its natural state and is surrounded by a narrow fringe of native vegetation. The level in both lakes is artificially maintained by controlling discharge volumes to drains.

Monger has been disturbed by man's activities and is now virtually surrounded by parks and playing fields with little of the original native vegetation now remaining. The water level in this lake is also artificially maintained.

The time limit for the study was set at 12 months. During this period it was hoped to monitor any trends or changes in physical and chemical parameters in the three lakes, in relation to the productivity and species composition of algae. Sampling was undertaken at one monthly intervals with additional samples being taken when an algal water-bloom developed. It was not the intention of the Working Group to study the through-flow or the seepage of chemicals and nutrients into the lakes but it was thought that by including samples of water collected from each lake close to the shore-line at equally spaced intervals some understanding of nutrient flow would have been obtained.

Five sites were chosen at each lake and these were based on an assumed even shallow depth profile throughout.

Surface and depth samples, taken 0.1 metres below the surface and above the bottom respectively were collected from the middle of each lake. Because of the lack of specific detail regarding underground water flow, other sites were spread evenly around the edges of each lake. Surface samples only were collected from these sites for analyses. Blue Gum sample sites were located at:

Middle of the lake
Northern end - 15 metres from edge of water,
Southern end - 15 metres from edge of water,
Eastern bank - 15 metres from edge of water, and
Western bank - 7 metres from edge of water.

Booragoon sample sites were located at:

Middle of the lake
North east end - 3 metres from edge of thicket,
South east end - 3 metres from edge of thicket,
North west end - 3 metres from edge of thicket, and
South west end - 3 metres from edge of thicket.

Monger sample sites were located at:

Middle of the lake
North corner - 10 metres from water's edge,
South bank - 10 metres from water's edge,
North east bank - 10 metres from water's edge, and
South west corner - 10 metres from water's edge.

The samples were collected monthly.

Physical measurements and chemical analyses initially undertaken included depth, temperature, pH, colour, total salts, chloride, potassium, phosphorus (total and "in solution"), nitrogen (ammonia & nitrate), dissolved oxygen and biochemical oxygen demand. After several months as indicated in Figures 1 & 2 additional tests for algal identification and counts, chlorophyll

A and orthophosphate phosphorus were undertaken. These were determined by methods outlined in "Standard Methods for the Examination of Water and Waste water - 13th Edition 1971 - APHA AWWA WPCF". Where samples needed filtration for the determination of a particular component, the sample was filtered within 24 hours through a 0.45 micron membrane. All analyses for those components whose levels could alter during storage were carried out within 24 hours. This eliminated the need to add preservatives. All containers used for sampling were made of glass. Biochemical oxygen demands were initiated at the lake site. Algal counts were done on unconcentrated samples using a Sedgwick-Ralter cell at 100x magnification.

All analyses, other than algal counts and identification, were carried out by the Government Chemical Laboratories. Algal counts and identifications were performed by the Metropolitan Water Board.

The Working Group took the opportunity of looking at other bodies of water such as Bibra Lake, Lake Yangebup and Peel Inlet, when these developed algal water-blooms with pesticide-like odours.

RESULTS

The results presented in Table 1 are for algal identifications and counts. Where counts did not exceed 200 per ml for a particular species the results were not recorded.

The results presented in Figures 1 and 2 are for the surface and depth samples from the middle of each of the three lakes. There was little or no variation between the results for surface and depth samples. This was not unexpected in view of the shallow nature of all lakes. The results from the close to shore sites are not included in this report. They were collected in February, March and April and again in July, but in no instances were their results significantly at variance with the results of samples taken from the centre of the lakes. Regular sampling of close to shore sites was therefore discontinued in August.

In Figures 1 and 2 the phosphorus levels for Booragoon are on a different scale to the other two lakes. All other reported levels are on the same scale.

On the days selected for sampling there was no noticeable pesticide-like odour at any of the lakes, but a very mild swampy odour was often noticed.

Only once during the study period was there a significant odour noticed at any of the three lakes in the study. This occurred on November 20, 1975 at Blue Gum, but it was so mild that there were no complaints received by the City of Melville from the neighbouring householders. The odour could not be detected at distances greater than 100 metres from the north shoreline where a scum, about 0.5 metres wide and 30 metres long, had formed. A sample of the scum in the water was collected for analysis, the results of which are detailed hereunder:

i) Physical Characteristics

The appearance of the scum was that of a thick green mass of floating algae, which made up about 20 per cent by volume of the water. The odour of the contained algal sample was very strong, earthy-musty with clear overtones of the characteristic odour of mixed isomers of benzene hexachloride.

ii) Odour Strength

The analyses for odour strength was performed after six days storage at $5^{\circ}C$. The results showed that the threshold odour number (APHA at $40^{\circ}C$) was 2000.

iii) Algal Counts

These were mainly *Anabaena* and *Anacystis* and gave the following counts:

Anabaena

filaments/ml	86 000
mean filament length (microns)	270
mean cell diam. (microns)	5.4
cells per filament	50

Anacystis

colonies/ml	3 200
mean colony diam. (microns)	100
mean cell diam. (microns)	4.6
cells per colony (assume sphere with cells at 7 micron centres)	1 500

Total cells/ml

Anabaena	4.3×10^6
Anacystis	4.9×10^6
	9.2×10^6

iv) Chemical Parameters

	mg/l
Suspended solids	1 200
Chlorophyll A	3.0
Pesticides (B.H.C. and other organo chloro)	less than 0.00002

During the period of study, water-blooms containing *Anacystis* and *Anabaena* were recorded in Bibra Lake (11 November, 1975) and Lake Yangebup (December, 1975). Both of these recorded water-blooms produced odours of the benzene hexachloride type. A water-bloom of *Nodularia* at Peel Inlet (December, 1974) was also recorded.

DISCUSSION

As there were no complaints of odours from householders in the study areas or any unusual odours detected by the sampler during the selected days of sampling, the Group decided that it would be inappropriate to conduct the proposed survey amongst residents to characterise the odour as they would have no recent experience of the problem.

It was observed that the strength of the odour of the Blue Gum algae sample increased with the degree of breakdown of cells. No attempt was made to quantify the odour with this breakdown and despite its high threshold odour number the small body of affected water did not impart sufficient odour to be detected at a distance 100 metres down wind of the occurrence. Thus, to assess the extent of an odour problem at a lake it would be desirable to assess the threshold odour number at the in situ temperature, in preference to the standard of $40^{o}C$, and then make an adjustment based on the volume or surface of the water affected by the water-bloom.

The above observation is not at variance with a similar observation at Bibra Lake where the algal species were predominantly _Anacystis_ and _Anabaena_ and where the odour persisted for several days. About one month later a similar phenomenon was recorded at Lake Yangebup and an odour in Peel Inlet in late 1974 was attributed to a water-bloom of _Nodularia_. The first two genera of algae have been reported to produce pesticide-like odours in N.S.W. All three have previously been recorded in the water-bloom stage in Western Australia.

The results of algal counts applied only to the surface samples. Algal counts were commenced in both surface and depth samples. However, because the algal species were the same and as numbers were significantly lower in the depth samples, subsequent determinations were confined to the surface samples only. The blue-green algae, _Anabaena_ and _Anacystis_, known to be responsible for benzene hexachloride type odours (1) have been detected at measurable levels only in Blue Gum. This lake was the only one of the three lakes under observation where hearsay had indicated that such odours had occurred in recent years. A reasonable correlation between algal counts and chlorophyll A levels was established as indicated in the values recorded in Table 1 and Figures 1 & 2.

Despite natural winter runoff (rainfall approx. 0.9 metres) and high evaporative rates in summer (annual evaporation approximately 2 metres) there was very little fluctuation in <u>depth</u> recorded in three lakes. This uniformity of depth was apparently due to natural and controlled drainage.

The <u>temperature</u> cycle varied from 12^{o}C in winter to 27^{o}C in summer. The temperatures between May and September could have been considered less favourable for the growth of algae but this was not supported by algal counts or chlorophyll A levels, at Blue Gum and Monger.

Blue Gum and Monger showed high <u>pH</u> values in summer and lower values in winter; Booragoon, where weed and algal growth were almost completely lacking, showed lower values than Blue Gum and Monger.

The <u>colour</u> of the water at Booragoon which is the most intense of the three lakes studied is not readily reduced by bacterial oxidation as indicated by its low biochemical oxygen demand. The ample supply of major nutrients such as carbon, nitrogen and phosphorus and the almost complete lack of algal growth in Booragoon suggests that there could be some interference with the availability of trace nutrients. N.B. The <u>chloride</u> level in all three lakes was higher in late summer.

The <u>total salts</u> content within the lakes ranged from 250 to 900 mg/l. Rainfall runoff probably caused the lower salinity values in winter and evaporation the higher values in summer.

The ratio of potassium to chloride (K/Cl) in all three lakes was approximately twice that of sea water and natural surface streams close to the Perth metropolitan area.

Analyses for chlorophyll A commenced in May. This method showed a close correlation between total algae population and chlorophyll A levels (see Table 1).

At Booragoon, despite artificial jet spray aeration, the dissolved oxygen levels did not exceed 50 per cent saturation. This was in keeping with the steady low pH values - whereas at Blue Gum, which also had artificial jet spray aeration, dissolved oxygen levels at the surface were more than 50 per cent saturated.

At Monger, dissolved oxygen levels were nearly always at saturation or higher, the level in March being almost 200 per cent saturated.

The consistently low biochemical oxygen demand (5 day B.O.D.) at Booragoon was probably due to the lack of easily decomposable organic matter such as weeds, algae and the excreta of water fowl.

B.O.D. values at Blue Gum and Monger were somewhat higher in the summer months and this was probably due to the restriction of drainage and the consistently high water fowl populations in this period in both lakes.

The values of nitrogen, N-total, include all the dissolved nitrogen plus that in the insoluble particulate material such as algae. There was a significant drop in total nitrogen levels in all lakes during the winter months which could not be accounted for by dilution. The total nitrogen level in Blue Gum was significantly higher than that in the other two lakes.

Booragoon and Monger had lengthy periods when the ammonia nitrogen levels ranged between 0.1 and 0.4 mg/l but at Blue Gum the level rarely exceeded 0.1 mg/l. When Blue Gum exceeded 0.1 mg/l its increase was dramatic, such as in February and October.

In Booragoon nitrate nitrogen was frequently at or above 0.1 mg/l but in the other two lakes it exceeded this value only at Blue Gum in November.

There appeared to be a general lowering of total phosphorus levels at all three lakes during winter.

In Booragoon, because of the lack of particulate material most of the total phosphorus was soluble but in the other two lakes the soluble fraction was generally less than 50 per cent of the total.

In Booragoon which had a level of 1.0 mg/l almost all of the total phosphorus was in the orthophosphate form.

The orthophosphate phosphorus level at Blue Gum during winter was low but increased significantly during late spring and summer. In Monger the orthophosphate level remained low until the end of December.

The most noticeable feature of the results was that Booragoon, the least affected by algae, had by far the highest phosphorus level, nearly all of which was in the available orthophosphate form.

Nutrient levels of nitrogen and phosphorus in all lakes are generally adequate to support algal water-blooms. However, for reasons not yet fully understood, only Blue Gum supported an algal bloom which on one occasion developed sufficiently to impart an odour.

SUGGESTED REMEDIAL METHODS

It was assumed that as algae require certain levels of nutrients for growth, the reduction of nutrient levels could reduce algal populations. Nutrient levels may be reduced by the use of lake water to irrigate a vegetation buffer strip around the lake, which can subsequently be harvested, provided fresh water low in nutrients is used to maintain the water level in the lake. This has been implemented in part for Blue Gum by the City of Melville in a planting programme. In this lake, with a total nitrogen and total phosphorus content of approximately 4 mg/l and 0.3 mg/l respectively, in the lake water, and based on an approximate dimension of 100m x 500m x 1m, there are about 200 kg of nitrogen and 15 kg of phosphorus held as nutrients in the body of water. Preliminary analyses indicate much larger reserves of nutrients in the sediments of the lake beds.

The control and maintenance of lake water levels has been suggested as another means of controlling nutrient levels. If the main input of nutrient load occurred during a particular season the lake level could be lowered to a minimum value so that any subsequent input could dilute the concentration of nutrients in the body of water. However, it is likely that the large nutrient reserve in the sediment of the lake beds would readily increase the nutrient level of incoming water to previous levels. For this reason this method of control can not be recommended at this stage.

The lowering of nutrient levels by other means, such as exchange resins, was not considered feasible as a remedial method in view of the high costs involved.

Well aerated water is unlikely to produce nuisance odours such as hydrogen sulphide which is generated under anaerobic conditions and is less likely to allow the release of phosphorus from the bottom sediments of the lake. It was not possible to quantify the effects of aeration on the development of algal water-blooms in Blue Gum and Booragoon where centrifugal pumps had been established prior to the commencement of the study. This was due to the aeration operation being only nominally continuous and the variable heights of the jets. Based on lake dimensions of 500m x 100m x 1m for Blue Gum and a jet spraying rate of 40 000 litres per hour with 50 per cent aeration efficiency and water 50 per cent saturated with oxygen, the dissolved oxygen in the lakes should increase by approximately 0.1 mg/l per day.

Chemical control of algae, for instance by copper sulphate applications, was not recommended because of the possible deleterious effects on other forms of wildlife.

CONCLUSIONS

Pesticide-like odours were shown to be caused by water-blooms of certain blue-green algae. The relationship between the onset of a water-bloom to any of the factors measured could not be demonstrated.

Several remedial methods for overcoming the odour problem were suggested. This was based on the premise that by preventing or controlling algal water-blooms pesticide-like odours would be obviated. The remedial methods had to be consistent with the need to maintain the aquatic environment in a viable state. However in the absence of further relevant data, nearly all of the methods could not be implemented.

No data which was likely to indicate the source and throughflow of nutrients was presented. As a result, no long-term solutions to the algal odour problem was offered.

RECOMMENDATIONS OF THE WORKING GROUP

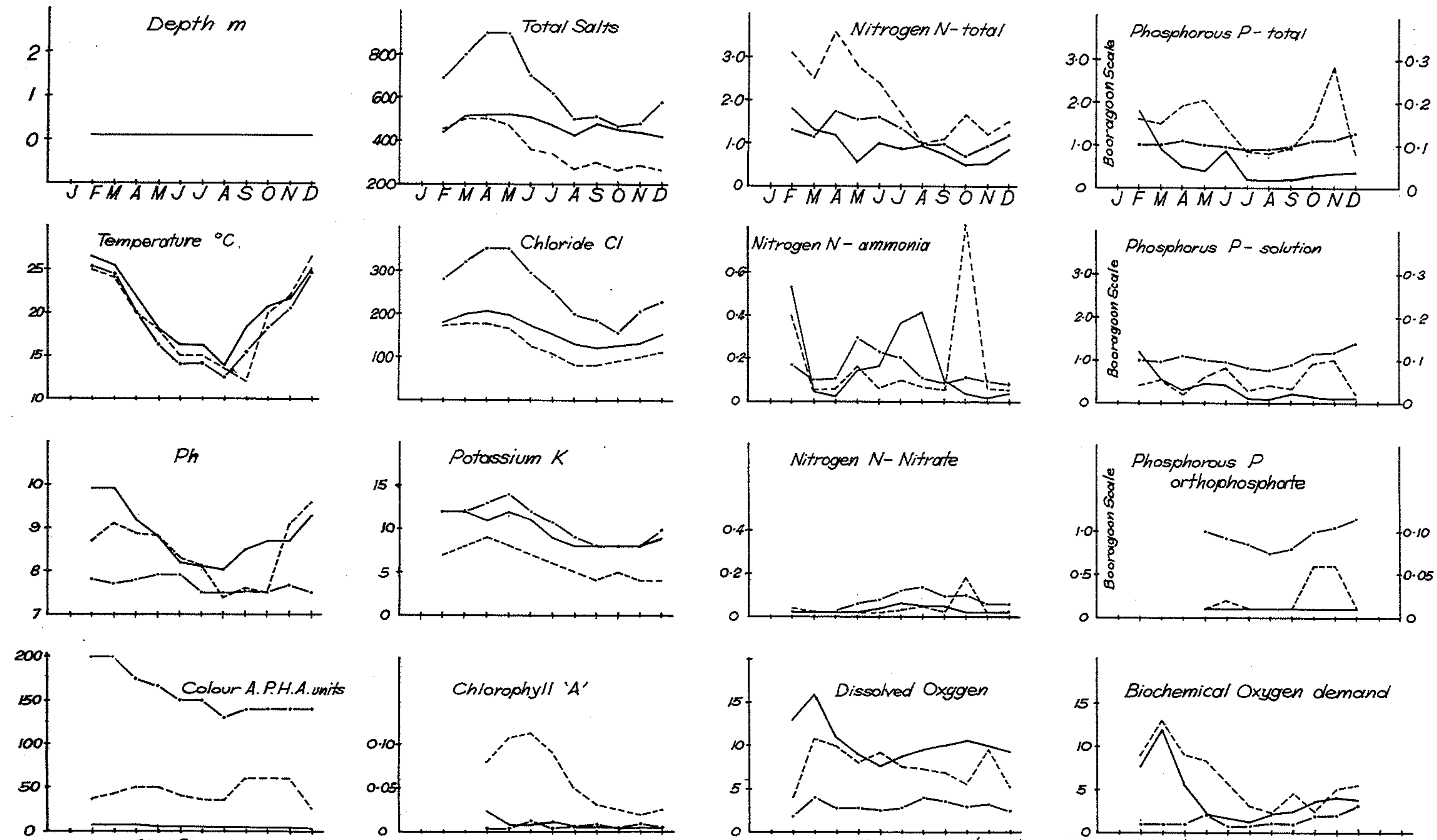
The Working Group recognised that the problems associated with algal water-blooms in the metropolitan lakes were, in all probability, manifestations of the degrading effects of urban development pressures on the unconfined ground water systems of the coastal plain. The Group therefore saw the need to establish a technical study group under the direction of some multi-disciplinary authority set up to study and/or advise on ground water resources of the Swan Coastal Plain.

Part of the function of the technical group would be to undertake studies into the taxonomy, physiology and ecology of aquatic life (plants, animals and micro-organisms), hydrology, water quality, surface runoff, seepage, leaching and through-flow of nutrients. These studies would be an input into the development of management programmes for wetland resources.

Relevant factors to be studied on selected lakes should include solid waste disposal, septic tanks, intensive farming and other potential sources of pollution. Other parameters which could have either a general or a specific influence on the aquatic environment are trace elements, vitamins and other organic compounds, pesticides, oils, greases and surfactants.

REFERENCE:

(1) Aplin, T.E.H. and D.C. Main (1974). Western Australia Department of Agriculture Bulletin No. 3940.



Blue Gum - - - - -
Booragoon -·-·-·-
Monger ———

all units in mg/l - unless otherwise indicated
N.B. Booragoon P scale on left hand side of graph

FIGURE 1 Surface

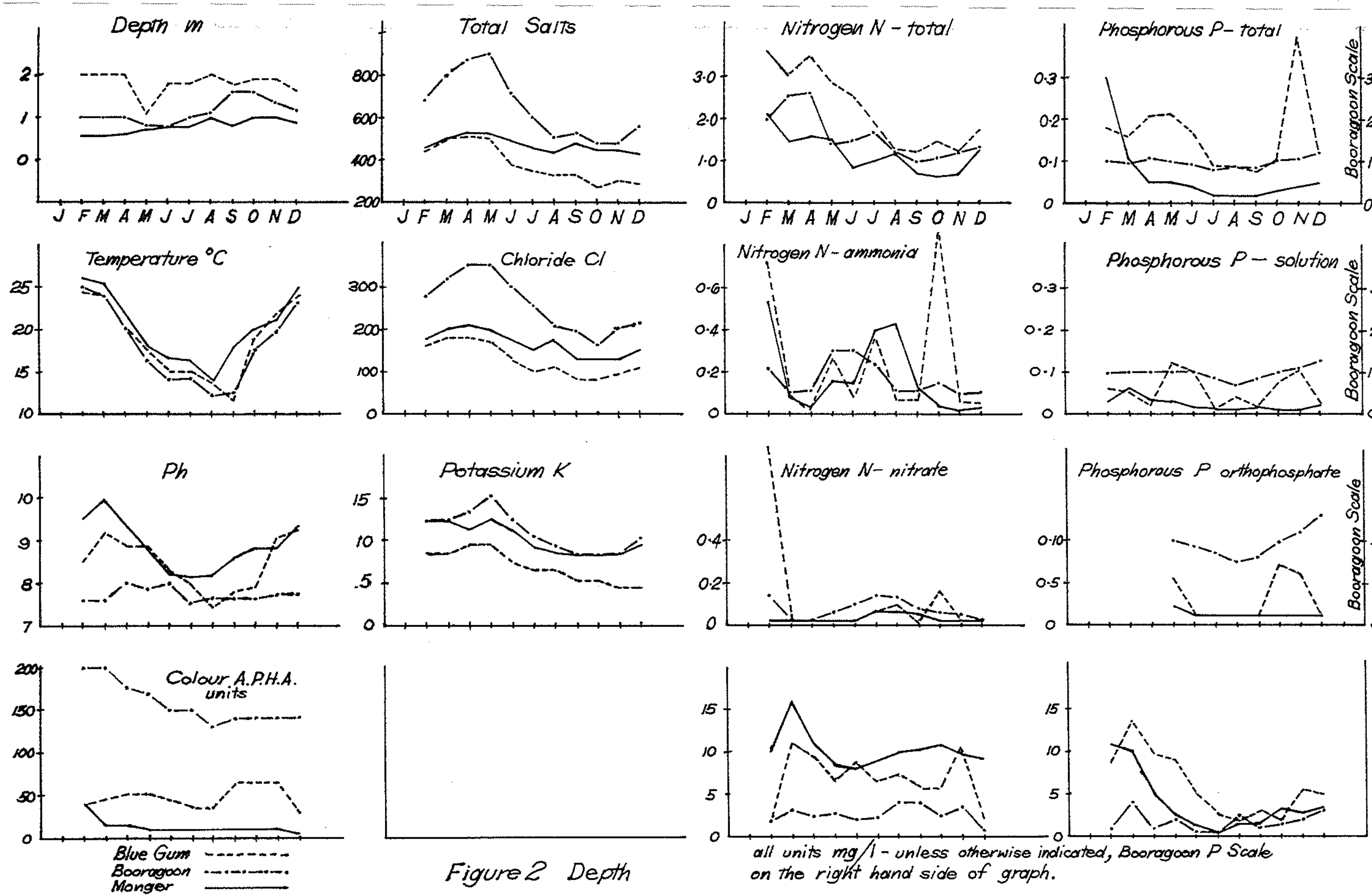


Figure 2 Depth

all units mg/l - unless otherwise indicated, Booragoon P Scale on the right hand side of graph.

TABLE 1

ALGA	BLUE GUM							BOORAGOON							MONGER						
	J	J	A	S	O	N	D	J	J	A	S	O	N	D	J	J	A	S	O	N	D
CHLOROPHYTA																					
1. Schroedaria setigera (cells/ml)																*1100*					
2. S. ancora (Cells/ml)															*300*	*440*					
3. Oocystis (colonies/ml)																	*440*	*4100*	*7500*	*1900*	*560*
4. Ankistrodesmus (cells/ml)			*2200*			*1200*															
CYANOPHYTA																					
5. Anacystic (colonies/ml)	*250*	*2000*	*430*			*480*	*240*														
6. Lyngbia (filaments/ml)	*420000*	*170000*	*780*																		
7. Anabaena (filaments/ml)	*2900*	*3500*	*220*																		
EUGLENOPHYTA																					
8. Euglena (cells/ml)								*450*													