THE EFFECTS OF AMMONIA IN DISCHARGES FROM HOGSMILL STW ON THE WATER QUALITY OF THE RIVER THAMES AT TEDDINGTON

SUMMER 1990 – AN UPDATE

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1. SUMMARY

This report examines the effects of ammonia in discharges from Hogsmill STW on the quality of the River Thames at Teddington for the Summer of 1990. It should be read as an update of the report dated June 1990. The findings of this present investigation reinforce the conclusions made previously, and highlight one or two points indicative of changing trends in effluent quality and the effect of diminished flow.

2. INTRODUCTION

This study is an update of the report dated June 1990 on the effects of ammonia discharged from Hogsmill STW on the River Thames at Teddington, using available data for the summer months of 1990. Several conclusions were made from the previous study, a summary of which are given below:

A. A relationship between the ammonia concentrations in Hogsmill STW final effluent and those in the River Thames was established.

B. The diurnal pattern of ammonia in the effluent was replicated in the River Thames after a time of travel of ammonia.

C. Similarities in loadings of ammonia were found in the effluent and in the River Thames.

D. Elevated ammonia concentrations did not appear to decrease dissolved oxygen levels in the Thames at Teddington. Conversely the duration of sunshine is the influencing factor on diel patterns.

E. Storm sewage discharges from Hogsmill greatly influenced the water quality of the Thames at Teddington, in terms of ammonia concentrations and dissolved oxygen.

F. Poor performance of the STW caused elevated ammonia in the effluent and river and in turn caused elevated levels of unionised ammonia in the Thames above EIFAC threshold recommendations.

The main objective of the present study was to investigate changes in river quality specifically with reference to ammonia levels over the period between June and October 1990, in light of the conclusions summarised above. Any calculations made were carried out as indicated in the previous investigation and data sources were as stipulated therein.

3. RESULTS OF INVESTIGATION

Each month throughout the summer of 1990 was investigated and any changes in water quality were studied.

3.1 June 1990

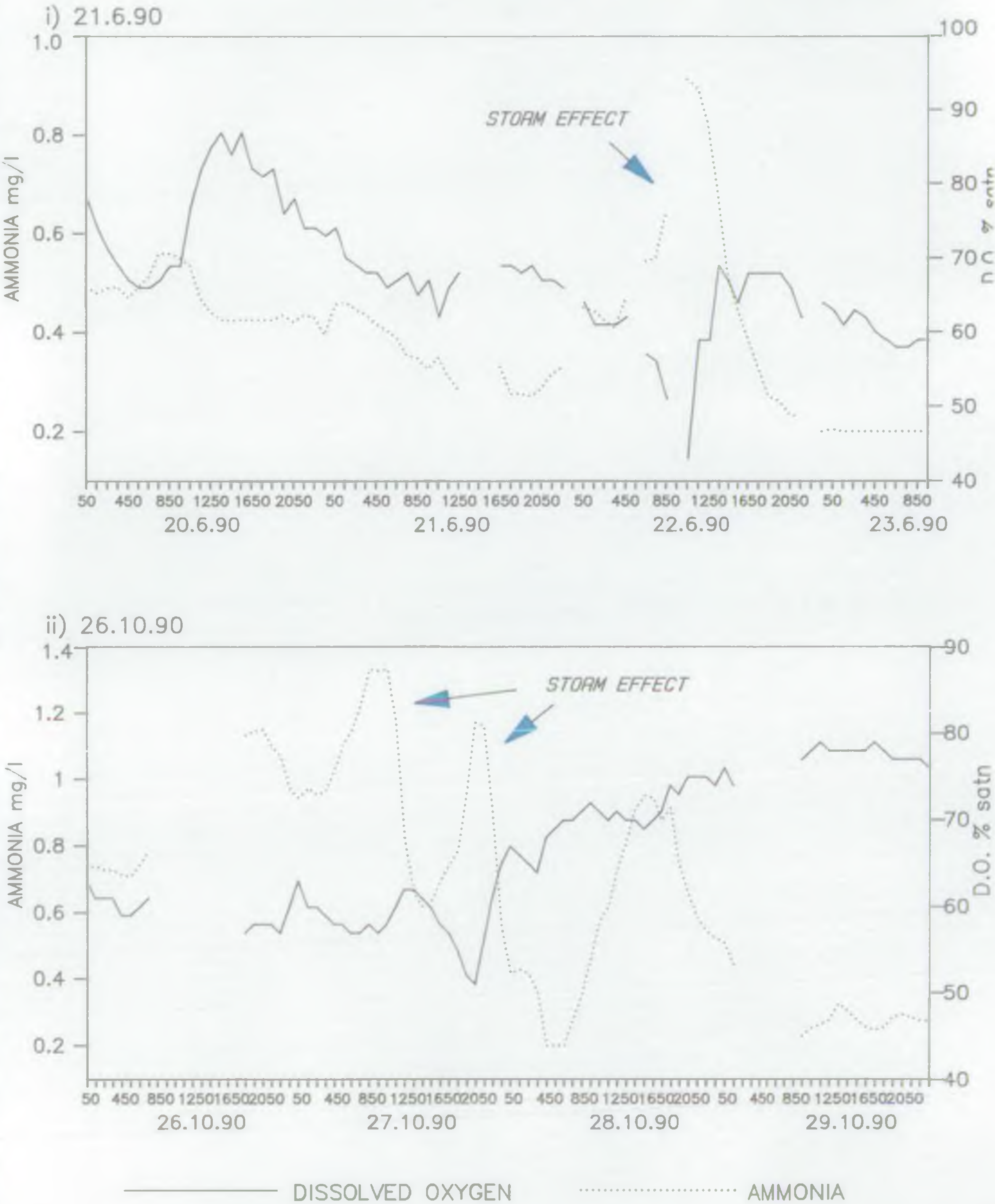
The flows in the River Thames for much of June were some of the highest for the Summer period. Data from the automatic quality monitoring station (AQMS) at Teddington showed dissolved oxygen (D.O.) to be quite elevated in the first two weeks of June due to high levels of sunshine and algal activity. Any decrease or changes in D.O. were as a result of fluctuations in these factors and tended to be demonstrated at other locations in the freshwater Thames, such as at Molesey Weir. After this period D.O. appeared to settle into a diel pattern with peaks between 100-110% and troughs at between 60-70%. Ammonia concentrations in the Thames fluctuated over this period and were found to be dependent on the concentrations and loadings of ammonia in the final effluent of Hogsmill STW. Fig. 5 shows the total ammonia in the effluent, and indicates high concentrations in the first few weeks of June and the influence of these concentrations on the Thames. Loadings as shown in Fig. 4 reflect this.

The concentration of ammonia on the River Thames on the 4th and 5th June increased, (Appendix, Fig.6) peaking above 0.8 mgl^{-1} on the 5th June. The loadings of ammonia from the STW on the 3rd and 4th were greater than 500 kg/d (Fig.4) and calculating the time of travel to be 24.21 and 19.37 hours respectively on these days, the effects would have been seen on the 4th and 5th June, as demonstrated, which shows the effects of elevated levels of ammonia in the effluent.

On the 21st June there was 8.7 mm of rain, with less on 20th, 22nd and 23rd June. The duration of sunshine dropped on the 21st to 3.6 hours and remained below 6 hours until 26th June. The D.O. profile recorded at the AQMS showed a decrease in D.O. saturation on the 21st June and a flattening of D.O. on consecutive days (Fig.7). Storm sewage was discharged from Hogsmill STW with a flow of 9.27 tcmd on the 21st June. Flows in the river were seen to increase between 1620 hours and 1750 hours on the 21st June. The time of travel of storm sewage in the River Thames

FIG. 1

PLOTS OF AMMONIA AND DISSOLVED OXYGEN IN R. THAMES AT TEDDINGTON ON TWO OCCASIONS WHERE STORM SEWAGE DISCHARGED FROM HOGSMILL STW



was calculated to be 18 hours. This would suggest that the first flush of storm sewage would reach Teddington at between 10.20 hours and 1850 hours on the 22nd June. Fig.1, Graph i) indicates that the storm sewage did, in fact, arrive approximately at this time and a peak of ammonia of 0.914 mgl^{-1} was recorded. The D.O. dropped dramatically from 65-70% down to 42%. The first flush of storm sewage will have a high BOD, suspended solids and ammonia concentrations which cause D.O. to decrease. Fig.5 shows the peaks of ammonia in the Thames at this time and Fig.4 indicates the increased loading of ammonia on 22nd June caused by the storm discharge.

From the 23rd June the STW effluent quality improved considerably after requests from the NRA and concentrations and loadings of ammonia at Teddington decreased accordingly (Figs. 4 and 5). D.O. recovered after 25th June and returned to the familiar diel pattern.

3.2 July 1990

For the first half of July loadings from Hogsmill STW increased somewhat compared to the end of June but these increases did not appear to adversely affect the River Thames at Teddington. D.O. levels were fluctuating between 65% and 85% saturation. For the week ending 27th July, diurnal variation in D.O. was maintained with peaks up to 130-140%. Minimum D.O. saturations were in the region of 80-90%. Ammonia levels increased significantly for a period of approximately 24 hours commencing on the afternoon of the 22nd July. The minimum D.O. dropped slightly to 75% on 23rd July. Ammonia profiles supplied by Hogsmill STW indicated that a high effluent peak in ammonia of 15 mgl^{-1} occurred between 2000 and 0200 hours on 21st and 22nd July. The time of travel of this peak has been calculated to be between 24 and 32 hours and therefore a peak would be seen at between 2000 hours on the 22nd and 1000 hours on the 23rd. This is evident in Fig.8. The mean effluent ammonia, as seen in Fig.5 was 13.7 mgl^{-1} on 22nd July, which was the highest for the whole period studied and loadings were correspondly high at 694.18 kg/d (Fig.5). This increase in ammonia loadings from the works has caused the increase in ammonia in the Thames at this time. The flow in the River Thames decreased dramatically from 22nd July (Fig.4) which may have, in part, highlighted the effects of these high loadings from Hogsmill STW. Fig. 4 and 5 show high loadings from Hogsmill on the 17th and 18th July, but these loads did not appear to affect the River Thames so markedly. This may be due to the higher flows in the Thames at this time.

Fig.2 represents plots of ammonia loadings and concentrations in Hogsmill STW final effluent and in the River Thames at Teddington in the last few days of July. The plots for the River Thames show an increase in ammonia concentrations from the latter part of the 28th and 29th July and a greater increase on 30th July. This is also seen in Fig.9. On 28th an input of toxic trade effluent was received by Hogsmill STW which caused temporary loss of nitrification. The effluent ammonia increased above the previous days peaks to a level of 18 mgl^{-1}. The calculated time of travel of this peak is 47 hours and a corresponding peak of ammonia at Teddington with a concentration of 1.267 mgl^{-1} was evident on the 30th July. The ammonia levels in the Thames appeared to increase late on the 28th and throughout the 29th July, and the cause for this gradual increase is uncertain but may be due to slightly elevated diurnal peaks of ammonia in the effluent on the 26/27th July and the marked decrease in river flows from 22nd July over this period (Fig.4). The loadings of ammonia in the River Thames and in the final effluent are also shown in Fig.2. The graph for Hogsmill STW effluent shows the increase in loadings on the 28th July. The plot for the Thames shows loadings for 30th July. The time scale indicates the calculated time of arrival at Teddington of each hourly load of ammonia from the Hogsmill effluent, taking into account the time of flow between Kingston and Teddington. The peaks of loadings coincided, and were of a similar value. Any disparity evident was most likely due to pulses of flow in the Thames from upstream opening of locks, etc. Correlation analysis was undertaken on these values for the whole period plotted and results are shown in Table 1. The correlation coefficient, r, was found to be:

$$r_s = + 0.767$$

The significance of r was tested using correlation coefficient tables (Neave, 1978). The null hypothesis is that $e = 0$ where no significant correlation exists between the two variables; in this case the loadings in Hogsmill STW final effluent and in the River Thames at Teddington. From the tables using n - 2 degrees of freedoms, the tabulated value of r

FIG 2: PLOTS OF AMMONIA LOADINGS AND CONCENTRATIONS IN HOGSMILL STW EFFLUENT AND R. THAMES AT TEDDDINGTON

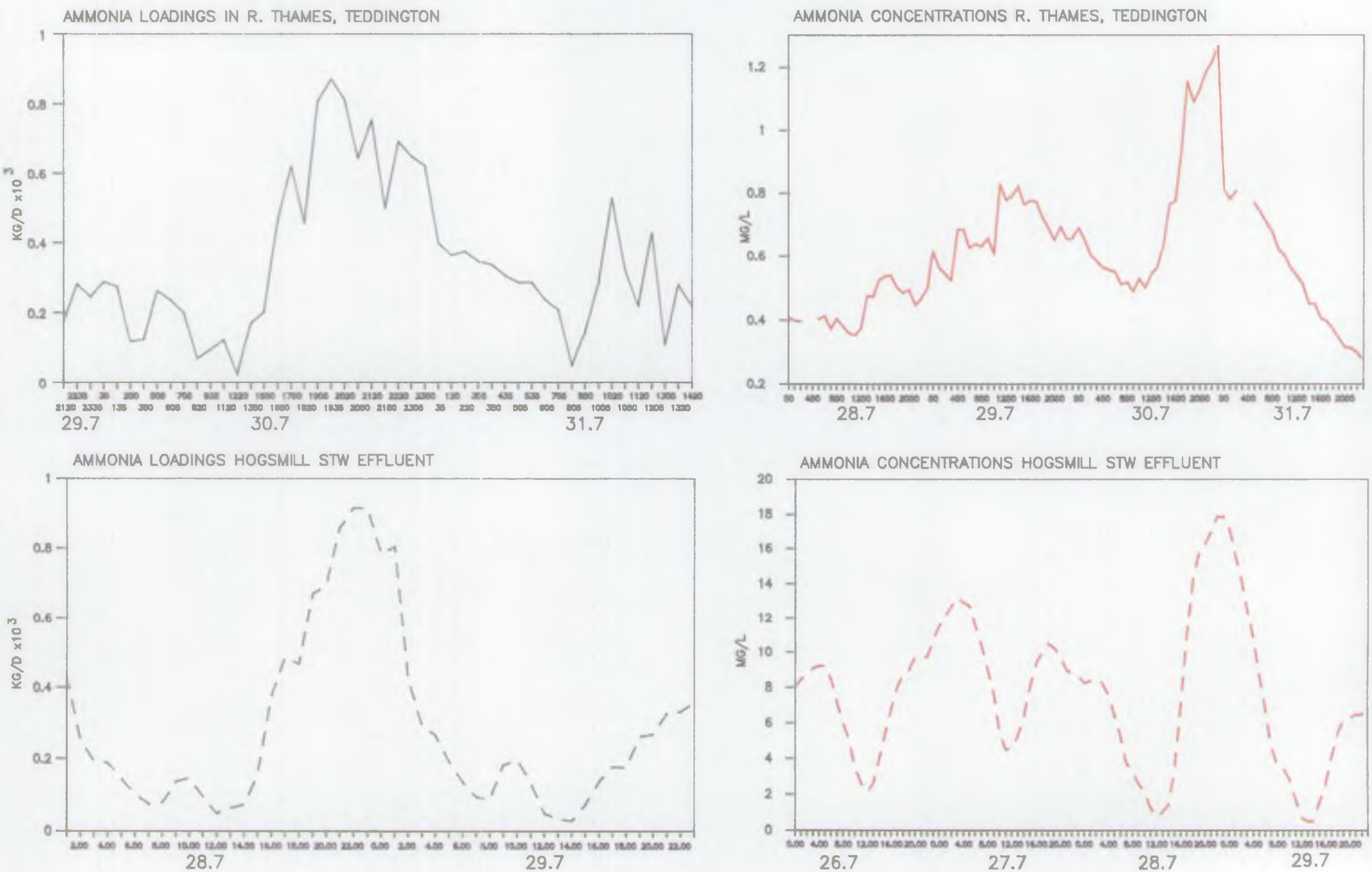


TABLE 1: LOADINGS FROM HOGSMILL STW AND IN R. THAMES, TEDDINGTON

LOADINGS IN FINAL EFFLUENT			LOADINGS IN RIVER THAMES		
DATE	TIME	LOADS (KG/D)	DATE	TIME	LOADS (KG/D)
28.7	0100	431.078	29.7	2120	174.580
	0200	253.368		2235	281.918
	0300	192.456		2335	243.237
	0400	187.758	30.7	0035	286.862
	0500	143.208		0135	274.173
	0600	102.06		0250	114.652
	0700	72.9		0350	120.295
	0800	75.816		0505	261.678
	0900	136.0905		0605	234.523
	1000	145.962		0705	199.042
	1100	94.47		0820	67.038
	1200	46.656		0935	92.822
	1300	62.856		1120	120.446
	1400	71.28		1220	22.895
	1500	155.844		1350	170.131
	1600	374.22		1550	203.442
	1700	484.704		1650	463.544
	1800	465.75		1750	621.229
	1900	673.596		1820	457.143
	2000	694.98		1905	807.617
	2100	859.248		1935	872.869
	2200	915.057		2020	810.346
	2300	915.057		2050	643.493
29.7	0000	782.46		2120	754.728
	0100	804.25		2150	498.995
	0200	424.764		2220	692.466
	0300	291.6		2305	650.757
	0400	264.708		2350	621.345
	0500	192.78	31.7	0035	399.681
	0600	133.65		0120	362.823
	0700	92.34		0220	374.422
	0800	84.564		0305	343.430
	0900	181.454		0350	335.208
	1000	197.478		0435	304.894
	1100	132.258		0505	284.577
	1200	46.656		0535	284.577
	1300	31.428		0605	237.009
	1400	25.92		0705	207.772
	1500	71.928		0805	46.453
	1600	136.08		0850	144.808
	1700	176.256		1005	284.610
	1800	174.15		1020	529.234
	1900	261.954		1050	321.632
	2000	267.3		1120	218.601
	2100	328.536		1205	429.329
	2200	332.748		1305	105.284
	2300	358.344		1320	280.048
MEAN		284	MEAN		346.077
STD DEV		252.383	STD DEV		219.618

CORRELATION COEFFICIENT, r = 0.767

SIGNIFICANCE T TEST, t = 8.018

was found to be 0.288 at $p = 0.05$ (5% level of significance) and 0.372 at $p = 0.01$ (1% level of significance). The value r_s was found to be greater than both these figures and therefore the null hypothesis is rejected, and a significant correlation exists at $p \leqslant 0.01$.

The significance of the relationship was also tested using the students t - test where:

$$t_s = r \sqrt{\frac{n-2}{1-r^2}}$$ with n - 2 degrees of freedom

t_s was calculated to be 8.018. This was then tested using tables and the tabulated value for t with n-2 degrees of freedom (for a two-tailed test) was found to be 3.551 at $p \leqslant 0.001$. Therefore, as $t_s > t$ tabulated, the null hypothesis is rejected and a significant relationship exists. This confirms the significance testing using the correlation coefficient. The coefficient, r, is positive which indicates that as the loadings in the effluent increased, the loadings at Teddington increased correspondingly.

Fig.9 also shows the dissolved oxygen profile over this period. The D.O.% saturation dropped dramatically from 27th July to 31st July, a minimum of 40% being seen on the 29th July, with a diminished diel pattern being evident. The flattening of this pattern, and a decrease in D.O. were also visible at Molesey Weir and in the Rivers Mole and Ember at East Molesey, but were less dramatic. The duration of sunshine dropped from 9.3 hours on the 26th July to 1.0 hour on the 27th. Sunshine hours were also low on the 28th and 30th July which may have suppressed the D.O. over this period. There appeared to be no additional resultant decrease on the 30th July owing to the high ammonia concentrations and it is suggested that sunshine levels were the cause of the decrease. D.O. levels picked up on the 31st July.

3.3 August 1990

From 1st August to 14th August, ammonia concentrations in the Thames (Fig. 4) were at or near baseline. Hogsmill STW discharged improved quality effluent and loadings were fairly low over this time (Figs.4 & 5).

D.O.% saturation at Teddington showed a typical diel pattern, although levels were enhanced due to algal activity, with maxima at approximately 100% and minima at 80%.

On 14th and 15th August the duration of sunshine dropped to 3.5 hours and 0.7 hours respectively. D.O. levels dropped dramatically on 15th August to approximately 60-70%. This reduced level was maintained until 21st August when the diel pattern started to reappear. Although duration of sunshine hours picked up on 16th and 17th, they were reduced again on 18th and 19th to 1.1 and 0.2 hours respectively causing the flattening of the diel pattern to be maintained over this period (fig.10). Several millimetres of rain fell between 15th and 19th August with highest levels of 4.5 mm on 18th, and 13.8 mm on 19th. Ammonia levels increased noticeably in the afternoon and evening of 19th August through to the morning of 20th. Data from Hogsmill STW indicates that storm sewage was discharged on 19th with a flow of 2.35 tcmd. Time of travel on this day was calculated to be 41 hours which would cause the effects of storm sewage in the river at Teddington to be evident on 20th/21st August. It would appear that the effects seen at Teddington were a day earlier than what would be expected from the storm sewage. From fig. 5, it can be seen that the Hogsmill STW effluent concentrations were very low on 18th and 19th August (0.48 and 0.85 mgl^{-1} respectively) when heaviest rainfall was recorded, which can be indicative of storm sewage discharging from the works (cf 22nd June, fig.5), and it might be suggested that some storm sewage was discharged on 18th August. Alternatively, mean daily flows at Kingston have been used to calculate the time of travel which may not reflect sudden flow increases for part of the day when storm sewage may have been discharged.

After 21st August, the D.O levels started to increase, and a diel pattern returned on 23rd August. The diel pattern was maintained up to the 30th August with minima of 70% and maxima of 90-100%. Ammonia concentration returned to at or near baseline levels up to the afternoon of 30th August. On this day the ammonia levels dramatically increased to an incongruous peak (fig.11). On investigation the monitoring station equipment (measuring ammonia) was found to be faulty and had caused this large increase.

Fig.11 shows the ammonia concentrations and D.O.% saturation for the week ending 4th September. As aforementioned, the ammonia peak on 30th August was due to a system fault, but that seen in the afternoon and night of 31st August was representative of the quality of the Thames at that time. From Hogsmill STW data it can be seen that the loading of ammonia in the effluent (fig.4) increased considerably on 29th August to the highest level for the month, that being 470.31 kg/d. The time of travel of ammonia in the Thames on this day was calculated to be 44.69 hours, which suggests that this increased loading would arrive at Teddington some time on the afternoon of the 31st August, as indicated. In addition there was also a small discharge of storm sewage of 0.01 tcmd flow on 30th August after 4.0 mm of rain on 29th August. This was likely to have been discharged on the morning of 30th August, with a travel time of 44.60 hours on this day, and therefore would have arrived at Teddington late on 31st or early on 1st September. This discharge, together with high loadings from the STW, has caused the ammonia concentration at Teddington to peak at a concentration above 1.6 mgl^{-1} on 31st August. The dissolved oxygen pattern shown in Fig.11 indicates a loss of diel fluctuations on 30th and 31st where sunshine duration was diminished, and a decrease in D.O. in the afternoon of 31st August corresponding with the storm effect and high loading.

3.4 September 1990

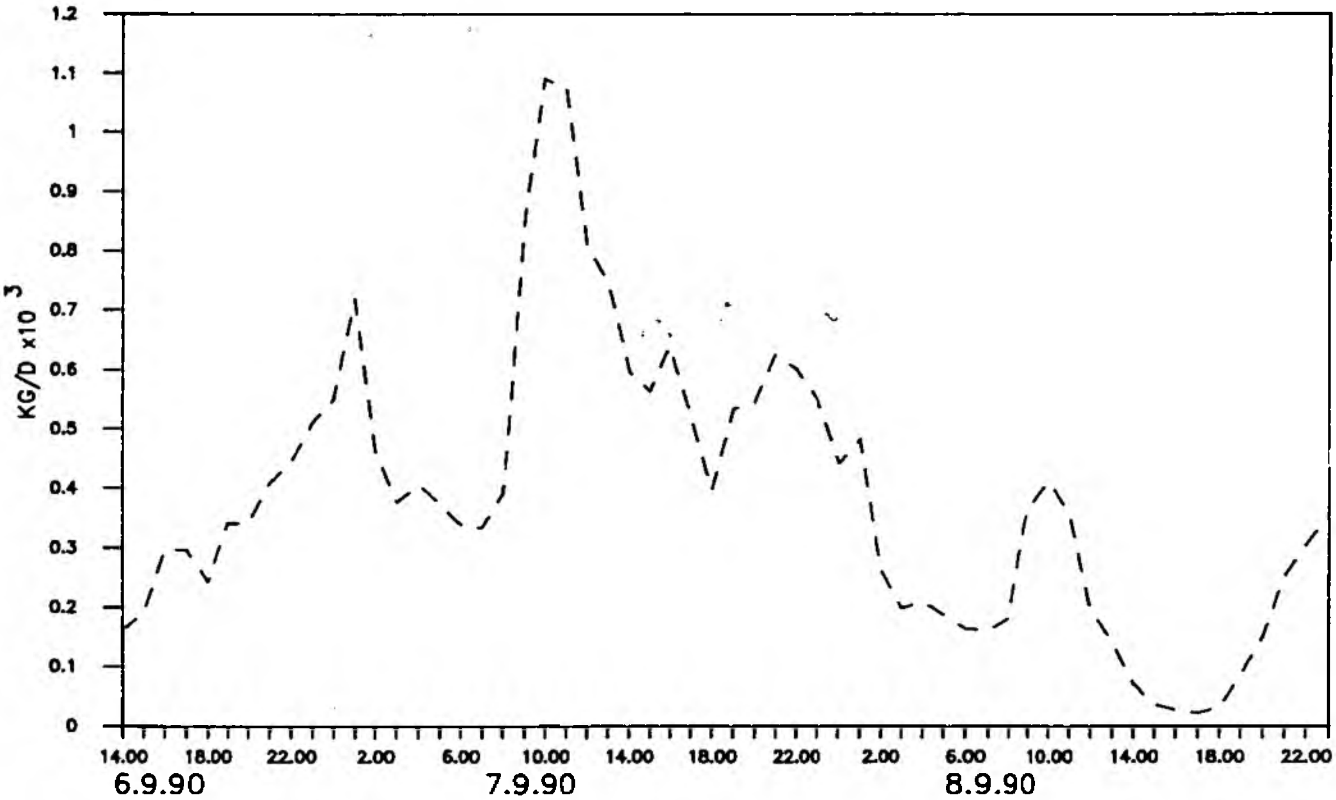
From the 1st September, ammonia concentrations were higher in the Thames than they had been for much of August (fig.5). D.O. levels were satisfactory although generally lower than experienced towards the end of August (figs. 11 & 12). Sunshine duration was less in the first five days of September, the lowest level was on 5th September at 1.8 hours. A diel pattern was still evident up to the 4th, but was lost on 5th due to lower illumination. Ammonia loadings from Hogsmill STW were elevated and effluent ammonia concentrations increased compared to August (figs. 4 & 5). There was a partial loss of nitrification at Hogsmill STW during the week as a result of trade effluent/operational difficulties.

On the 5th September (fig.12) ammonia in the Thames at Teddington increased significantly to a level exceeding 1 mgl^{-1}. The loss of nitrification caused high concentrations of ammonia to be present in the

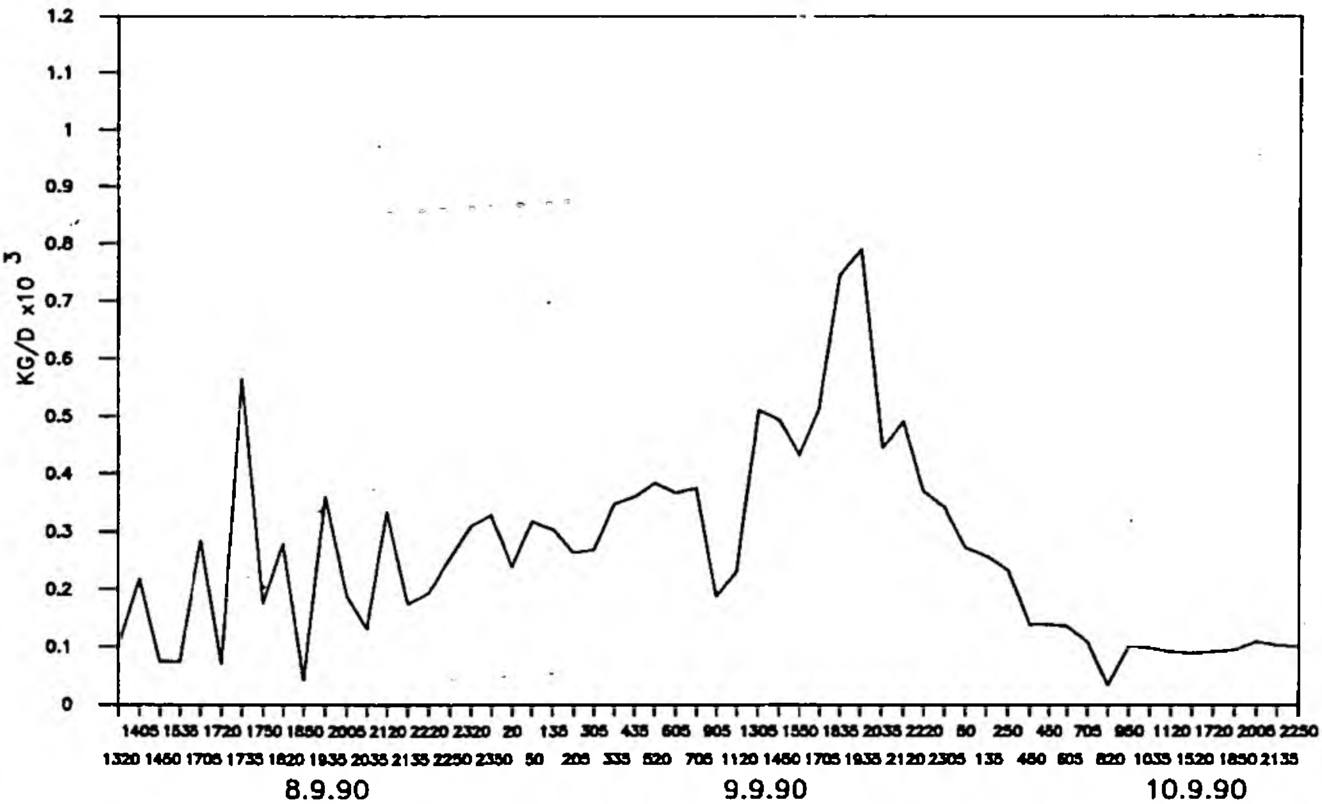
FIG 3

PLOTS OF AMMONIA LOADINGS FROM HOGSMILL STW AND IN R. THAMES, TEDDINGTON

i) HIGH LOAD FROM HOGSMILL ON 7.9.90



ii) HIGH LOAD IN THAMES ON 9.9.90



——————— R. THAMES   – – – – – – – HOGSMILL STW effluent. Ammonia loadings from Hogsmill STW for this period were highest on 3rd September, the load being 429.08 kg/d. The time of travel of ammonia for this day was calculated to be 53.15 hours and therefore the highest ammonia concentrations in the Thames on 5th reflected this level of ammonia loading.

Fig.12 also shows elevated ammonia concentrations in the Thames at Teddington on 9th September. A peak of 1.55 mgl^{-1} of ammonia occurred in mid-afternoon on 9th. Trade effluent problems at the STW on the 7th caused high loadings (424.65 kg/d) from the works. The ammonia profile from Hogsmill STW shows a peak of ammonia of 17.5 mgl^{-1} between 0200 hours and 0800 hours on 7th, and with mean travel time of 60.11 hours, a resultant peak at Teddington would be expected between 1400 hours and 2000 hours on 9th September. This was observed as shown in fig.12. Fig.3 represents loadings from Hogsmill STW, and loadings in the Thames over this time. Fig.3(i) shows the actual hourly loadings from Hogsmill and Fig.3(ii) shows the loadings in the Thames after a calculated time of travel of each hourly load from Hogsmill STW. For each load from Hogsmill STW, the time taken to travel the distance between Teddington and Kingston using 15 minute flow readings was calculated, and therefore these graphs could be superimposed and the peaks should coincide. It is apparent however that this is not the case, and the most likely reason for this is varying pulses of flow caused by opening of locks upstream of Kingston. Another source of variance may be changes in flow regime between Kingston and Teddington which may be exaggerated by the general low flow conditions.

On the 9th September the high loadings of ammonia from Hogsmill STW did not appear to adverseley affect the D.O.% saturation level in the Thames (Fig.12).

From 10th September until 14th September the D.O. profile in the Thames showed diel fluctuations with maxima between 70-80% and minima at 60%. Ammonia concentrations were above baseline averaging at approximately 0.5 mgl^{-1}, which reflected increased loadings from Hogsmill STW (fig.4). After the 14th the diel pattern of D.O. was lost, and there was a flattening of diurnal levels in the region of 60-70%. This was as a result of reduced incidence of sunshine. This pattern was maintained

FIG 4

PLOTS OF AMMONIA LOADINGS AND FLOWS IN R. THAMES AT TEDDINGTON AND HOGSMILL STW FINAL EFFLUENT – JUNE TO OCTOBER 1990

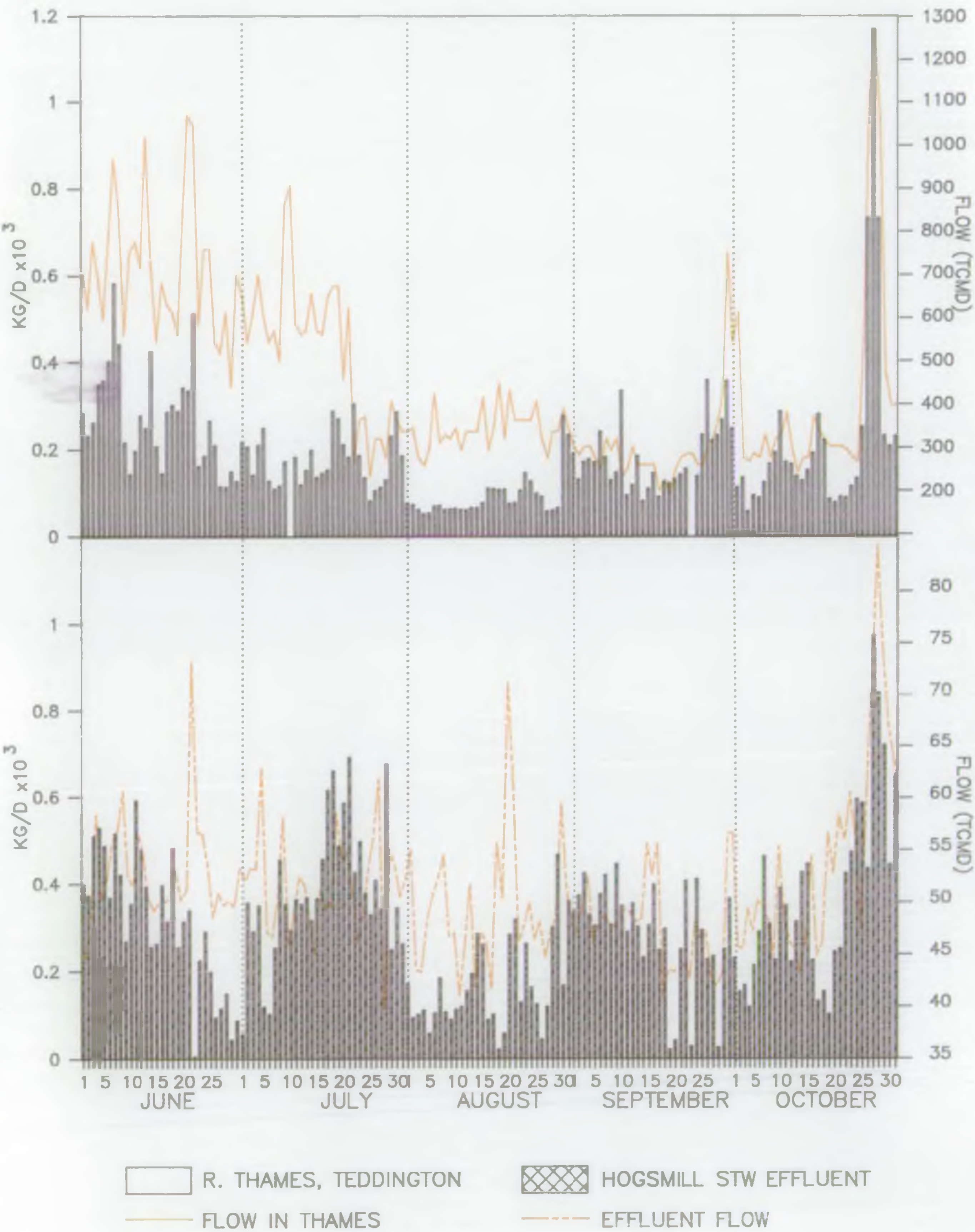
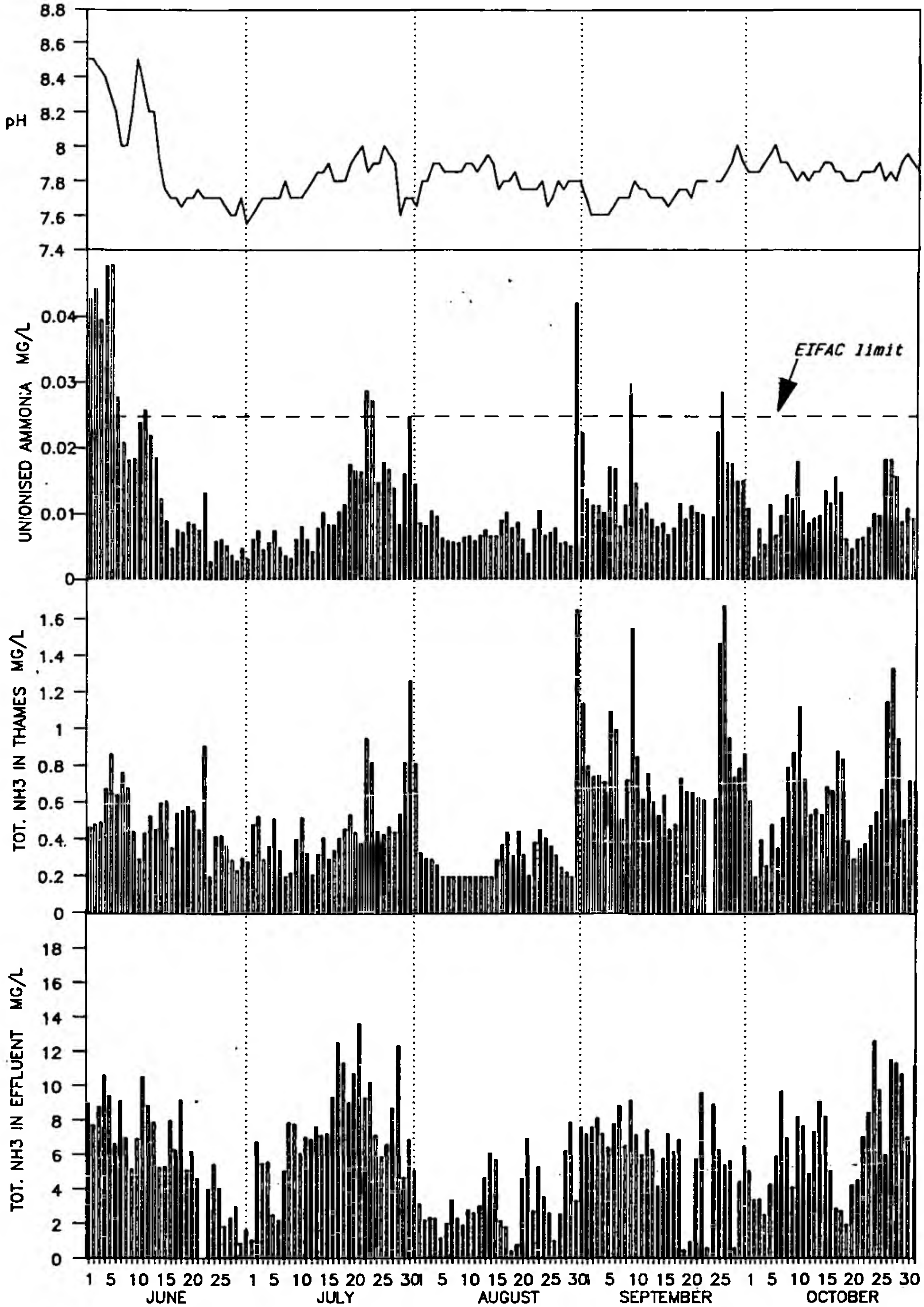


FIG 5: PLOTS OF UNIONISED & TOTAL AMMONIA IN R. THAMES, pH, AND TOTAL AMMONIA HOGSMILL STW FINAL EFFLUENT



until 20th September although a further drop in D.O. by about 10%, due to even lower levels of sunshine, was observed.

D.O. levels at Teddington showed a marked improvement from 26th September (fig.13) with the reappearance of a diel pattern peaking to 100% on 28th. On 25th and 26th September there was a dramatic increase in ammonia concentrations to a level exceeding 1.5 mgl^{-1}. Hogsmill STW experienced problems on 22nd and 24th September which caused a deterioration in effluent quality and produced loadings of ammonia exceeding 400 kg/d. The flows in the Thames during this period were low, and times of travel for these days are in excess of 52 hours. The effects of the elevated ammonia levels from Hogsmill STW were responsible for an increase on 25th and 26th. After this period ammonia levels returned to approximately 0.5 mgl^{-1}.

3.5 October 1990

Diel variation of D.O. from the beginning of October declined leading to a flattening of levels at about 70%, as a result of low duration of sunshine. Ammonia levels remained generally low until 8th October. The Thames on 9th and 10th October showed an increase in ammonia levels due to increased loadings from the works on 7th and 8th (figs. 4 & 5). Ammonia returned to a fairly consistent level of approximately 0.5 mgl^{-1} after this period and this was maintained until 26th October. Small diurnal fluctuations in D.O. were noticed after 11th October but with increased reduction in sunshine hours the D.O. diel pattern was lost from 20th October. Loadings from Hogsmill STW increased from 23rd October and remained high for the rest of October (fig.4). Fig.5 shows the increase in ammonia concentration in the effluent and in the river Thames. Ammonia levels were elevated in the Thames from 26th to 28th October with highest levels exceeding 1 mgl^{-1} on 27th (fig.14). Rainfall was experienced between 24th and 29th October, the heaviest falling on 26th giving a total of 13.7 mm for the day. Storm sewage was discharged from Hogsmill STW from 25th to 30th October. The greatest flow of storm sewage was discharged on 26th and 27th, at levels of 20.00 and 26.35 tcmd respectively. The time of travel of this storm flow was calculated to be 28 hours on 26th and 13 hours on 27th. It can therefore be seen that the peak of ammonia evident on 27th (Fig.1, plot (ii)) was caused by these discharges. D.O. levels were diminished by the storm discharge and low sunshine hours. From 28th D.O. picked up by approximately 10-15% (Fig.14).

3.6 Toxicity of Ammonia

Plots of unionised ammonia, pH and total ammonia in the Thames and in Hogsmill STW effluent are shown in Fig.5. Thirteen days throughout the Summer of 1990 had levels of unionised ammonia in the River Thames at Teddington at or exceeding the EIFAC recommended threshold for unionised ammonia of 0.025 mgl^{-1}. (EIFAC Technical Paper No. 11, 1970).

The pH for the first half of June was high, up to 8.5 for some days, and this factor appears to be the main cause of the elevated levels for the first six days of June, together with slightly elevated levels of ammonia at Teddington. On other occasions throughout the Summer where the EIFAC threshold was exceeded, high loadings or storm discharges from Hogsmill STW were responsible. Fig.15 shows plots of unionised ammonia in the Thames and total ammonia concentrations in the effluent for the Summer of 1989. It is worth comparing these with the plots in Fig.5, to illustrate changes in water quality. In 1989 the EIFAC threshold was exceeded on many more occasions, and in June and October over a period of consecutive days. Ammonia concentrations in the effluent in 1989 were somewhat higher, especially in June and July, than those in the effluent in the Summer months of 1990.

4. DISCUSSION

In undertaking this study of the effects of ammonia in discharges from Hogsmill STW on the River Thames at Teddington for the Summer of 1990, the conclusions drawn from the previous report have been used to assess water quality and identify any trends apparent in comparing consecutive years data. Each month has been given a running commentary on the water quality in the Thames in terms of D.O. and ammonia and the likely causes of any detrimental changes.

It is evident that the effluent from Hogsmill STW affects the Thames at Teddington considerably, such that a deterioration in the quality of the effluent results in a deterioration in quality of the Thames. High loadings and storm discharges from Hogsmill STW caused increased ammonia concentrations in the river (in some cases exceeding 1.5 mgl^{-1}) and storm sewage resulted in diminished D.O. levels in the river. Although high loadings from the works did little to deplete D.O. at Teddington it is likely that these may have affected the upper tideway.

Unionised ammonia levels for the majority of the Summer of 1990 were well below the EIFAC recommended threshold of 0.025 mgl^{-1}. Where this level was exceeded, high pH, elevated loadings or storm sewage discharges were the causative factors.

By comparing data from the Summers of 1989 with 1990, some changes or trends can be highlighted. For example, there were fewer days in 1990 where the river Thames contained levels of unionised ammonia greater than 0.025 mgl^{-1}. There are several reasons for these differences which include environmental factors such as pH and temperature, or due to improvement in the effluent quality, or the amount and frequency of storm sewage discharged from the works. By comparing plots as shown in figs. 5 and 15 two factors in particular can provide explanations for these differences in unionised ammonia concentrations in the river in 1989 and 1990. Firstly the pH in 1989 was above 7.9 for the whole period studied, and in particular, in June the pH was greater than 8 for most of the month. The pH of the river has a direct influence on the levels of unionised ammonia. In June 1989 the EIFAC recommended threshold was exceeded when the pH was high and the effluent ammonia was high. In 1990 the pH for most of the summer was below 8. The first half of June, however did show levels exceeding pH 8, and here again the unionised ammonia levels exceeded 0.025 mgl^{-1}. Figs.5 and 15 also show the effluent ammonia concentrations for 1990 and 1989 respectively. It can be seen that for a majority of the days in the Summer months of 1990 the effluent ammonia levels were below 10 mgl^{-1}, and no days exceeded 14 mgl-1. In 1989 the quality of the effluent, especially in June and July, was greatly in excess of 10 mgl^{-1}, and in one instance above 20 mgl^{-1}. This might suggest some improvement in effluent quality in 1990, although unfortunately loadings comparison has not been undertaken.

Another important factor which has had little mention throughout this report is that of flow conditions in the River Thames. Fig.16 presents flow data from June to October 1989 and 1990. It is obvious that flows in 1990 were lower than in 1989 due to prolonged dry weather conditions over this time. With lower flows the dilution of Hogsmill STW effluent in the Thames was less and the effects of elevated effluent ammonia were more apparent in the River Thames at Teddington. An illustration of this can be made by comparing July and September 1990 in terms of the level of loadings which caused visible increases in ammonia at Teddington (see Figs. 4 & 5, and text 3.2 and 3.4 vide supra). In July loadings of 500 and 600 kg/d caused significant increases in ammonia at Teddington, yet in September loadings of ammonia in the region of 400 kg/d gave similar (or equivalent) levels of increases in the Thames at Teddington.

In some instances during the Summer of 1990, small increases in loadings (which might on paper appear fairly insignificant) from Hogsmill STW were registered at the AQMS at Teddington and caused significant increases in ammonia.

5. CONCLUSIONS

Hogsmill STW have been shown to incur pronounced effects on the quality of the River Thames at Teddington during the Summer of 1990. The conclusion drawn from the previous report, as highlighted in the introduction, are corroborated by this present study. Some additional points of interest are summarised below:

(i) The frequency of days exceeding the EIFAC recommendation of 0.025 mgl^{-1} from June to September was diminished compared to the equivalent period in 1989.

(ii) Hogsmill STW effluent quality, in terms of ammonia concentrations, showed some improvement especially during June and July, compared to the previous year's results.

(iii) Flows in 1990 were much reduced, and as a result, provided less dilution of ammonia from the STW.

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Neave, H.R., (1978). Statistical Tables for mathematicians, engineers, economists and behavioural and management sciences.

APPENDICES

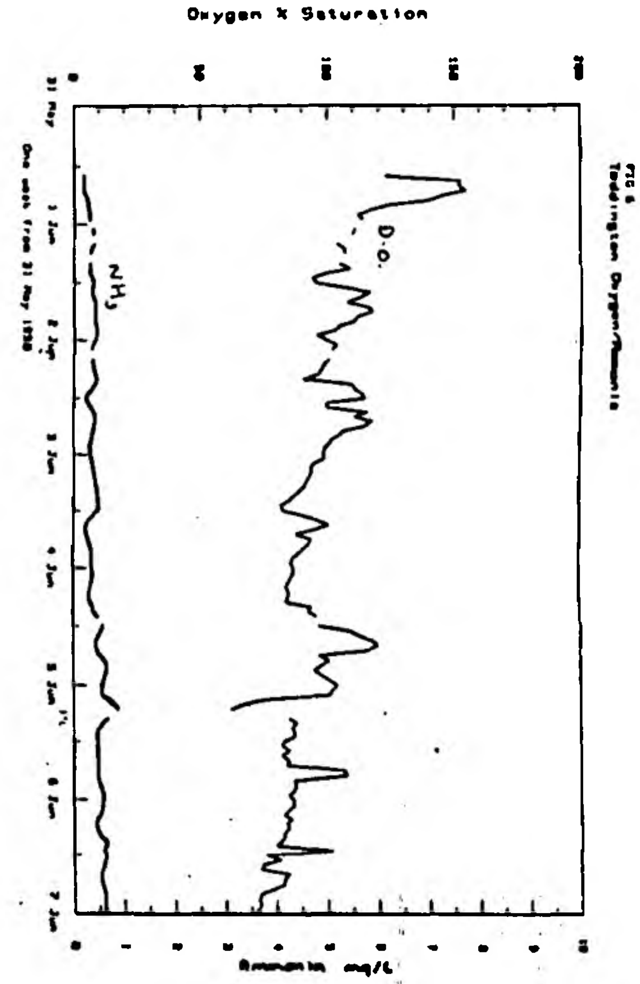
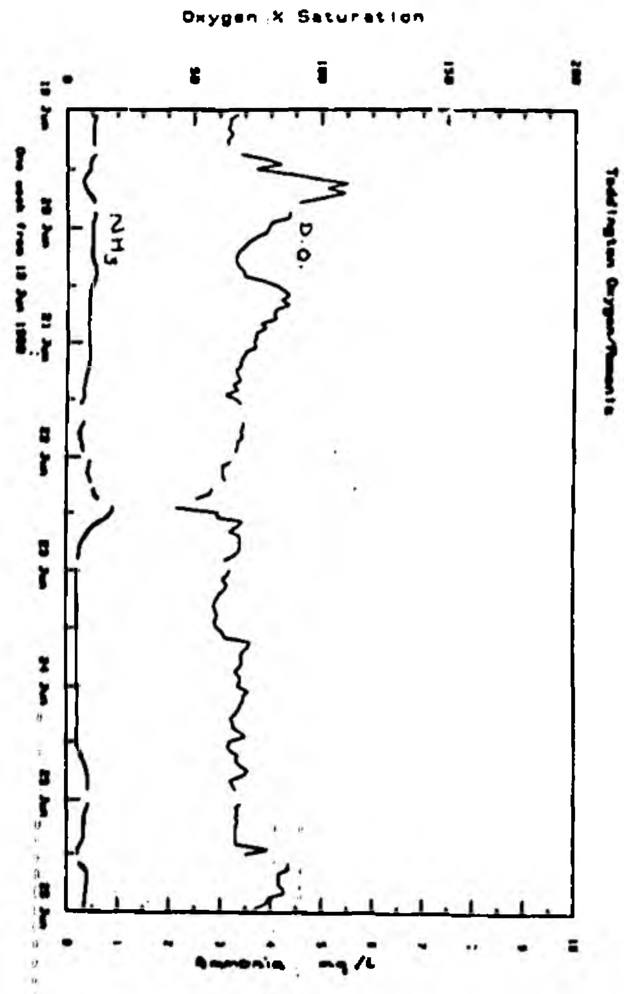


FIG 6 Teddington Oxygen/Ammonia



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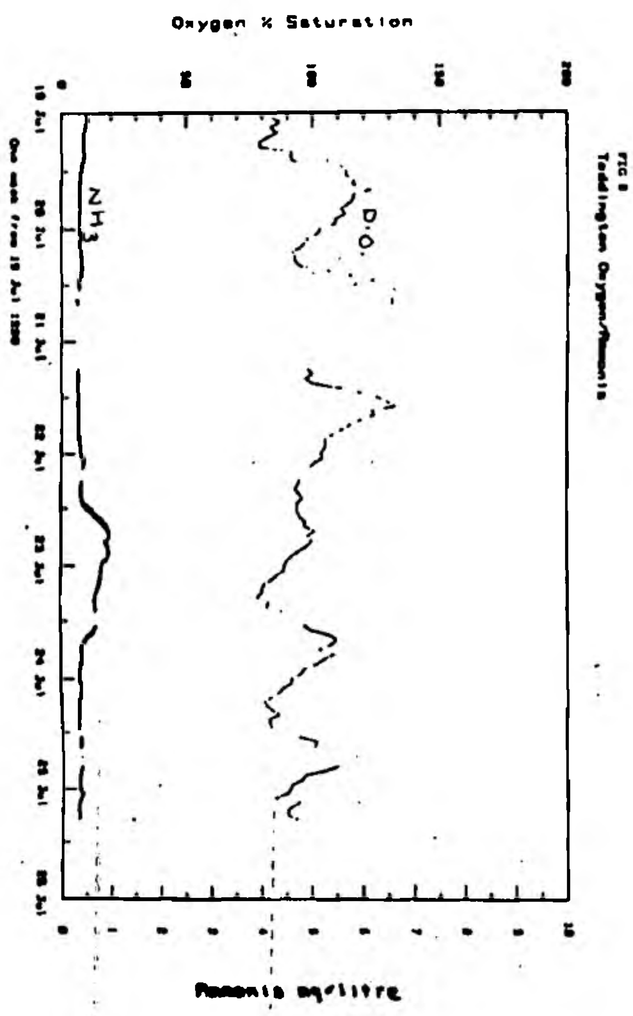
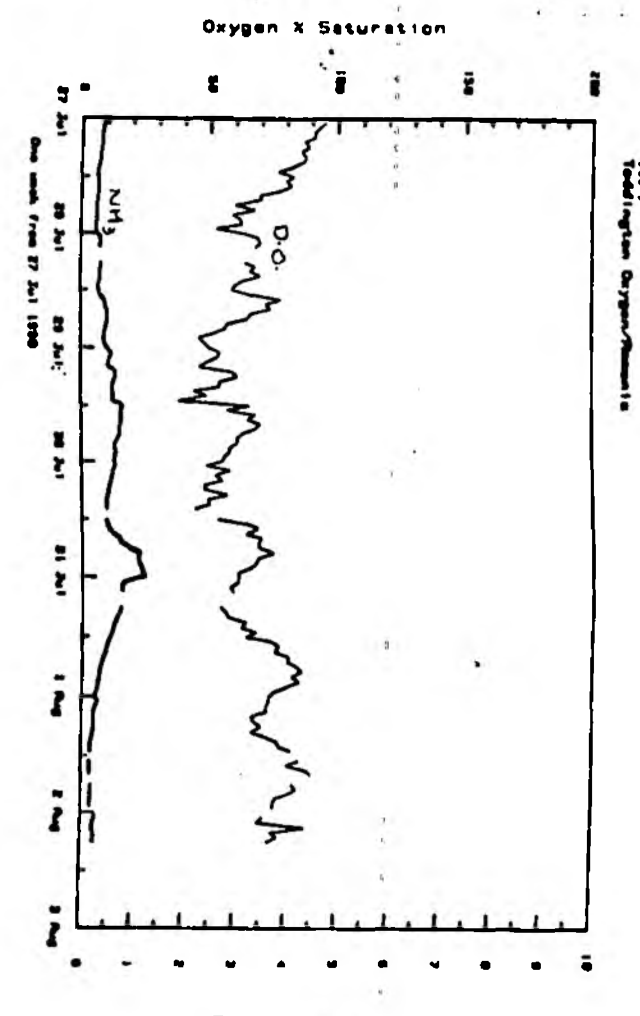


FIG 8 Teddington Oxygen/Ammonia



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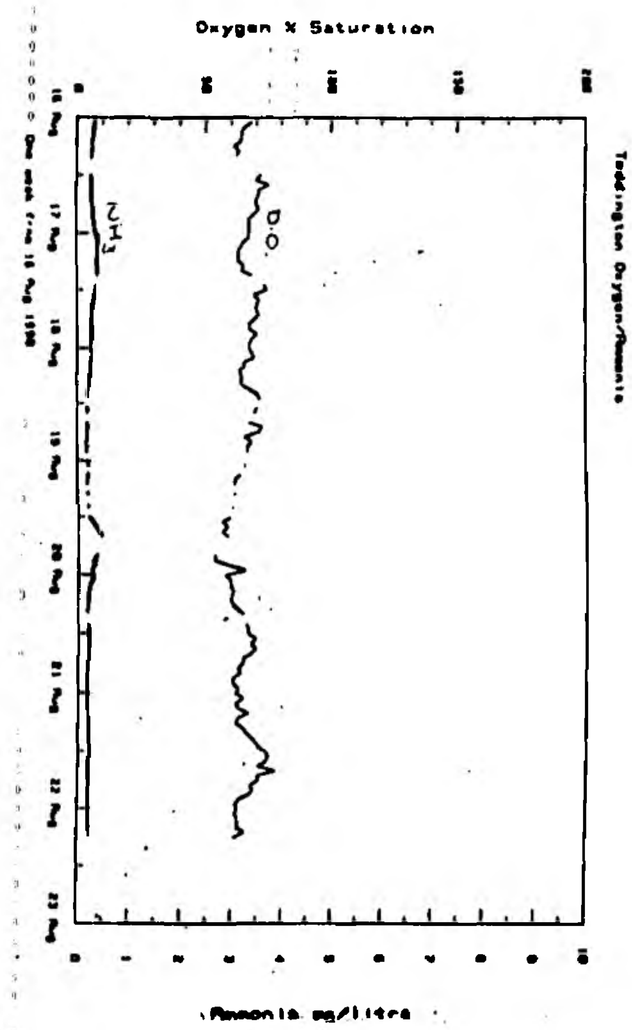

FIG 10 Teddington Oxygen/Ammonia

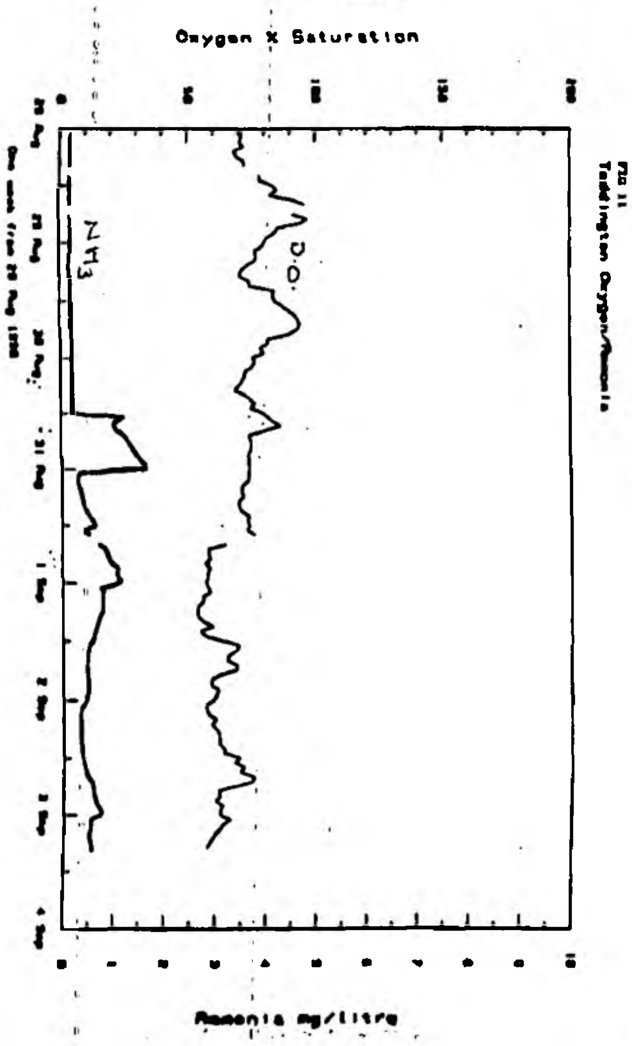

FIG 11 Teddington Oxygen/Ammonia

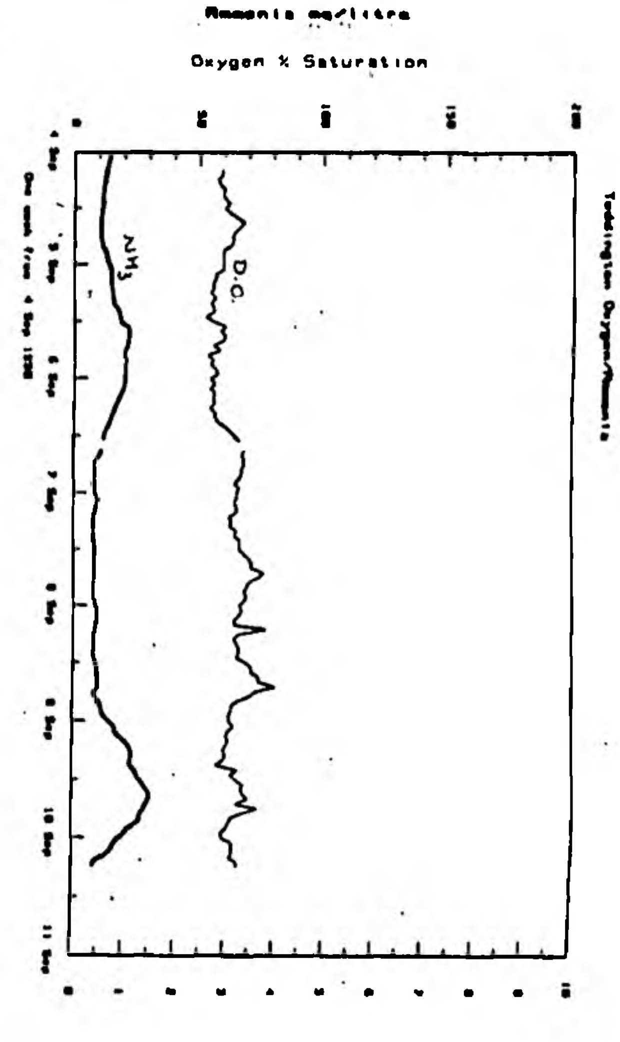

FIG 12 Teddington Oxygen/Ammonia

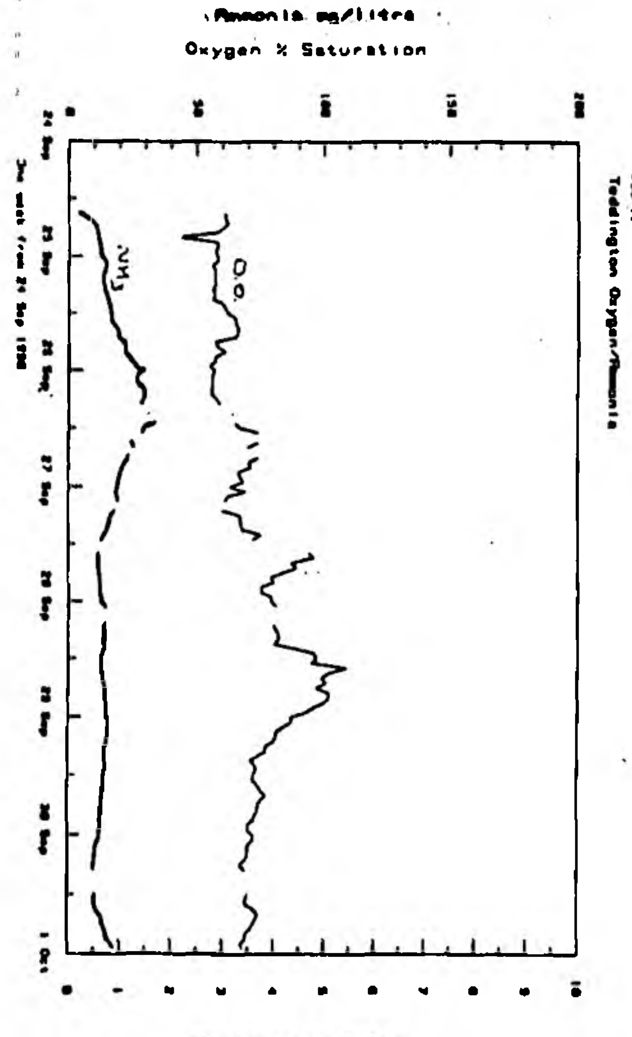

FIG 13 Teddington Oxygen/Ammonia

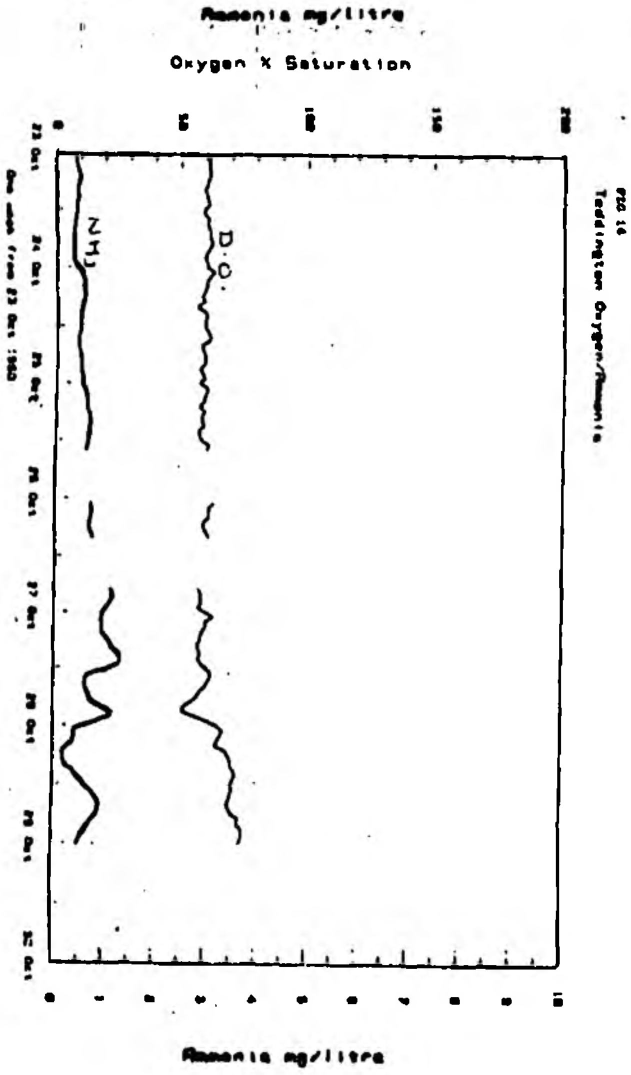

FIG 14 Teddington Oxygen/Ammonia

FIG 15: PLOTS OF TOTAL AMMONIA IN HOGSMILL STW EFFLUENT AND UNIONISED AMMONIA IN R. THAMES AT TEDDINGTON – JUNE TO OCTOBER 1989

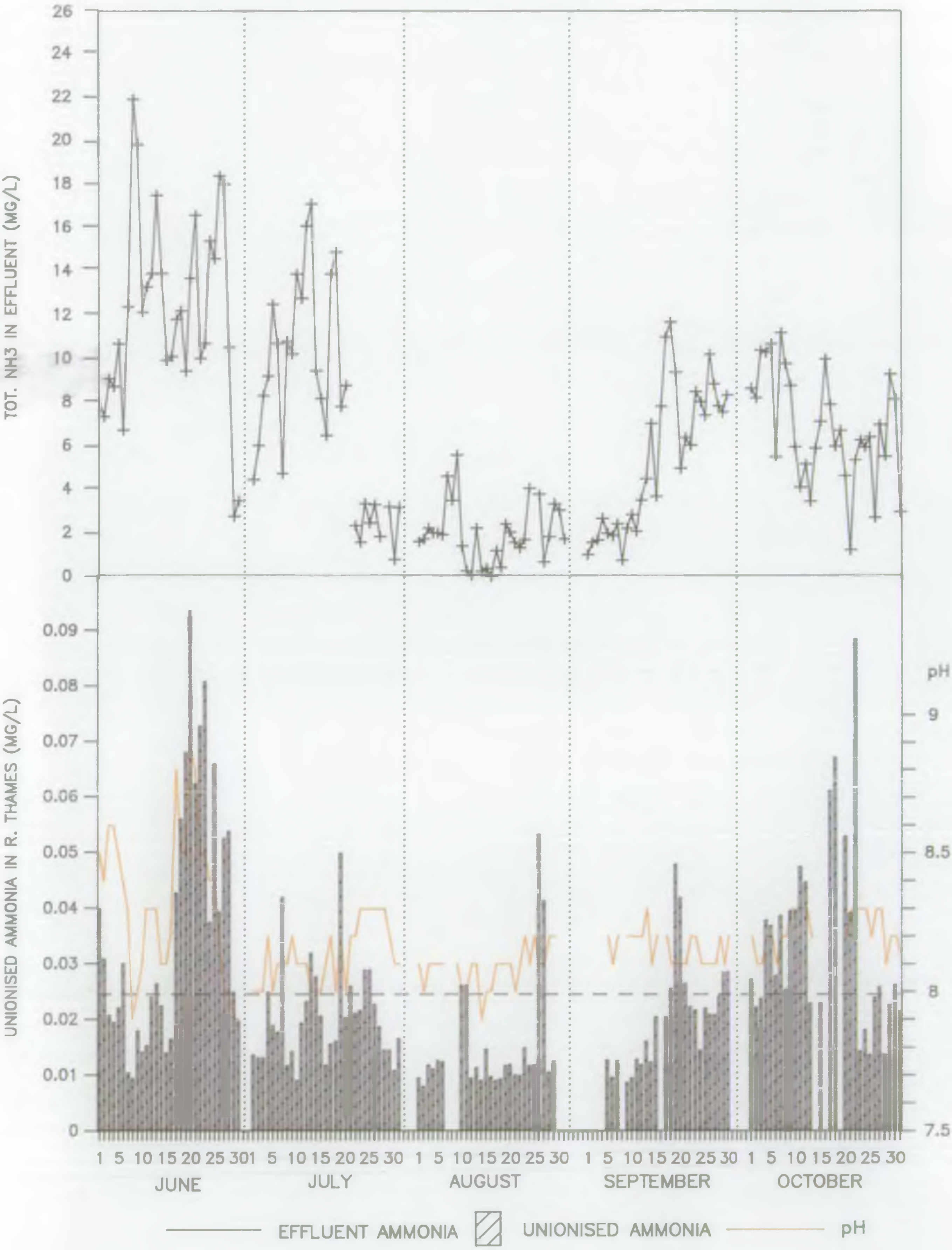

FIG 16: FLOWS IN THE RIVER THAMES FOR JUNE TO OCTOBER 1989 & 1990