CHAPTER III

THEORY AND APPLICATION

The conventional Activated Sludge Process

The conventional process can use either long, rectangular aeration tanks which approximate plug flow with some longitudinal mixing or cross - flow or circular aeration tanks which approach complete mixing.

The long, rectangular aeration tanks have been used for the treatment of large volumes of sewage or waste. Return sludge is mixed with waste in a mixing box or at the head end of the aeration tank. The mixed liquor then flows through the aeration tank ; during this process progressive removal of the organics occurs.

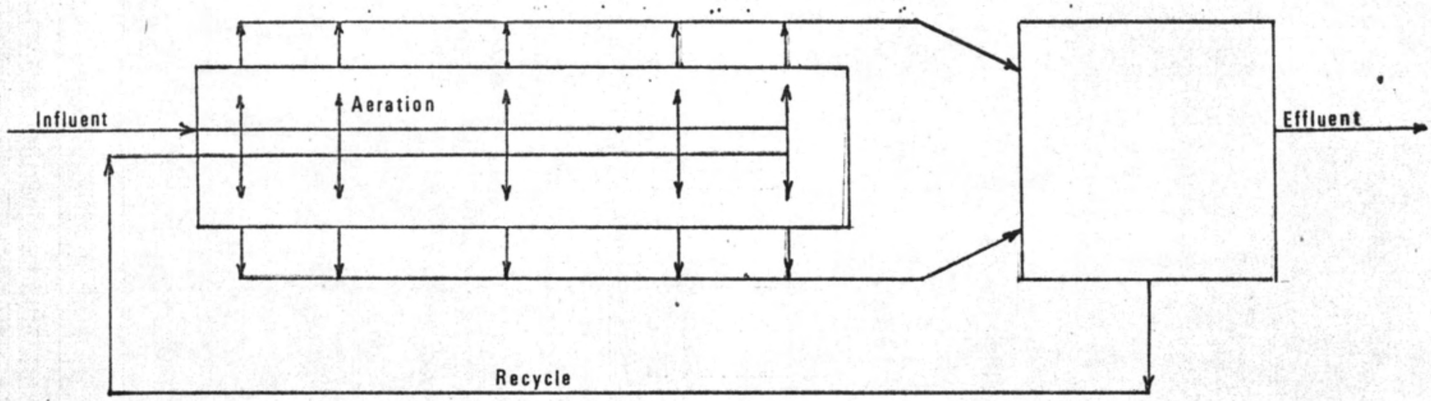
The oxygen - utilization rate is high at the beginning of the aeration tank and decreases with aeration time. Where complete treatment is achieved, the oxygen - utilization rate will approach the endogeneous level toward the end of the aeration tank.

The principal disadvantages of this system in the treatment of industrial wastes are :

1. The oxygen - utilization rate varies with tank length and requires irregular spacing of the aeration equipment and / or a modulated air supply.

2. Load variation may have a deleterious effect on the activated sludge when it is mixed at the head end of the aeration tank.

3. The sludge is susceptible to slugs or spills of acidity, causticity, or toxic materials.

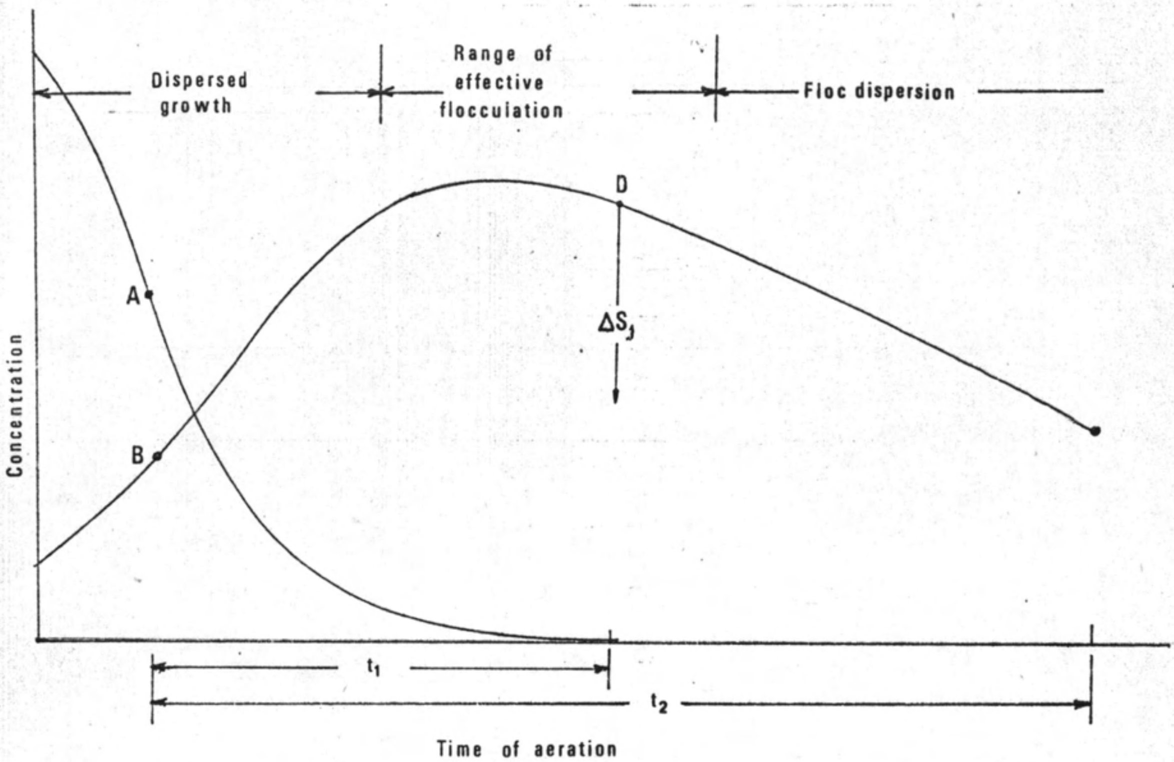


Fig(iii) Completely mixed activated sludge flow sheets.

In the complete mixing system, the aeration tank serves as an equalization basin to smooth out load variations and as a diluent for slugs and toxic materials. Since all portion of the tank are mixed, the oxygen-utilization rate will not vary, and aeration equipment can be equally spaced.

The conventional process can operate over a wide range of loading conditions, varying from an active sludge with high synthesis yields to extended aeration in which most of the sludge synthesized in the process is destroyed by oxidation. The loading limitation on the process is that required to effect flocculation and permit settling and separation of the biological flocs.

The process phases are shown in Fig. (iv)



Fig(iv) Range of operation of the activated sludge process.

After the contact period, the activated sludge is separated from the clarified liquor by sedimentation. A sludge reaeration or stabilization period is required to stabilize the organics remove in the contact tank.

The retention period in the stabilization tank is depent upon the time required to assimilate the soluble and colloidal material removed from the waste. Suspended solids agglomerated in the floc are slowly degraded and are carried with the biological sludge through the various phase of the process.

The total oxygen requirements in the process are those required for synthesis of the organics removed and those required for endogeneous respiration. The split of this oxygen between the contact tank and the stabilization tank depends on the solids level carried in both units and on the detention period in each tank. Increasing the contact tank solids level or detention period will increase the percentage of the total oxygen to that unit.

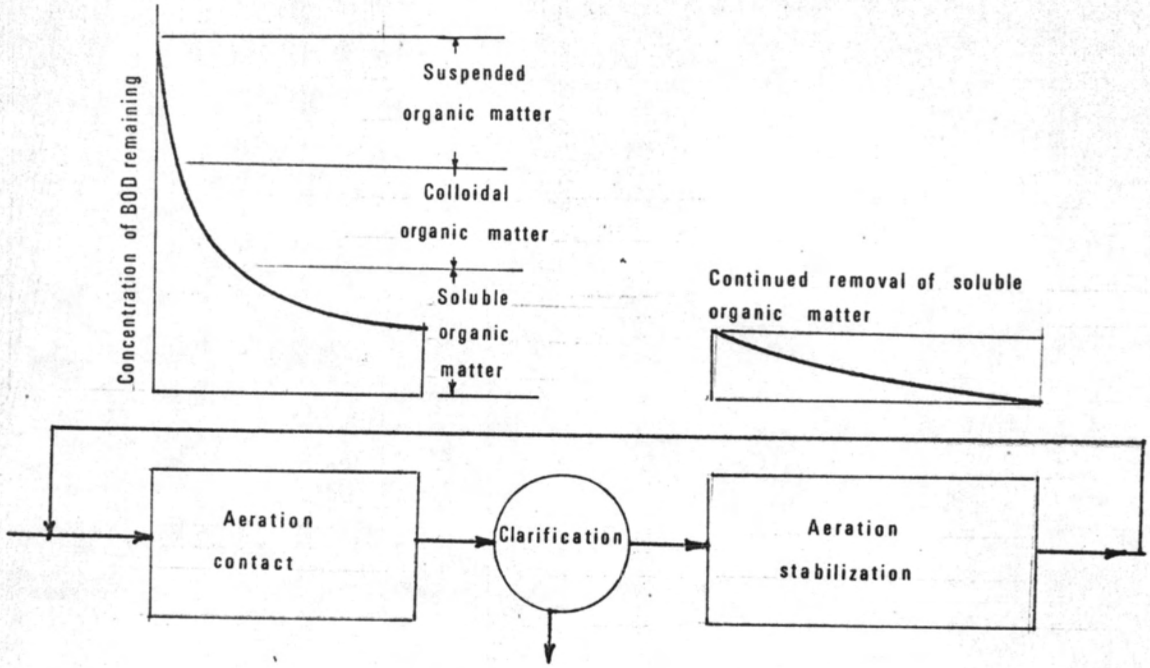


Fig (V) Schematic representation of the contact stabilization process.

Biological oxidation

BOD removed from a waste by a biological sludge may be considered as occuring in two phases. An initial high removal of suspended, colloidal, and soluble BOD is followed by a slow progressive removal of soluble BOD. Initial BOD removal is accomplished by one or more mechanisms, depending on the physical and chemical characteristics of the organic matter. The mechanisms involved in the removal of BOD from solution during bio-oxidation can be interpreted as a 3 phase process.

(I) An initial removal of BOD on the contact of a waste with a biologically active sludge which is stored in the cell as a reserve food source.

(II) Removal of BOD in direct proportion to biological sludge growth.

(III) Oxidation of Biological cellular material through endogeneous respiration.

These reactions can be illustrated by the following general equations :

$$\text{Organic matter} + O_2 + NH_3 \xrightarrow{\text{cells}} \text{new cells} + CO_2 + H_2O$$

and

$$\text{Cells} + O_2 \longrightarrow CO_2 + H_2O + NH_3$$

Of primary concern to the engineer in the design and operation of industrial waste treatment facilities are the rate at which these reactions occur, the amount of oxygen and nutrient they require, and the quantity of biological sludge they produce.

Tamiya (1935) stated that all cell synthesis reactions are exothermic and hence energy is supplied by the reaction. Exact quantitative relations can be determined only by experiment since they will vary depending upon the specific environment.

Oxygen Requirements

During the BOD removal process, oxygen is utilized to provide energy for synthesis and for basic cell maintanance. The total oxygen required is estimated from the relationship

$$lb O_2/day = a' \, lb \, BOD_5/day + b' \, lb \, MLVSS$$

MLVSS = Mixed liquor valatile suspended solids.

a' = The coefficient, represents that fraction of organics consumed to supply energy for synthesis

b' = The coefficient, represents the endogeneous respiration rate.

a' can be estimated from the slope and b' from the intercept of a plot of lb O_2/(day)(lb MLVSS) versus lb BOD_r/(day)(lb MLVSS). A plot for an industrial waste is shown in Fig (vi)

In addition to the total oxygen required, the distribution of oxygen in the aeration tank is important for the design of aeration equipment.

In a plug flow system, the oxygen-utilization rate will decrease with time of aeration as the substrate is removed. The shape of the oxygen-utilization time curve will depend upon the initial Lo/So ratio. At a high ratio Lo/So ratio, a high BOD is available relative to the concentration of sludge, and a relatively high rate will be maintained over a long aeration period. At a low Lo/So ratio, the high concentration of sludge available will rapidly utilize the BOD, yielding a very high initial rate which rapidly decrease to the endogeneous level.

At a high initial BOD concentration, a high rate will be maintained and even increase with increasing solids by synthesis, and will be followed by a rapid decrease to the endogeneous level.

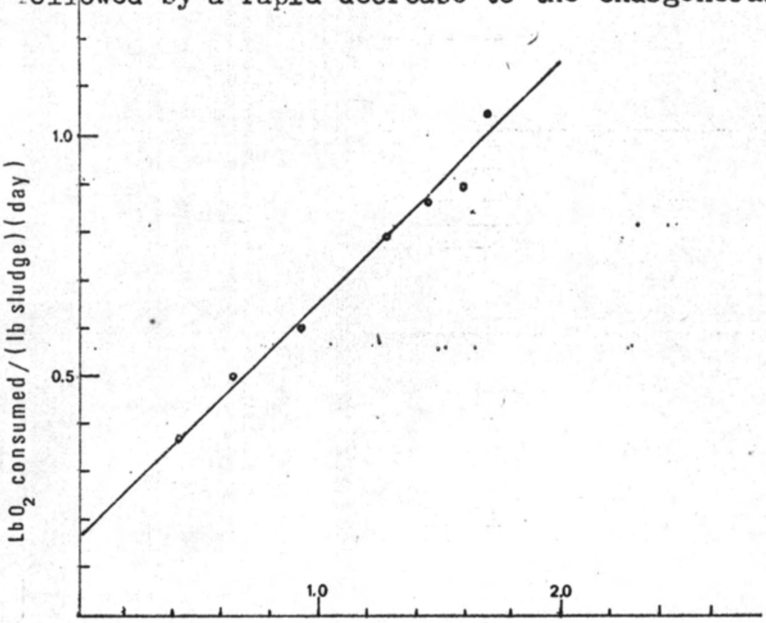


Fig (VII) Oxygen requirements for a mixture of sewage.

The maximum oxygen uptake rate encountered in a waste oxidation system will be related to the sludge growth rate and to the endogeneous respiration rate. The rate at which oxygen will be utilized by micro organisms can be expressed by the relationship

$$\frac{do_2}{dt} = \left(\frac{a'}{a} . K_1 + b'\right) S \qquad (1)$$

where a = The fraction of BOD_5 or COD removal

<u>Dissolved oxygen</u> (Oxygen Concentration)

When the oxygen concentration in the mixed liquor is greater than 0.2 - 0.5 ppm., the rate of bacterial respiration is independent of oxygen concentration. When the oxygen concentration is below this value, the system becomes oxygen dependent and the rate of BOD removal is decreased.

Sludge tends to clump, hence to decrease the quantity of oxygen which can be transfered to them by an increase in resistance to transfer. Mathematical relationships for oxygen diffusion into microbial cells which are a function of floc size, diffusivity, oxygen utilization rate and external concentration of dissolved oxygen (driving force). A relationship can be developed incorporating these variables for the case when the entire floc from the surrounding liquid can be approximately by the equation.

$$\frac{dM}{dt} = \frac{D}{R} . 4\pi R^2 (C_L - C_M) \text{ -------- } (2)$$

in which

C_L = Oxygen concentration at the cell interface

C_M = Oxygen Concentration within the cell

dM/dt = Weight rate of oxygen transfer

R = Mean floc radius

(Assuming the floc is spherical, the change in rate with decreasing floc radius is meglected)

The oxygen consumed by the sludge floc will be

$$\frac{dM}{dt} = k_r . \; . 4/3 . \pi R^3 \text{ -------- } (3)$$

where

is the floc density (1.018 - 1.210)

For steady state condition Equation (2) = Equation (3)

$$K_r \cdot \; . \; 4/3 / \pi . R^3 = \frac{D}{R} \cdot 4 \pi R^3 \, (C_L - C_M)$$

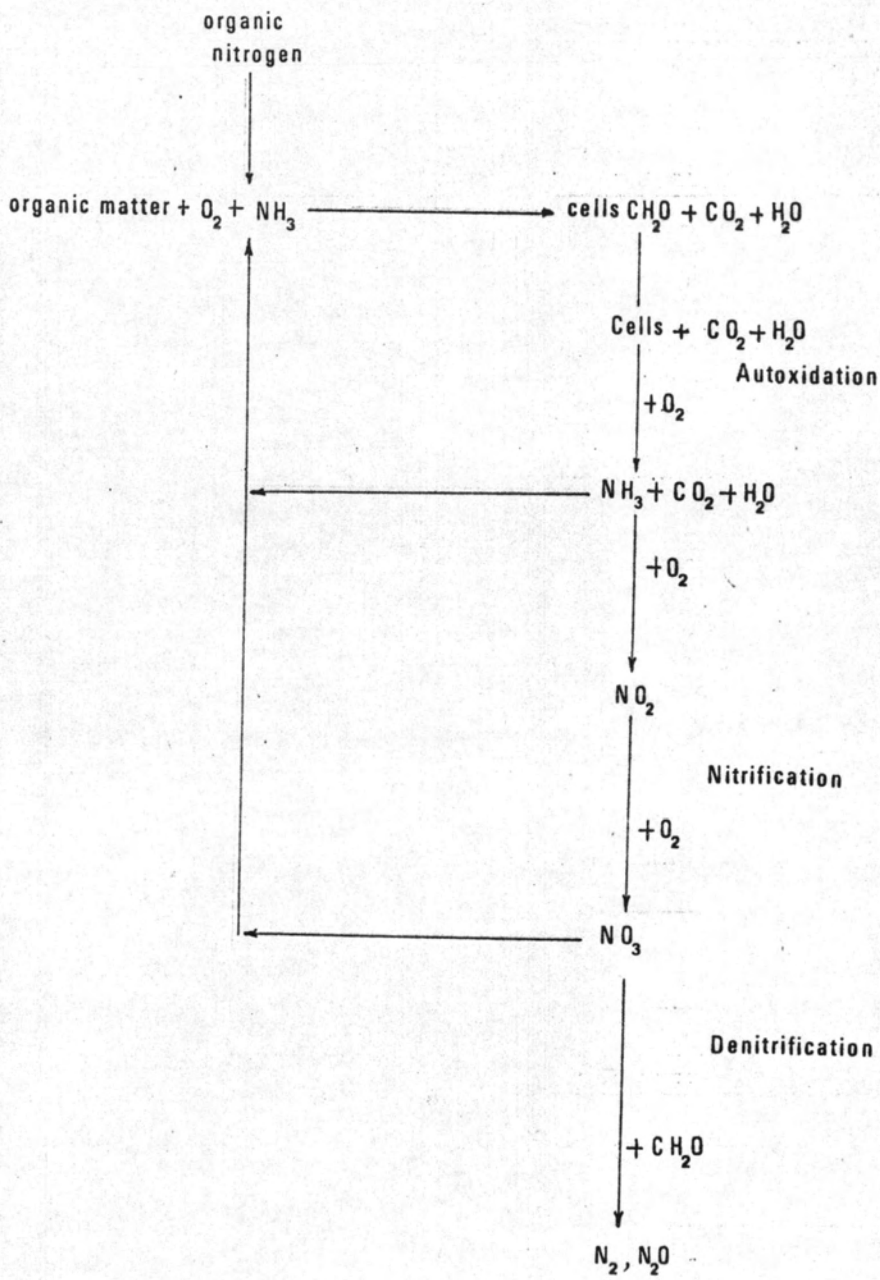
$$R = \frac{3D \, (C_L - C_M)}{K_r \cdot} \quad \text{-------------} (4)$$

IMHOFF and OTHERS (1971) stated that the air supply to aeration tanks (of the activated sludge process) must be abundant enough to maintain a dissolved oxygen concentration throughout the tanks of not less than 1 - 1 $\frac{1}{2}$ p.p.m. in high - rate plants, it should be even greater, perhaps up to 3 p.p.m.

Nutrient requirements

Several mineral elements are essential for the metabolism of organic matter by micro organisms. All but nitrogen and phosphorus are usually present in sufficient quantity in the carrier water. Sewage provides a balanced microbial dict, but many industrial wastes do not contain sufficient nitrogen and phosphorous and require its addition as a supplement.

In addition, trace quantities of several other elements such as potassium and calcium are required. These elements are usually present in natural waters in sufficient quantity to satisfy the requirements for bacterial metabolism. Nitrogen and phosphorus, however, are frequently deficient in waste substrates and must be fed as a nutrient supplement to the system to attain optimum efficiency.



The nitrogen of actively metabolizing sludge will vary from 6 - 15% and phosphorus from 2 - 5 % on a dry weight basis depending on the growth phase of the system. (After initial removal of carbonaceous BOD, the nitrogen content of the cell may be low. As oxidation and sludge growth proceeds the cell nitrogen will increase to a maximum). SYMONS and Mc. KINNEY (1958) obtained a sludge of 8.2 - 8.7% nitrogen from the oxidation of sodium acetate when the availability of nitrogen and phosphorus content of 7% and 1.2% by weight respectively of the total volatile solids should be maintained.

Organic Removal and Calculation

The specific relationship between the fraction removal of organics and the loading intensity for any particular waste can be e established with data derived from a batch process. Often it is found that the relation ship approximately.

$$\frac{C}{C_o} = 1 - 10^{-mi}$$

where

C = Concentration of Organics at Time t, mg/l

C_o = Initial Concentration of Organics, mg/l

i = Organic Loading Intensity $= C_o/\ (So.t)$

m = Constant

So = Initial Concentration of Activated Sludge, mg/l

t = time, hr.

A semi-log plot between $1-C/C_o$ and i can be used to established the value of m

Micro-organism in The Activated sludge process

In design, the importance of an adequate available supply of oxygen for the micro-organism in the micro-environment of the floc at all times can not be overstressed. This is not only measured in terms of cubic feet of air per volume of sewage in the aeration tanks, nor even in parts per million of dissolved oxygen in the aeration tanks alone, but involves the conditions throughout the circulation of the sludge.

Independent of any role they may play in the process, protozoa have been proved by experience to be of great value as indicator organism. It is however, dangerous to apply'rule of the thumb' methods when using any such indicators, but with a knowledge of the dominant species present in his plant an operator working on the general principles of the succession of dominant groups with increased purification, should find routine microscopial examination of the sludge of great value. Although REYNOLDSON (1942 a) found that there was a direct relationship betwsen the numbers of vorticellids in the sludge and the quality of the effluent, attempts to correlate the protozoa numbers with effluent quality showed that although such a relationship was established over shorter periods of several weeks, no such correlation existed throughout the year; it was concluded that the nature of the protozoa community was more indicative than were specific numbers (BAINES and others, 1953). As recently pointed out by McKINNEY and GRAM (1956) no simple quantitative relationship could be expected; for example, a decline in the free-swimming ciliates may in itself indicate decreased or increased efficiency. A study of the whole community, however, would tell whether this decline was associated with an increase in the flagellates or attached ciliates and thus would indicate the trend in efficiency. Experience from research has shown that some protozoa have a greater indicator value than others and some exceptions to the generally accepted pattern have been observed.

Although most species of Vorticella, an attached ciliate, occur in an efficient sludge together with Opercularia, Aspidisca and Lionotus, one species V. microstoma is more common at time when the effluent is inferior; it is also the dominant ciliate-usually the only one - in the partial activated sludge plants, its frequency there being more associated with the toxicity of the industrial sewages. Paramoccium caudatum, usually associated with a less-efficient sludge, has at time been present in large numbers when the effluent was good, but its number fluctuate violently. A species of Arcella, a rhizopod (a group quoted as indicative of inefficient sludges), has usually been found associated with the high-quality nitrified effluent.

In quating these exceptions, it is not intended to detract from the usefulness of protozoa as indicators, but merely to warn against over-rigid application of the general principle. It should also be pointed out that the protozoan population is indicative of the state of purification of the waste and as in the case of a light or bulking sludge, the effluent may contain microbial masses, the presence of which results in inferior-quality effluents, this not being reflected by the protozoa.

PH

For efficient aerobic biological treatment the PH of waste should be near nutrality, bacterial predomination and growth can be observed. Below pH 6.5, the fungi will begin to compete with the bacteria, with full predominant at PH 4.5. Above PH 9.0, the rate of metabolism is retarded. Thus it is important that PH should be maintained at the proper level (Mc. Kinney, 1962). The optimum PH range for activated sludge process is between 6.5 - 7.5.

Temperature.

The rate of biological activity depends on the temperature, the organisms active in aerobic treatment plants are usually mesophilic which can grow rapidly in the range of 25 - 30°c WHEATLAND (1967), studied the treatment of organic waste by activated sludge, found that in crease in temperature can be benificial but the performance at 30°C is not much than that of one operated at 20°C. This effcet can be neglected for Thailand where the average temperature is about 30°C.

CHAPTER IV

RESULT AND DISSCUSTION OF THE EXPERIMENT

Characteristic of waste from slaughterhouses

The concentration of the waste from slaughterhouses depends on the amount of animals and volume of water flush per animal. At the sedimentation pond of the plant, waste samples were taken at various time and found that COD and BOD_5 concentration was relatively high during and one hrs. after the animals were slaughtered.

At 9.00 - 10.00 p.m., the time during the hogs (300 - 400 units) are slaughtered, COD concentration varied from 612 mg/l to 950 mg/l and the BOD_5 concentration varied from 237 mg/l to 362 mg/l. the pH values obtained during the experiments varied from 6.8 to 7.0 , without any pH adjustment. The value of other physical and chemical characteristic shown on the table of raw characteristic of waste at the sample No 1 and sample No 2.

At 10.00 - 11.00 a.m, the time during the cattles (700 - 800 units) are slaughtered, COD concentration varied from 1145 mg/l to 1150 mg/l and the BOD concentration varied from 437 mg/l to 480 mg/l.

The pH value found during the experiments varied from 6.9

to 7.0, without any pH adjustment.

The value of Suspended solids, Nitrogen Content, temperature shown on the table of raw characteristic of waste at the Sample No 3 and Sample No 4.

Nitrogen Utilization

Nitrogen are frequently deficient in industrial wastes and must be fed as nutrient supplements to the system to attain optimum officiency. In the nitrogen requirement, nitrogen is used by bacteria in the form of ammonia and is released back to the solution in the form of NO_3 - N.

Sample No 1 according to table 25. showed that the quantities of NH_3 - N were 308 mg/l which had been reduced to 261 mg/l. after 24 hrs of aeration.

After the oxidation, nitrate - nitrogen had been oxidised from 6.8 mg/l to 20.0 mg/l.

Sample No 2 according to table 26. showed that the quantities of NH_3 - N were 212 mg/l which had been reduced to 181 mg/l after 24 hrs. of aeration.

After the oxidation, nitrate - nitrogen had been oxidised from 6.2 mg/l to 16.2 mg/l.

Sample No 3 according to table 27. showed that the quantities of NH_3 - N were 302 mg/l which had been reduced to 246 mg/l after 24 hrs. of aeration.

After the oxidation, nitrate - nitrogen had been oxidised from 2.8 mg/l to 21.15 mg/l.

Sample No 4 according to table 28. showed that the quantities of NH_3 - N were 347 mg/l which had been reduced to 295 mg/l after 24 hrs. of aeration.

After the oxidation, nitrate - nitrogen had been oxidised from 8.3 mg/l to 19.9 mg/l.

COD - BOD_5 at various time of Aeration.

From experiment was found that the percentage of COD and BOD_5 removal at every 2 hr. had been removed more than 90 % of COD & BOD_5 removal. The value shown that by table 9 to table 12, and the result obtained from the experiment was considered to be resonable for removing COD - BOD_5 by the activated sludge process.

Sample No 1. as shown in table 5, COD removal at 24 hrs. of aeration period had been reduced from 950 mg/l to 72 mg/l (92.42 % COD removal). The BOD_5 had been reduced from 362 mg/l to 31 mg/l (91.44 % BOD_5 removal).

Sample No 2. as shown in table 6, COD removal after 24 hrs. of aeration period had been reduced from 612 mg/l to 55 mg/l (91.01 %

COD removal). The BOD_5 had been reduced from 237 mg/l to 17 mg/l (92.83 % BOD_5 removal).

Sample No 3. as shown in table 7, COD removal after 24 hrs. of aeration period had been reduced from 1150 mg/l to 56 mg/l (95.25 % COD removal). The BOD_5 removal had been reduced from 437 mg/l to 25 mg/l (94.28 % BOD_5removal).

Sample No 4. as shown in table 8, COD removal after 24 hrs. of aeration period had been reduced from 1145 mg/l to 97 mg/l (91.52 % COD removal). The BOD_5 had been reduced from 480 mg/l to 36 mg/l (92.50 % BOD_5 removal).

Nitrogen Requirements.

The nitrogen content of sludge is dependent on the type and nature of the active organisms produced in aerobic waste treatment System, the concentration of biological volatile solids and the concentration of available nitrogen in the waste. The ratio of microbial mass to total volatile solids will be variable depending on the waste. HEUKELEKIAN and MANGANELLI (1951) stated that to prevent nitrogen deficiency affecting in the waste treatment, nitrogen must be added to satisfy a BOD/N ratio between 17/1 - 22/1.

From sample no.1, table 17. and 21 showed the nitrogen requirements which expressed as the ammonia - nitrogen requirements 5.17 lb n/100 lb. COD removal and. 13.8 lb. N/100 lb BOD removal.

From sample no.2, table 18 and table 22. showed the nitrogen requirements which expressed as the ammonia - nitrogen requirements 5.45 lb. N/100 lb COD removal and 14.28 lb. N/100 lb BOD removal.

From sample no.3, table 19 and table 23 showed the nitrogen requirements which expressed as the ammonia - nitrogen requirements 5.53 lb. N/100 lb. COD removal and 15.8 lb. N/100 lb. BOD removal.

From sample no.4, table 20 and table 24 showed the nitrogen requirements which expressed as the ammonia - nitrogen requirements 5.03 lb. N/100 lb COD removal and 13.5 lb. N/100 lb. BOD removal.

These value of the nitrogen requirements from the experinent are showed that the high contents of the ammonia - nitrogen in the waste from slaughterhouses are adequate for nutrition.

Relationship between BOD_5 and COD

BOD_5 and COD relationship were determined during the period of aeration at time of interval 2 hrs. The ratio BOD_5 / COD of sample no.1, sample no.2, sample no.3, and sample no.4, were shown in table 9, table 10, table 11, table 12, and curve pattern of relationships were shown in fig 9, fig 10, fig 11, fig 12.

The ratio of BOD to COD ranged from 0.36 to 0.41. The mean value was 0.39, could be calculated after COD test were determined.

Sludge production and oxidation

Sludge production depend on the detention time. From this experiment the maximum value of sludge production was found at 10 hr. to 12 hr. time of aeration. From 12 hr. to 24 hr. time of aeration, sludge production should not increase because the endogeneous respiration occurred in the last twelve hours. The errors in this experiment may be caused by non - uniform dispersion of mixed liquor suspended solids, on the side wall of the unit. The patterns of sludge growth and oxidation are shown in Fig. 17, Fig.18, Fig.19, Fig. 20, which follow the sigmoidal curve.

The Variation of PH

The value of PH during experiment was 6.9 to 7.0. The value obtained without adding any chemical reagent. It was probably due to the characteristic of waste which have the neutral value in itself.

Dissolved oxygen Available

The oxygen concentration is high enough to ensure adequate oxygen utilization. It is found that dissolved oxygen concentration varied from 6.5 mg/l. to 6.8 mg/l. The pattern of dissolved oxygen were shown in Fig. 33, Fig. 34, Fig. 35, Fig. 36.

Micro - organism

In this experiment, micro - organism are commonly found in the form of Stalke ciliates. After 10 hours of aeration, the bacteria were found to be Vorticellar Sp., Opercularia Sp. and Epistylis Sp., Colpedium Sp.

Free swimming bacteria are also found in the form of Paramoecium Sp., Trichoda Sp. At 24 hr. of aeration, Worms and Rotifers are Commonly found at the last period of the endogeneous growth phase.

Table 1 a

FREQUENCY AND PROBABILITY OF COD EQUAL OR LESS THAN

Range of COD mg/l	Frequency	% Probability less than or equal to.
0 - 200	2	2.72
200 - 400	6	10.88
400 - 600	19	36.72
600 - 800	23	68.00
800 - 1000	9	80.24
1000 - 1200	6	88.40
1200 - 1400	6	96.56
1400 - 1600	1	97.92
1600 - 1800	1	100
	73	

The COD of waste used as design creteria is 950 mg/l to 1150 mg/l with 80 % to 85 % of chance. More than 85 % certainty can be used but the COD of waste will be very high and it is found from the experiments that the COD of waste is seldom higher than 1150 mg/l.

Table 1 b.

RAW CHARACTERISTICS OF WASTE FROM SLAUGHTERHOUSES

	Hogs		Cattles	
Subjects	Sample No 1 9.00-10.00pm	Sample No 2 9.00-10.00 pm	Sample No 3 10.00-11.00 am	Sample No 4 10.00-11.00 am
BOD_5 mg/l	362	237	437.	480.
COD mg/l	950	612	1150	1145
D.O. mg/l	0	0.1	0	O.
NH_3 - N	308	212	302	347.
NO_3 - N	6.8	6.2	2.8	8.2
pH	6.9	7.0	7.0	6.8.
Suspended Solids	1364	1030	1477	1340
Temperature	28 °C	28 °C	28 °C	28 °C

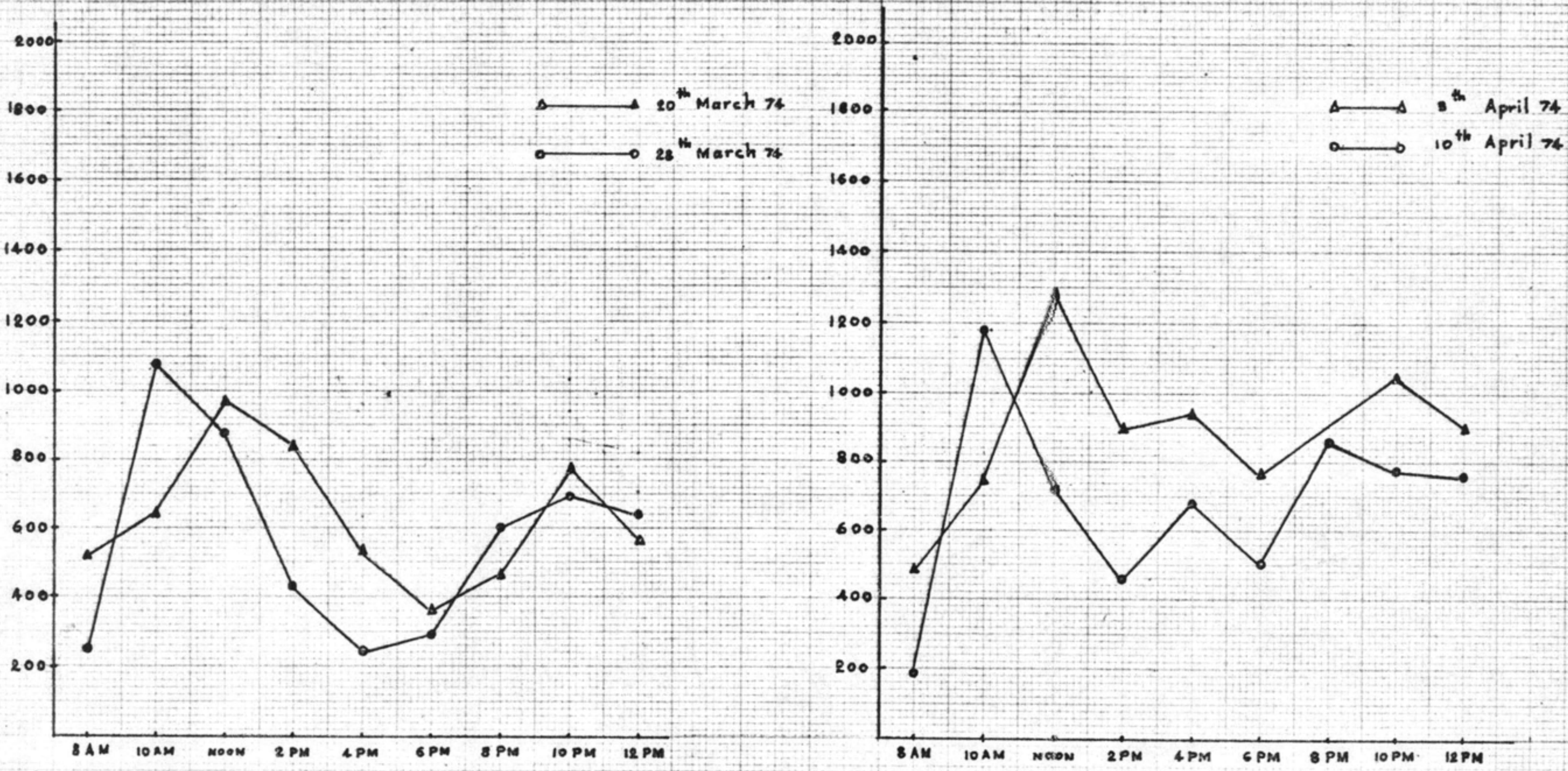


Fig 1a COD Variation of waste from Slaughterhouses

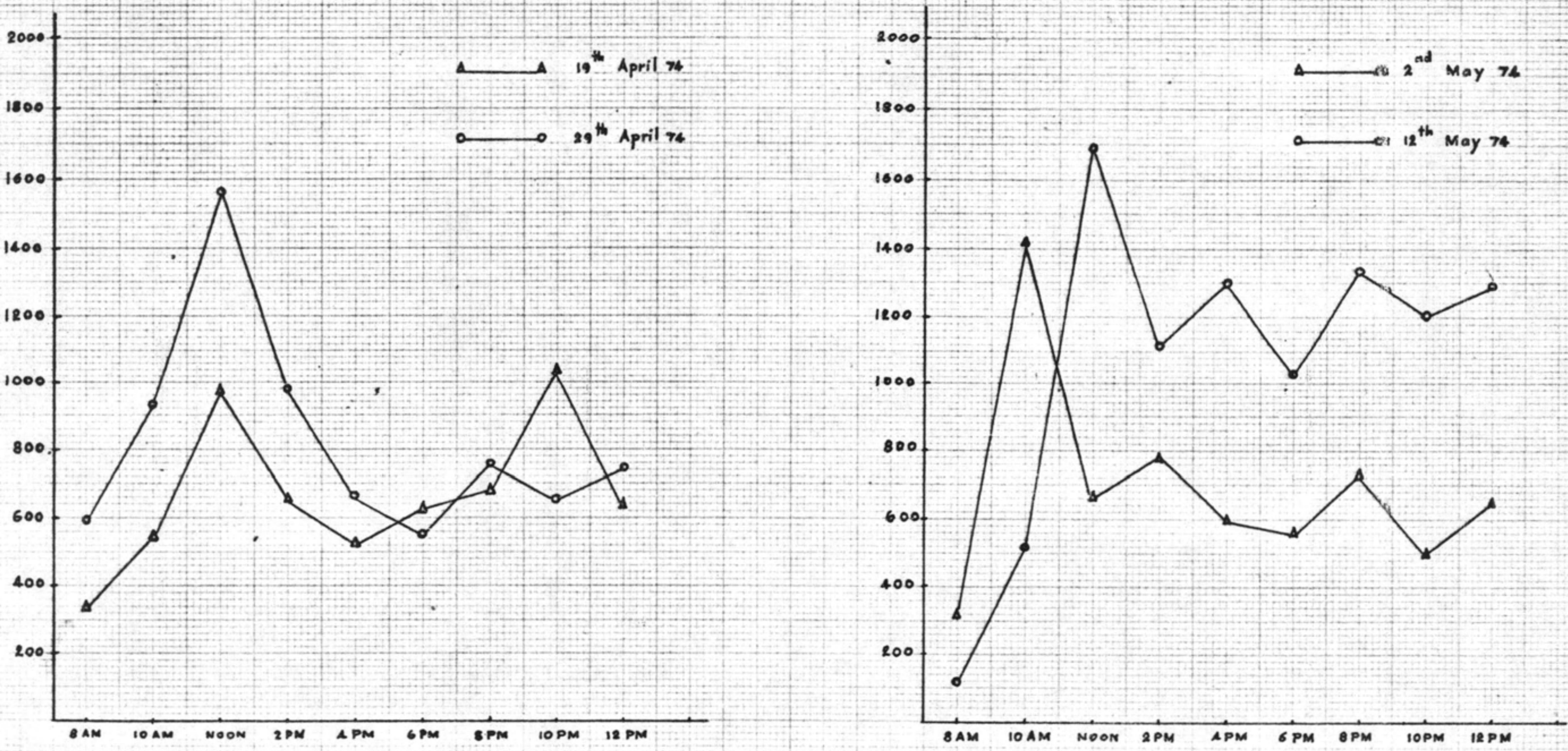


Fig 1b COD Variation of waste from Slaughterhouses

Table 1

COD REMOVAL CHARACTERISTIC

SAMPLE NO 1

t. hr.	Sa.t.	C_o	% COD Removal	% COD Remaining
0	0	950		
2	2990	472	50.32	49.69
4	5980	268	71.79	28.21
6	8970	245	74.21	25.79
8	11960	204	78.53	21.47
10	14950	139	85.37	14.64
12	17940	118	87.58	12.42
24	35880	72	92.42	7.58

Where : –

C_o = COD concentration at time t, mg/l

Sa = The Average Sludge Concentration over the Range Under Consideration = 1495

t = time of Aeration, hr.

Table 2.

COD REMOVAL CHARACTERISTIC

SAMPLE NO 2

t. hr.	Sa.t.	C_o	% COD Removal	% COD Remaining
0		612		
2	2176	305	50.16	49.84
4	4352	286	53.27	46.73
6	6528	235	61.60	38.40
8	8704	152	75.16	24.84
10	10880	95	84.48	15.52
12	13056	74	86.93	13.07
24	26112	55	91.01	8.99

Where :-

C_o = COD concentration at time t, mg/l

Sa = The Average Sludge Concentration over the Range Under Consideration = 1088

t = Time of Aeration, hr.

Table 3.

COD REMOVAL CHARACTERISTIC

SAMPLE NO 3

t. hr.	Sa.t.	C_o	% COD Removal	% COD Remaining
0		1150		
2	2930	728	36.21	63.79
4	5860	657	42.80	57.20
6	8790	515	55.22	44.78
8	11720	423	63.15	36.85
10	14650	358	77.56	22.44
12	17580	115	89.99	10.01
24	35160	56	95.25	4.75

Where :-

C_o = COD concentration at time t, mg/l

Sa = The Average Sludge Concentration over the Range Under Consideration = 1465

t = Time of Aeration , hr.

Table 4.

COB REMOVAL CHARACTERISTIC

SAMPLE NO 4

t. hr.	Sa. t.	COD	% COD Removal	% COD Remaining
0		1145		
2	2934	615	46.28	53.72
4	5868	523	54.32	49.68
6	8802	401	64.97	35.03
8	11736	303	73.53	26.47
10	14670	260	77.29	22.71
12	11604	117	89.78	10.22
24	35208	97	91.52	8.48

Where : -

COD = COD concentration at time t, mg/l

Sa = 1467 mg/l

t = Time of Aeration, hr.

Table 5.

BOD_5 – COD REMOVAL AND REMAINING AT VARIOUS TIME OF AERATION

SAMPLE NO 1

Time hr	COD mg/l	% COD Removal	% COD Remaingin	BOD_5 mg/l	% BOD_5 Removal	% BOD Remaining
0	950			362		
2	472	50.32	49.68	185	48.90	51.10
4	268	71.79	28.21	92	74.59	25.41
6	245	74.21	25.79	84	76.80	23.20
8	204	78.53	21.47	76	79.01	20.99
10	139	85.37	14.64	63	82.60	17.40
12	118	87.58	12.42	46	87.29	12.71
24	72	92.42	7.58	31	91.44	8.56

Start with the waste from Slaughterhouses 45 litre

Sludge Return = 25 %

pH = 6.9

Temperature = 28 °C

Table 6.

BOD_5 - COD REMOVAL AND REMAINING AT VARIOUS TIME OF AERATION

SAMPLE NO 2

Time hr	COD mg/l	% COD Removal	% COD Remaining	BOD_5 mg/l	% BOD_5 Removal	% BOD Remaining
0	612			237		
2	305	50.16	49.84	118	50.21	49.79
4	286	53.27	46.73	104	56.12	43.88
6	235	61.60	38.40	87	63.29	36.71
8	152	75.16	24.84	58	75.53	24.47
10	95	84.48	15.52	35	85.23	14.77
12	80	86.93	13.07	29	87.76	12.24
24	55	91.01	8.99	17	92.83	7.17

Start with the waste from Slaughterhouses = 50 litre

Sludge Return = 30 %

pH = 7.0

Temperature = 28 °C.

Table 7.

BOD_5 - COD REMOVAL AND REMAINING AT VARIOUS TIME OF AERATION

SAMPLE NO 3

Time hr.	COD mg/l	% COD Removal	% COD Remaining	BOD_5 mg/l	% BOD_5 Removal	% BOD Remaining
0	1150			437		
2	728	36.21	63.79	275	37.10	62.90
4	657	42.80	57.20	240	45.08	54.92
6	515	55.22	44.78	183	58.12	41.88
8	423	63.15	36.85	151	65.45	34.55
10	258	77.56	22.44	108	75.29	24.71
12	115	89.99	10.01	71	83.75	16.25
24	56	95.25	4.75	25	94.28	5.72

Table 8.

BOD$_5$ - COD REMOVAL AND REMAINING AT VARIOUS TIME OF AERATION

SAMPLE NO 4

Time hr.	COD mg/l	% COD Removal	% COD Remaining	BOD$_5$ mg/l	% BOD$_5$ Removal	% BOD Remaining
0	1145			480		
2	615	46.28	53.72	234	51.25	48.75
4	523	54.32	45.68	201	58.12	41.88
6	401	64.97	35.03	168	65.00	35.00
8	303	73.53	26.47	117	75.62	24.63
10	260	77.29	22.71	99	79.37	20.63
12	117	89.78	10.22	48	90.00	10.00
24	97	91.52	8.48	36	92.50	7.50

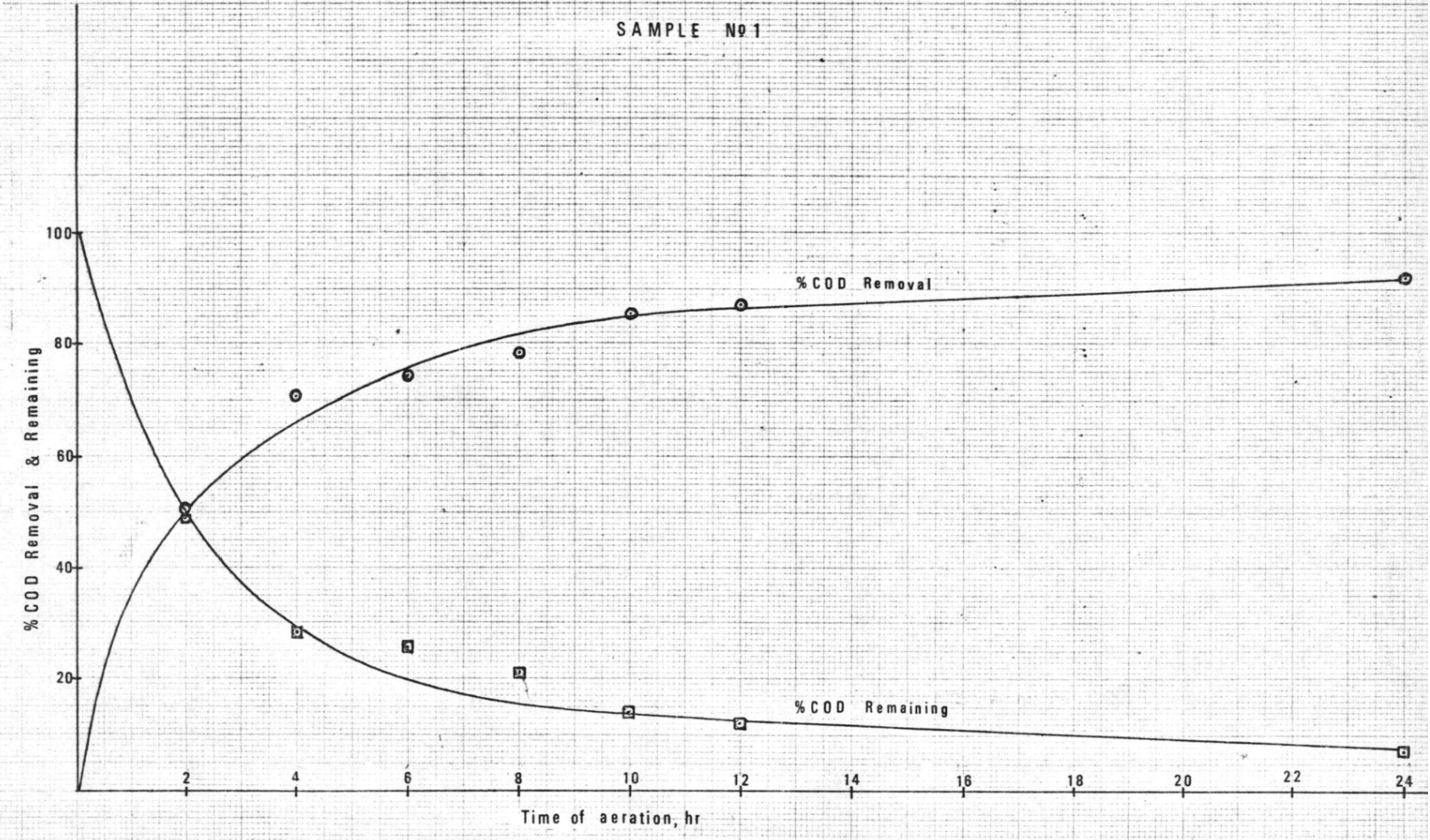


Fig 1 % COD Removal & Remaining VS Time of Aeration

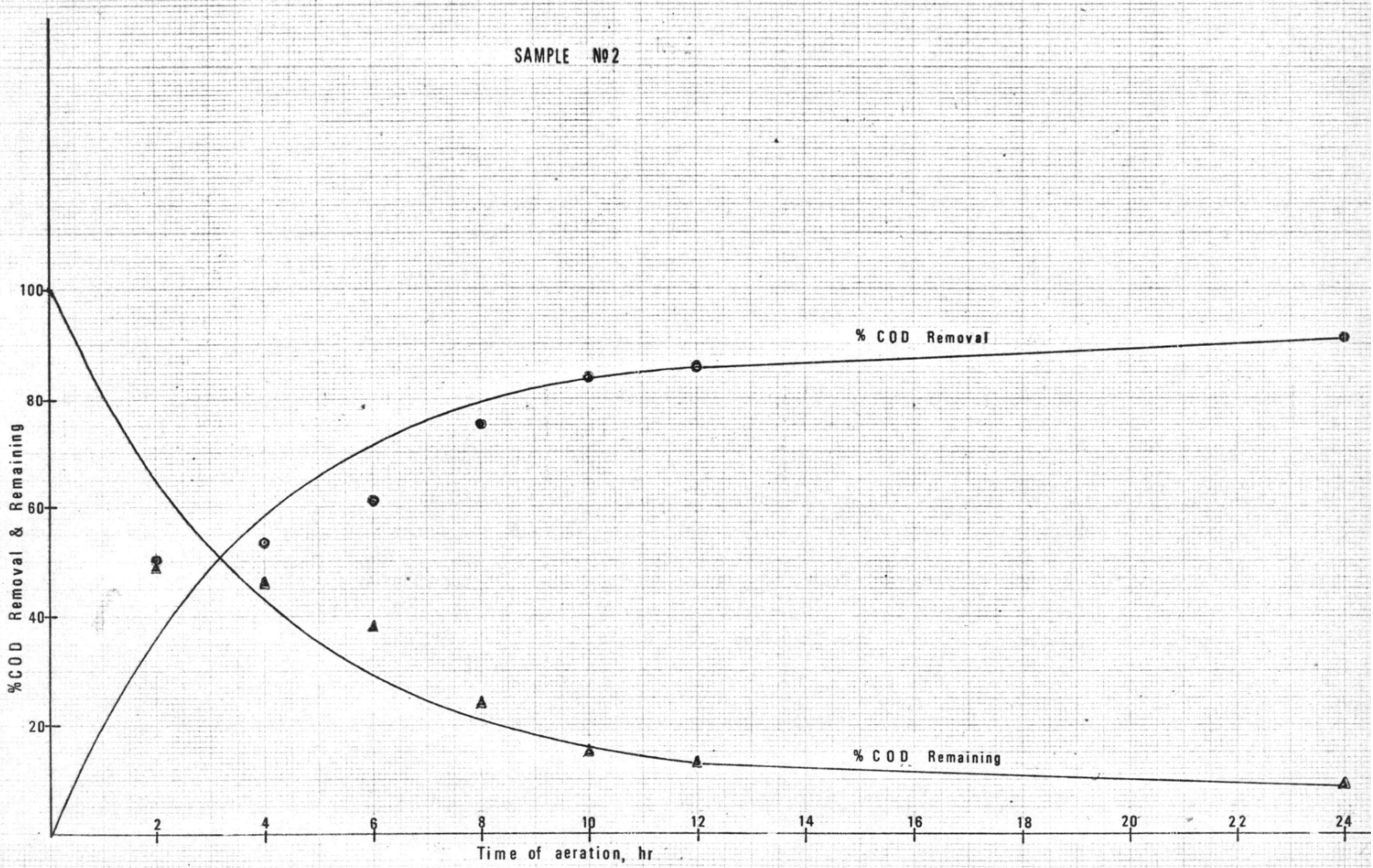


Fig 2 % COD Removal & Remaining VS Time of Aeration

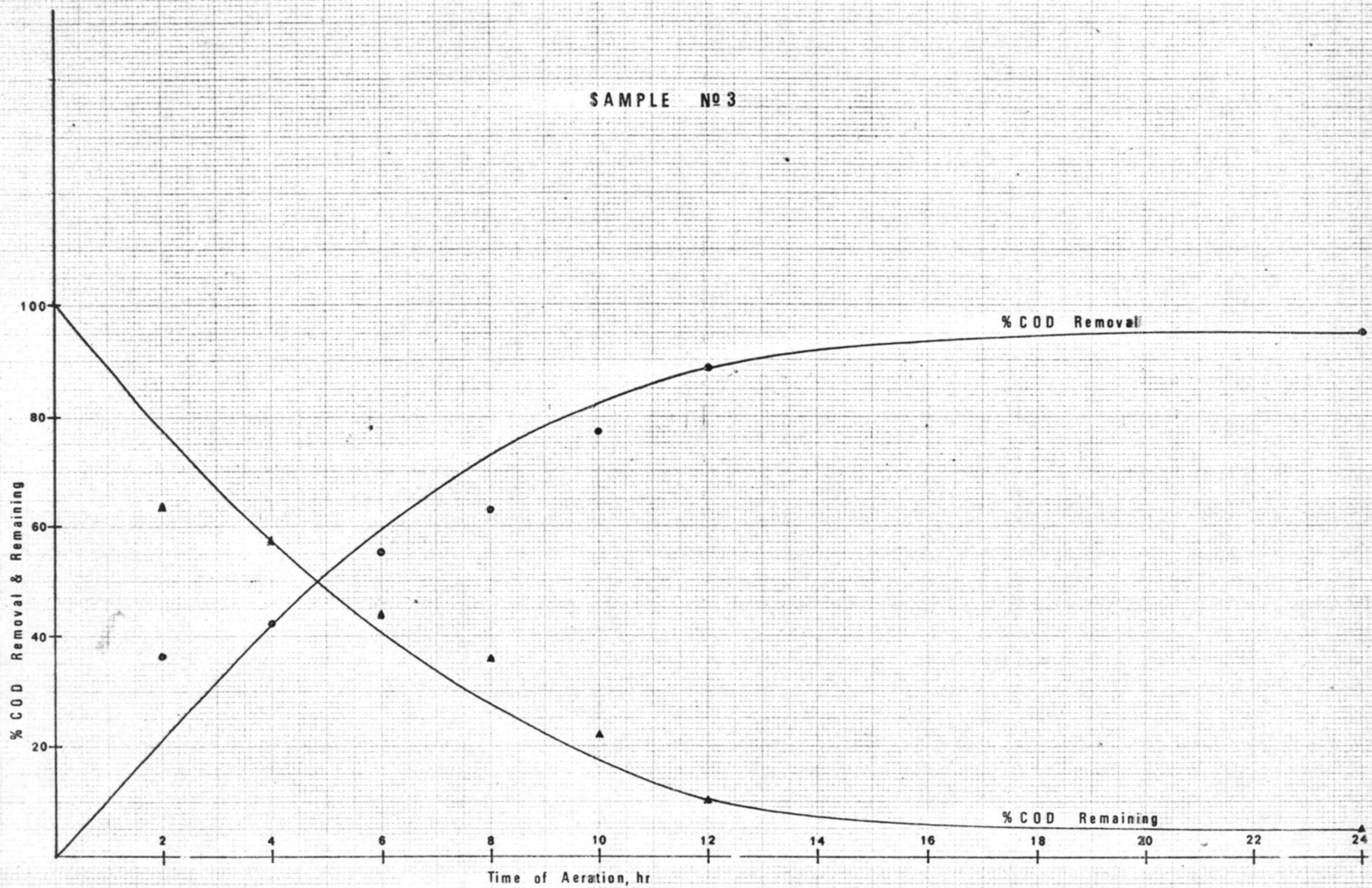


Fig 3 % COD Removal & Remaining VS Time of Aeration

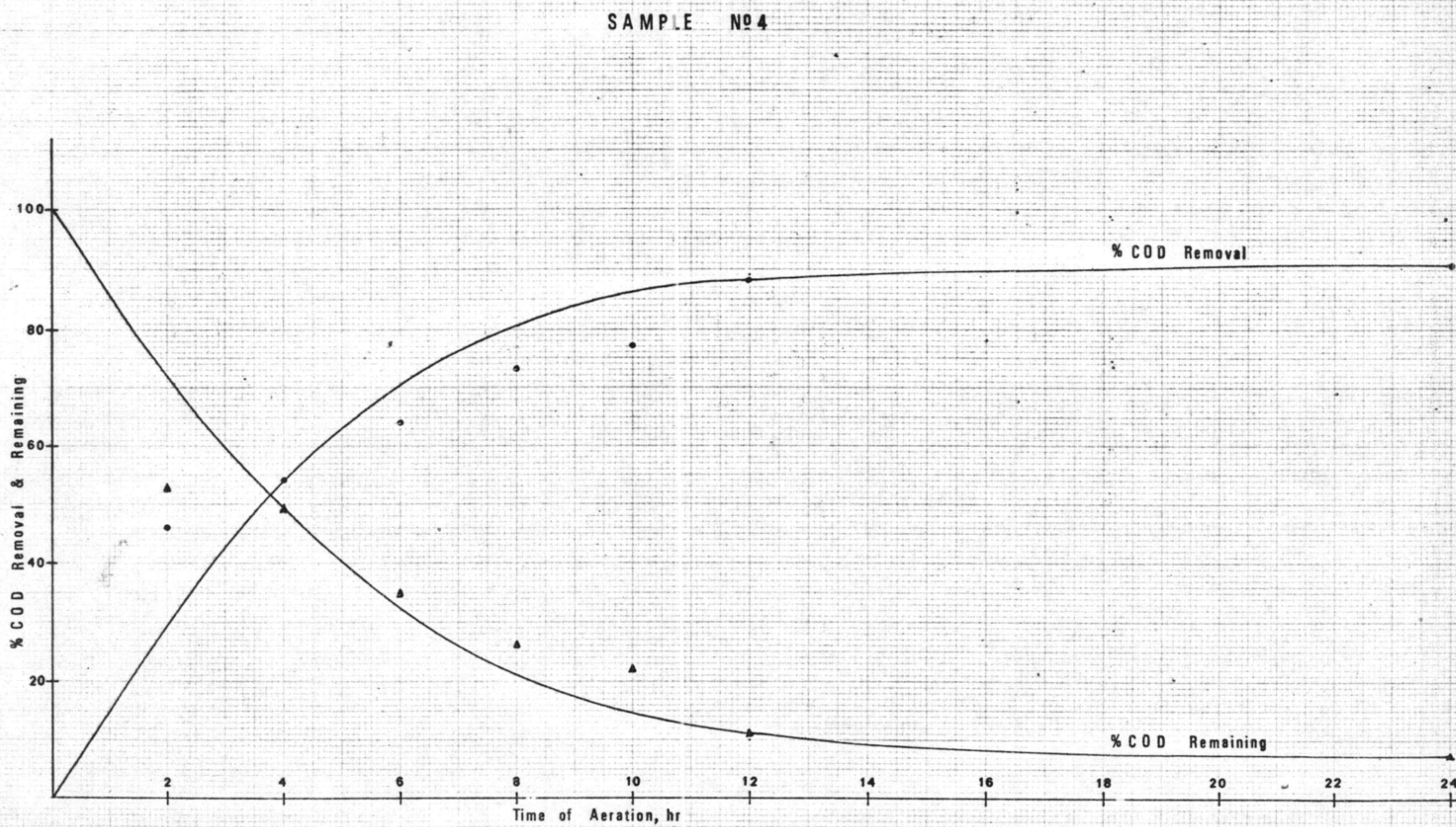


Fig 4 % COD Removal & Remainig VS Time of Aeration

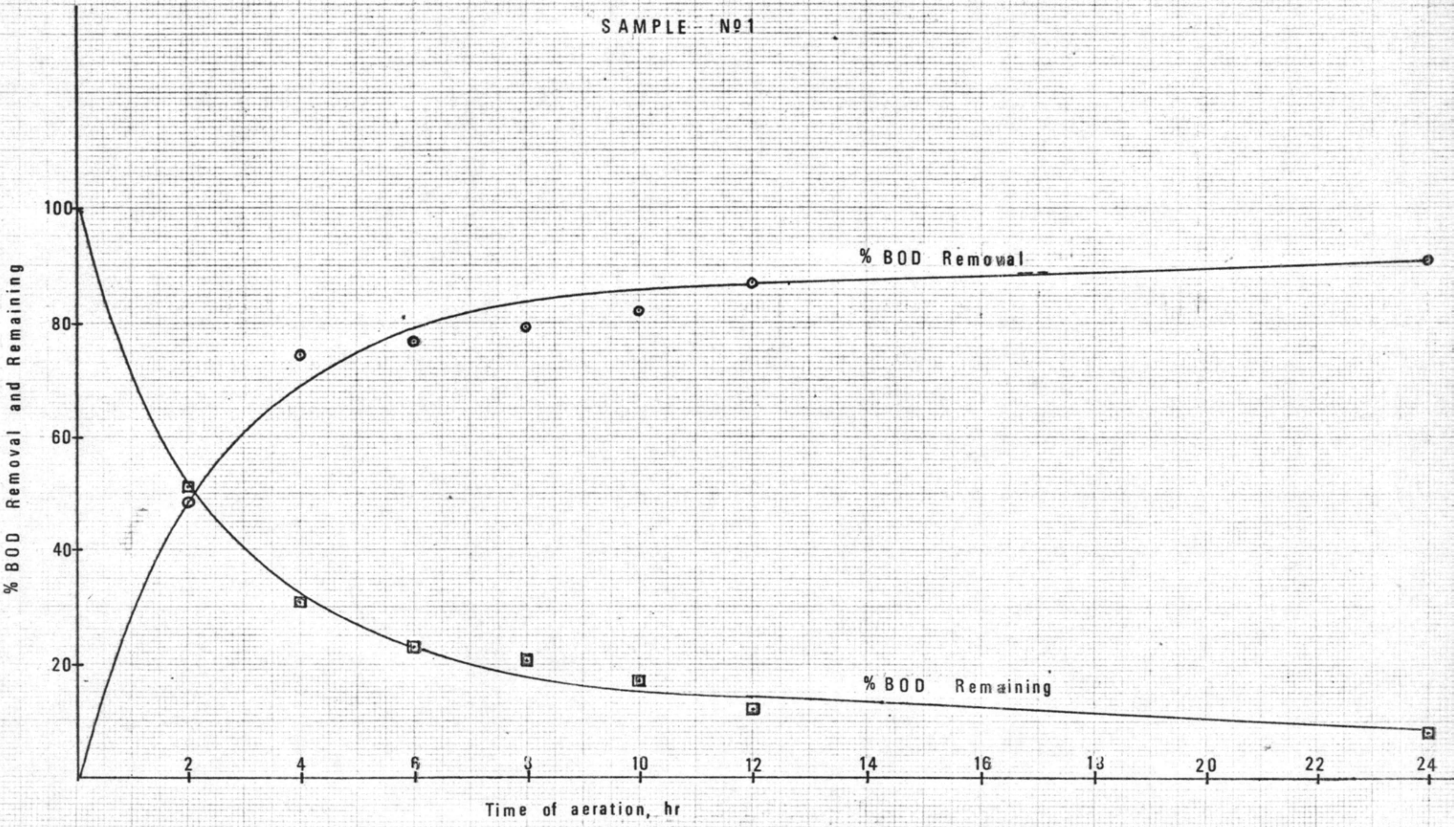


Fig 5 % BOD Removal and Remaining VS Time of Aeration

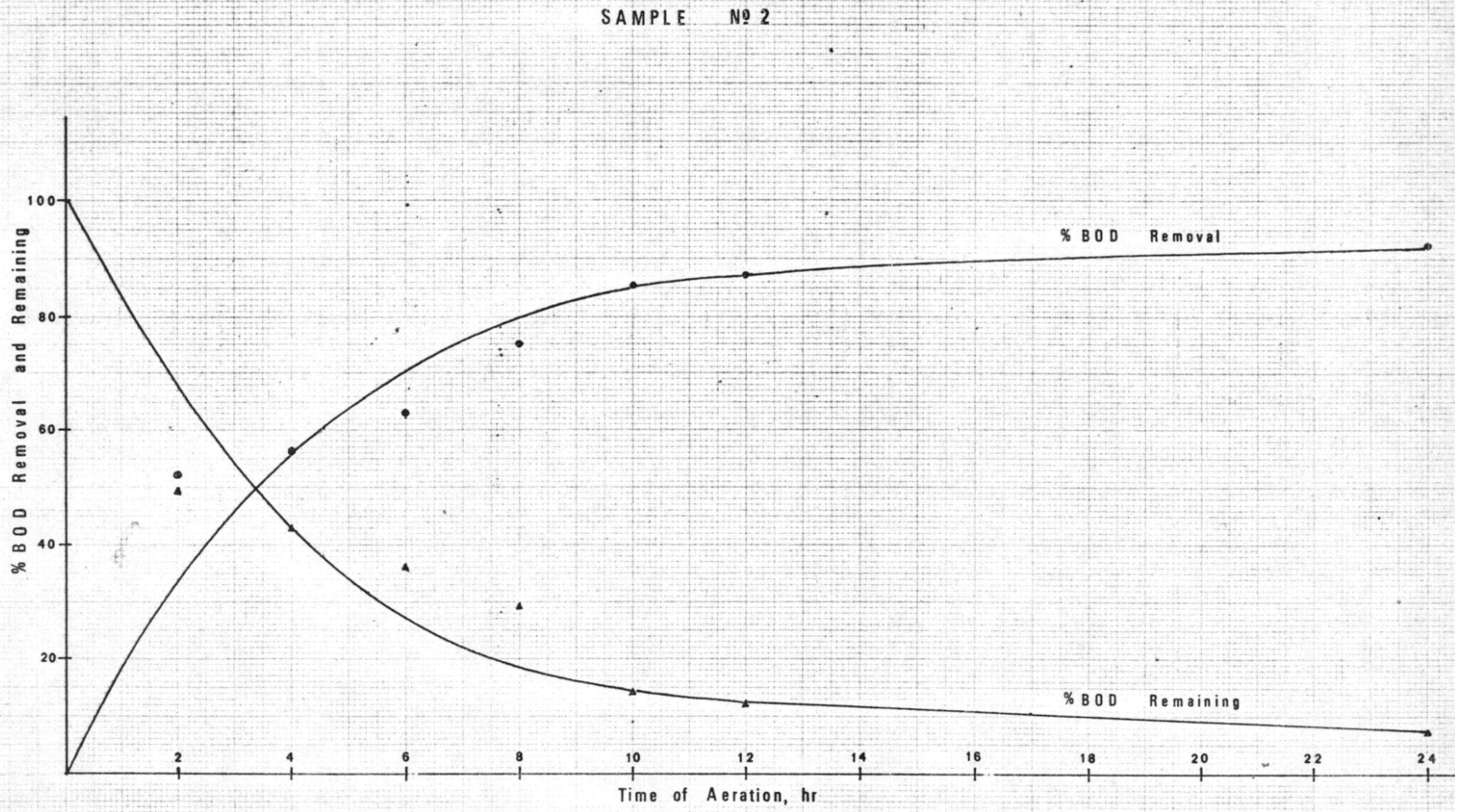


Fig 6 % BOD Removal and Remaining VS Time of Aeration

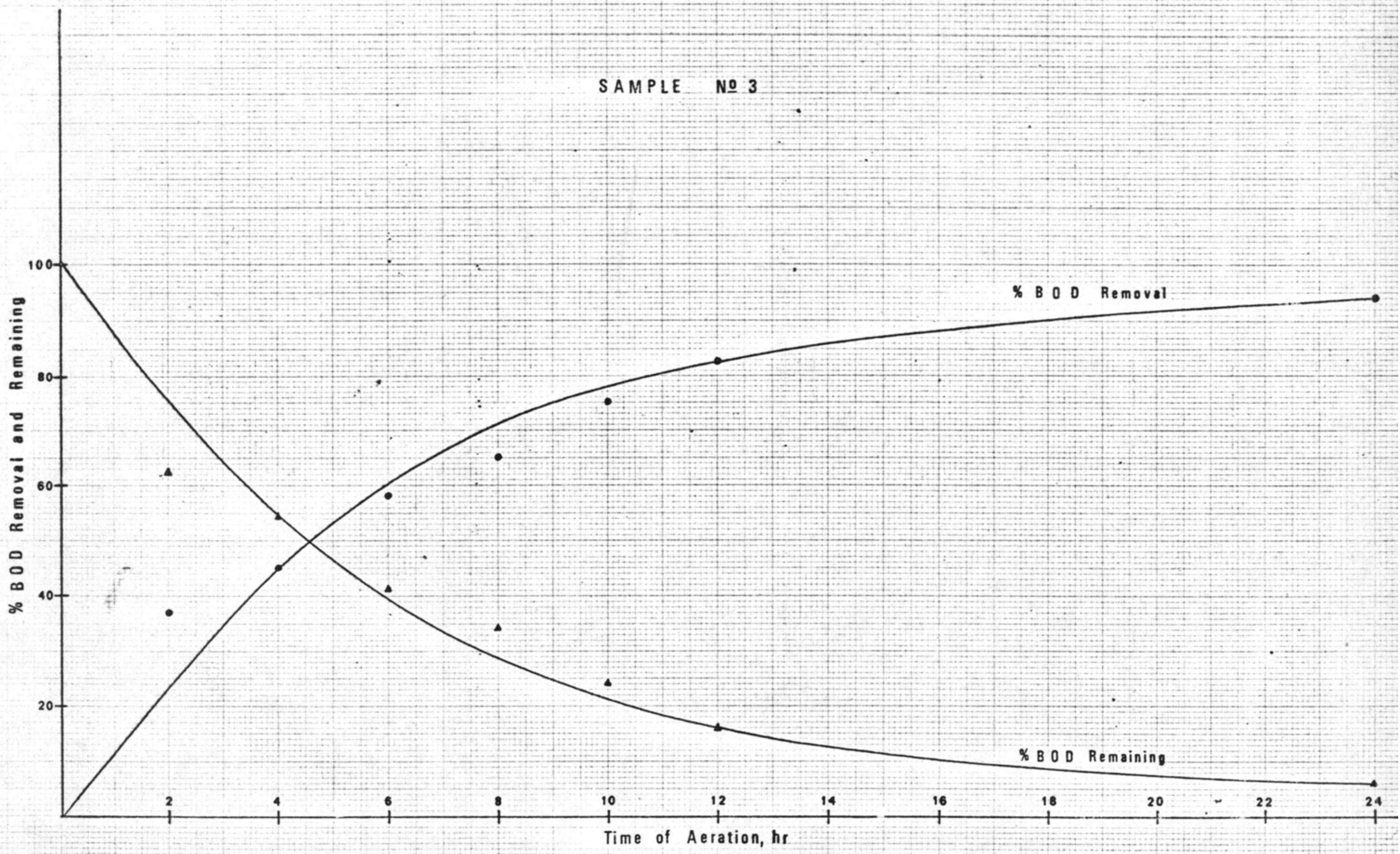


Fig 7 % B O D Removal and Remaining VS Time of Aeration

SAMPLE Nº 4

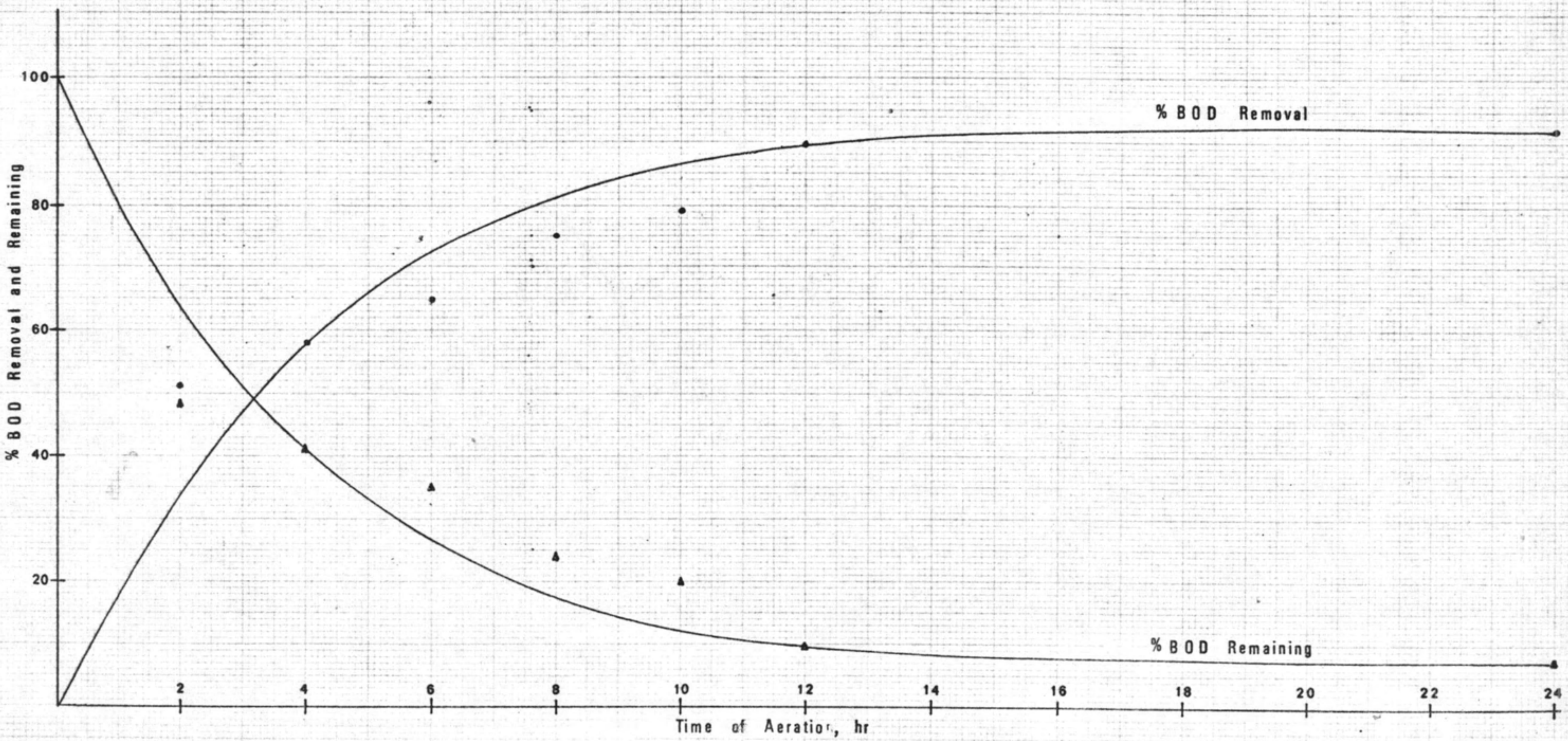


Fig 8 % B O D Removal and Remaining VS Time of Aeration

Table 9

DETERMINATION OF BOD_5 : COD

SAMPLE NO 1

Time hr.	COD mg/1	BOD_5 mg/1	BOD_5 / COD
0	950	362	0.381
2	472	185	0.391
4	268	92	0.342
6	245	84	0.342
8	204	75	0.371
10	139	63	0.452
12	118	46	0.389
24	72	31	0.430

Σx. 3.098

Average 0.387

Table 10

DETERMINATION OF BOD_5 : COD [illegible]

SAMPLE NO 2

Time hr.	COD mg/l	BOD_5 mg/l	BOD_5/ COD
0	612	237	0.387
2	305	118	0.386
4	286	104	0.363
6	235	87	0.370
8	152	58	0.381
10	95	35	0.368
12	80	29	0.362
24	55	17	0.309

$\Sigma x.$ 2.926

Average = 0.365

Table 11.

DETERMINATION OF BOD_5 : COD

SAMPLE NO 3

Time hr.	COD mg/l	BOD_5 mg/l	BOD_5 / COD
0	1150	457	0.38
2	728	275	0.377
4	657	240	0.365
6	515	183	0.355
8	423	151	0.357
10	258	108	0.418
12	115	71	0.617
24	56	25	0.446

Ex 3.315

Average = 0.41

Table 12.

DETERMINATION OF BOD_5 : COD RATIO

SAMPLE NO 4

Time hr.	COD mg/l	BOD_5 mg/l	BOD_5 / COD
0	1145	480	0.419
2	615	234	0.380
4	523	201	0.384
6	401	168	0.418
8	303	117	0.386
10	260	99	0.380
12	117	48	0.410
24	97	36	0.371

Ex. 3.148

Average 0.39

Ex. Sample No 1, 2, 3, 4 = 12.487

Average = 0.39

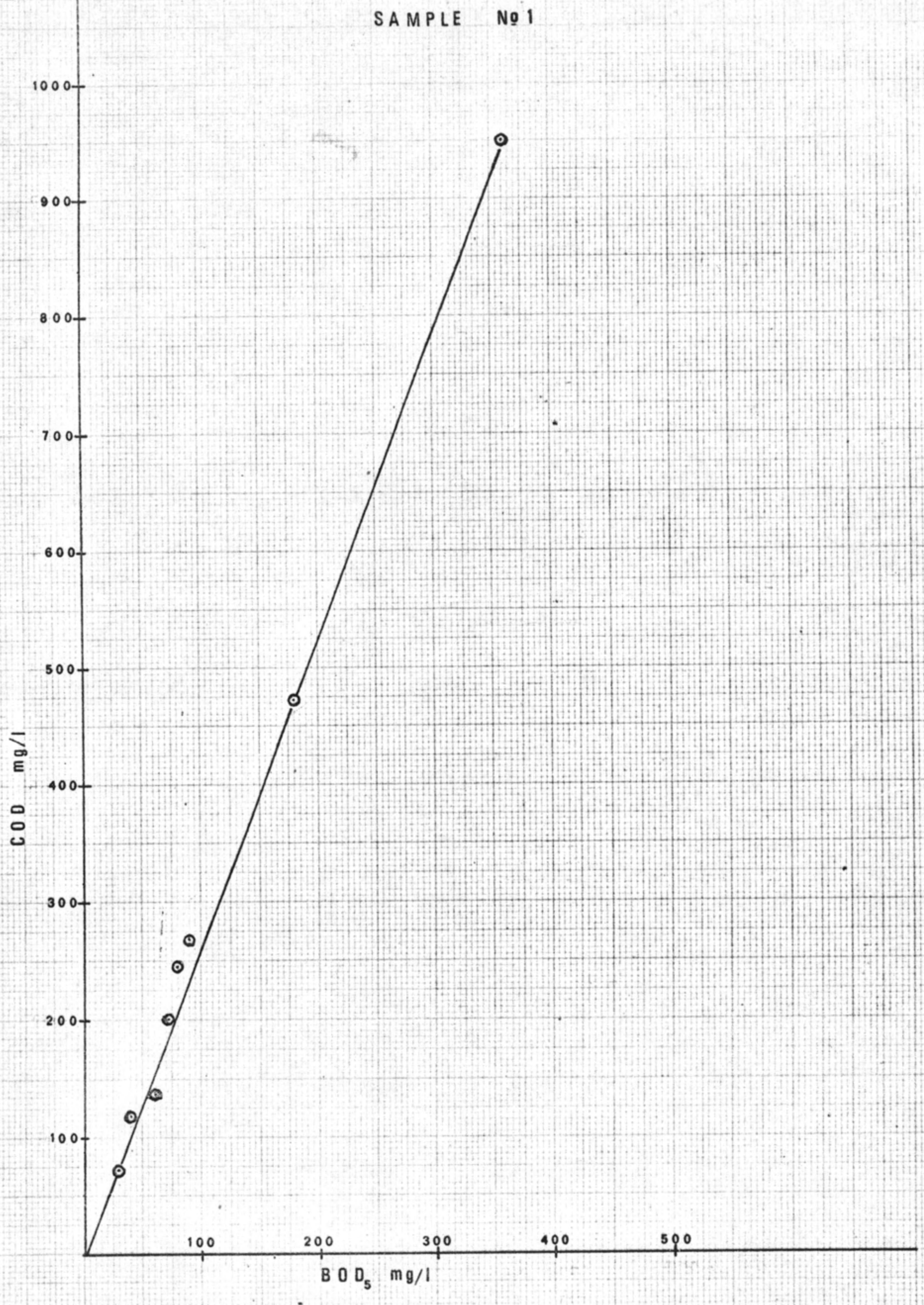


Fig 9 COD & BOD$_5$ Relationship

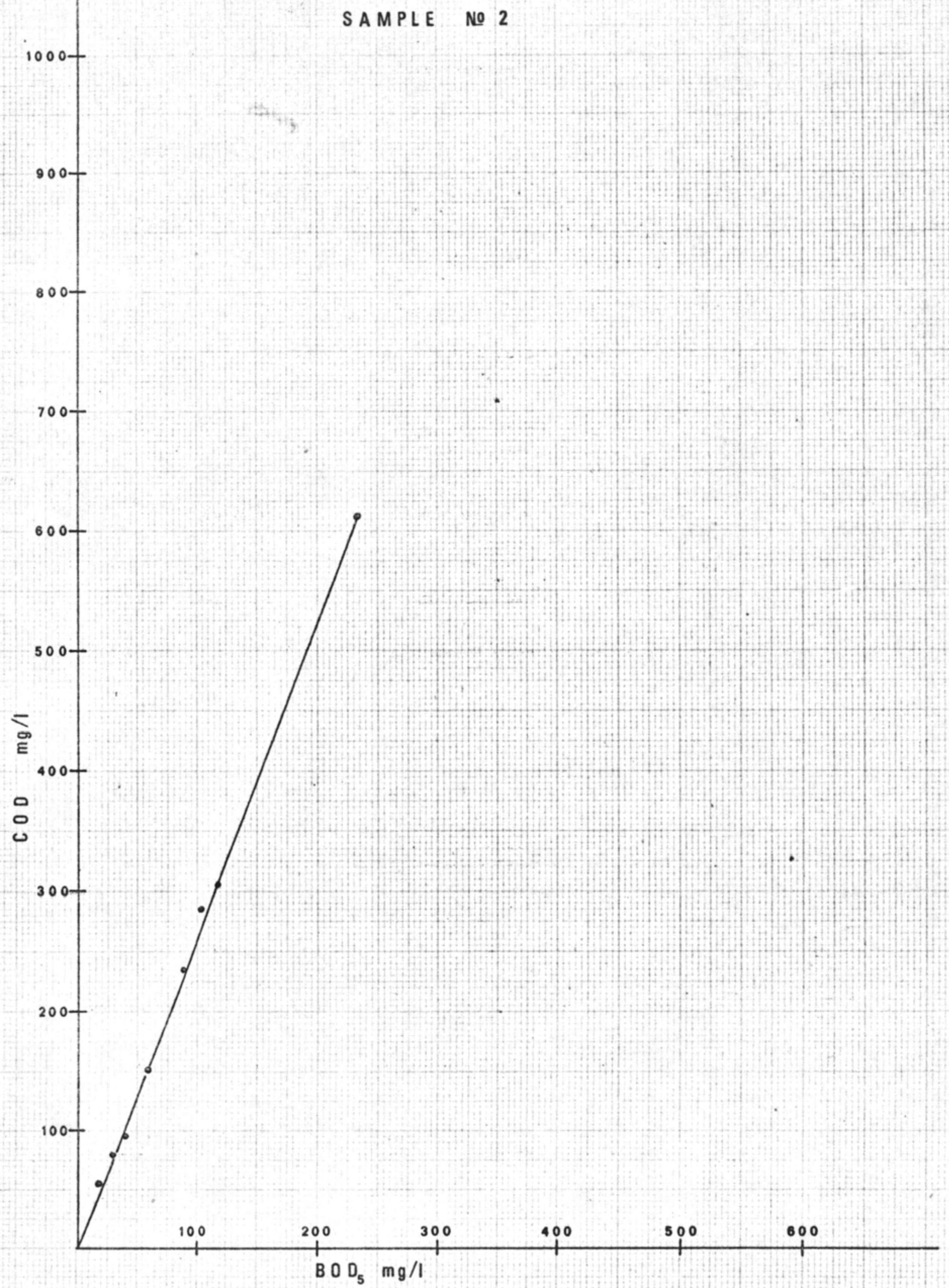


Fig 10 C O D & B O D_5 Relationship

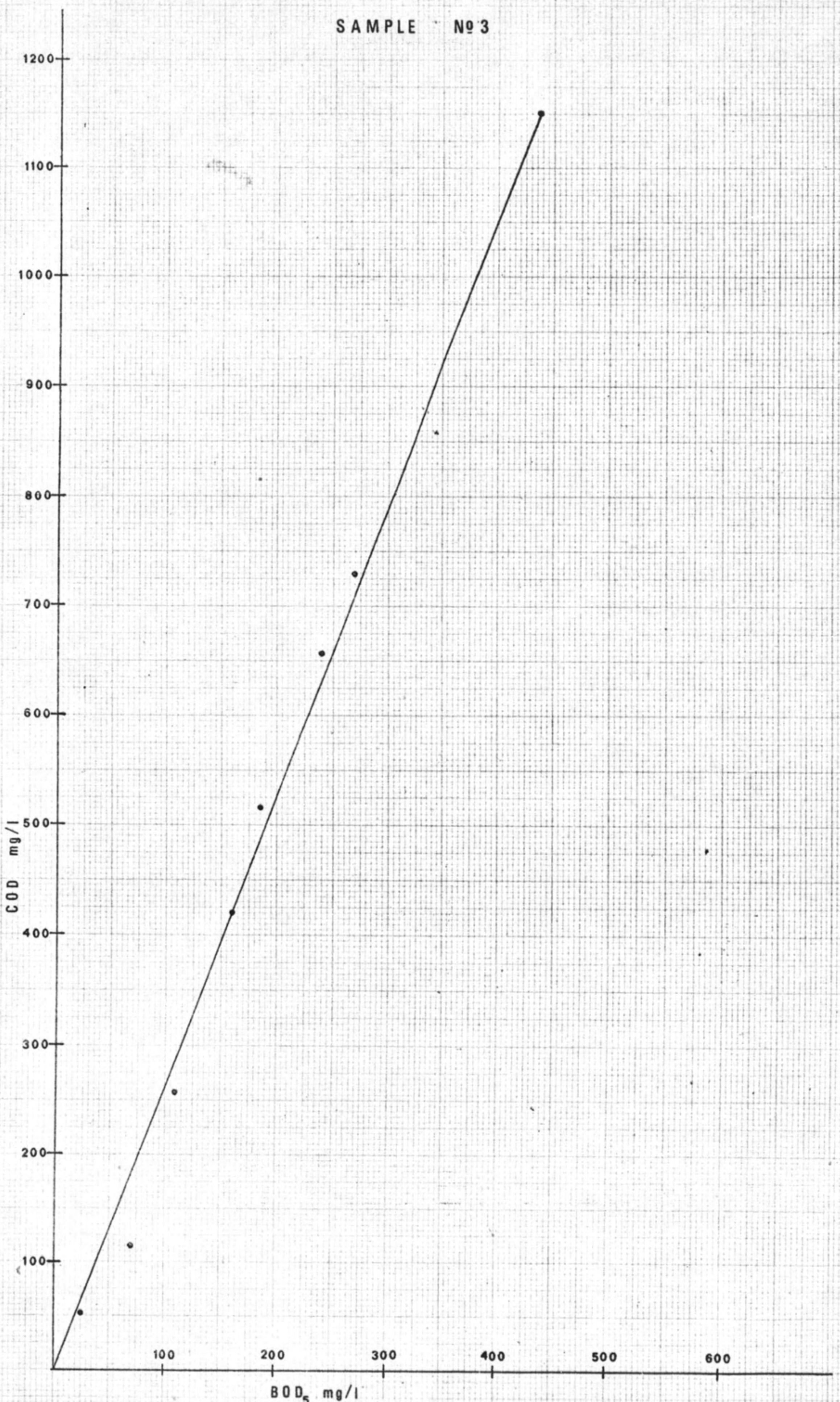


Fig 11 COD & BOD_5 Relationship

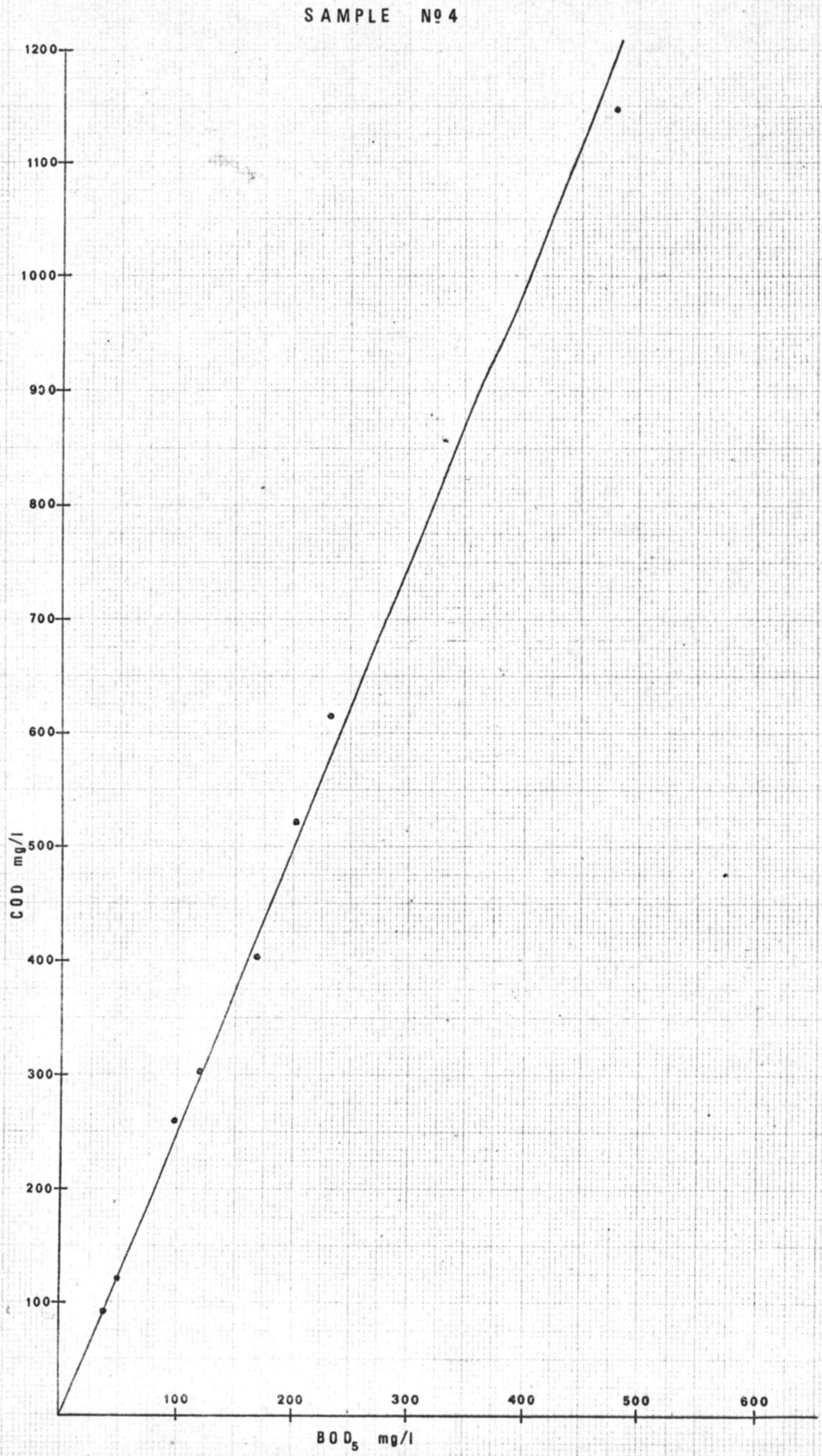


Fig 12 COD & BOD_5 Relationship

Table 13.

CONCENTRATION OF SOLID AT VARIOUS TIME OF AERATION

SAMPLE NO 1

T hr.	Volatile Solid mg/l	Suspended Solid mg/l	Dissolved Solid mg/l	Total Solid mg/l
0	1195	1364	969	2333
2	1280	1486	980	2466
4	1350	1582	997	2579
6	1395	1630	1009	2639
8	1446	1690	1011	2701
10	1482	1715	998	2713
12	1474	1680	902	2582
24	1266	1402	1021	2423

Where :

T = Time of Aeration, hr.

Table 14.

CONCENTRATION OF SOLID AT VARIOUS TIME OF AERATION

SAMPLE NO 2

T. hr.	Volatile Solid mg/l	Suspended Solid mg/l	Dissolved Solid mg/l	Total Solid mg/l
0	1017	1030	1010	2040
2	1047	1069	1021	2090
4	1050	1089	1011	2100
6	1063	1142	973	2115
8	1071	1237	893	2130
10	1083	1250	905	2155
12	1040	1224	836	2060
24	975	1152	788	1940

Wher :

T = Time of Aeration, hr.

Table 15.

CONCENTRATION OF SOLID AT VARIOUS TIME OF AERATION

SAMPLE NO 3.

T. hr.	Volatile Solid mg/1	Suspended Solid mg/1	Dissolved Solid mg/1	Total Solid mg/1
0	1281	1477	1085	2562
2	1304	1507	1096	2603
4	1348	1546	1098	2644
6	1362	1656	1074	2730
8	1423	1757	1074	2831
10	1464	1828	1032	2860
12	1399	1775	917	2692
24	1352	1583	1048	2631

Where : -

T = Time of Aeration, hr.

Table 16.

CONCENTRATION OF SOLID AT VARIOUS TIME OF AERATION

SAMPLE NO 4

T. hr.	Volatile Solid mg/l	Suspended Solid mg/l	Dissolved Solid mg/l	Total Solid mg/l
0	1180	1340	993	2333
2	1226	1370	996	2366
4	1305	1403	1020	2423
6	1360	1490	1098	2588
8	1432	1620	1146	2766
10	1452	1670	1100	2770
12	1440	1610	952	2562
24	1297	1380	1159	2539

Where : -

T = Time of Aeration, hr.

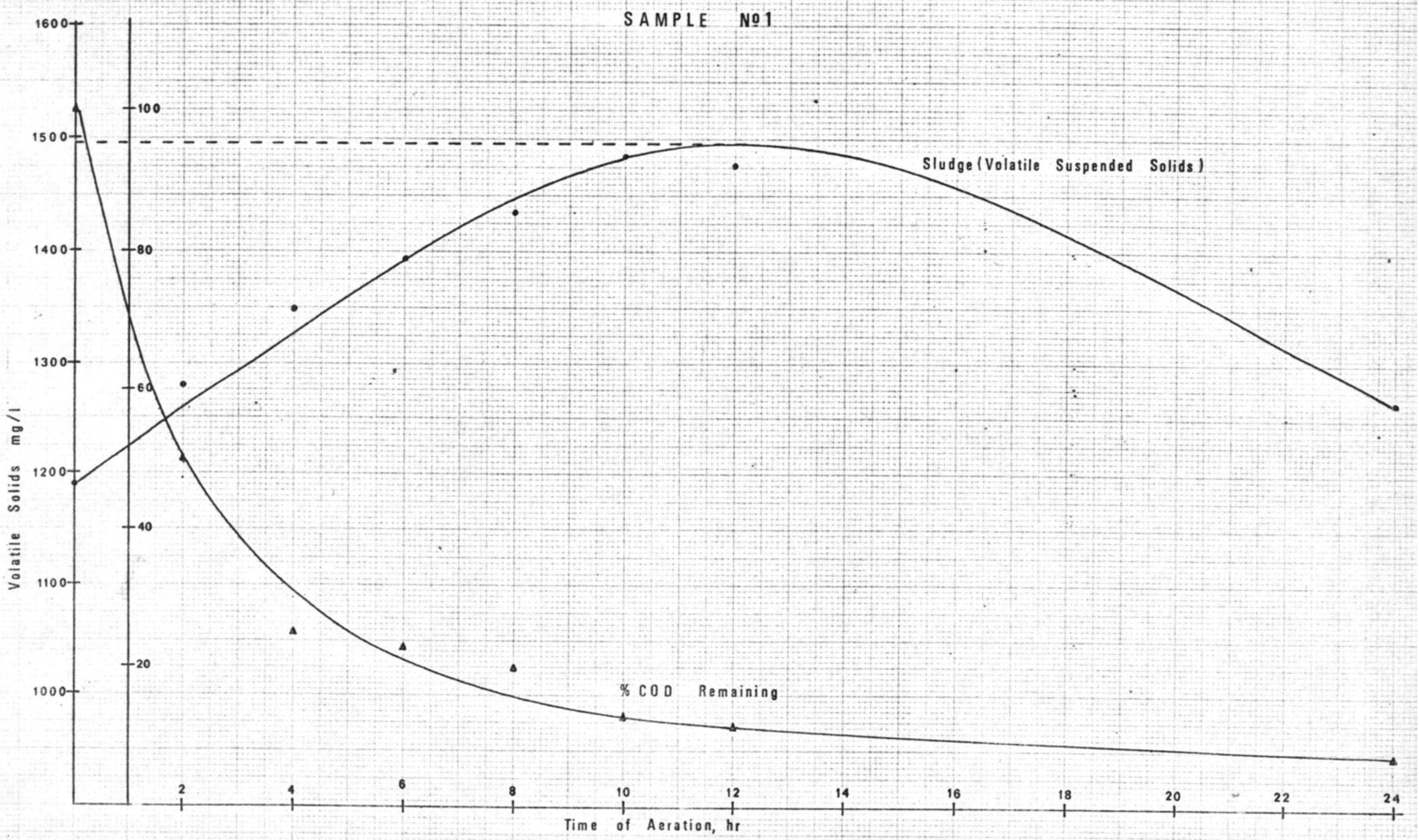


Fig 13 COD Remainining and Sludge Growth Relationship

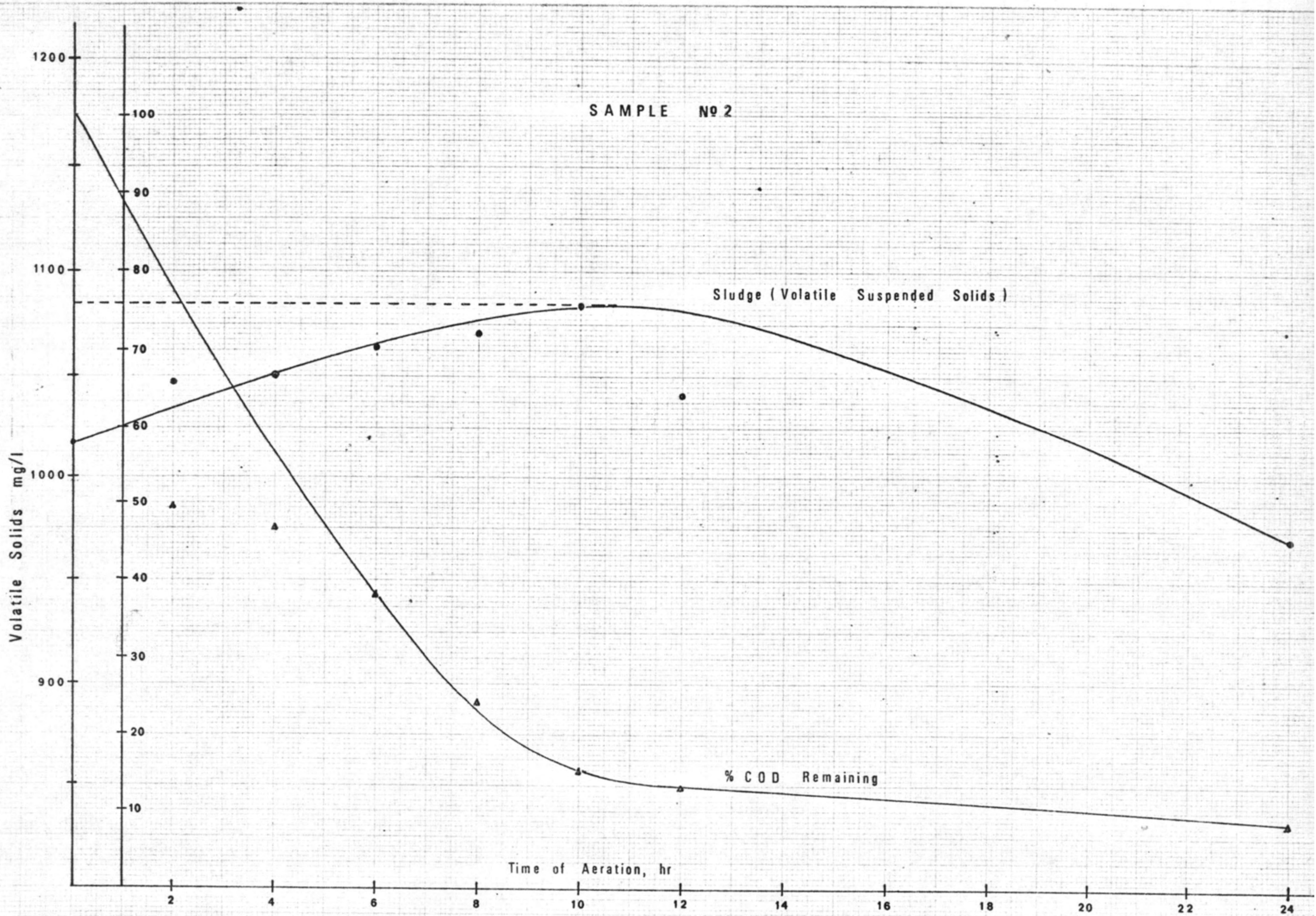


Fig 14 COD Remainining and Sludge Growth Relationship

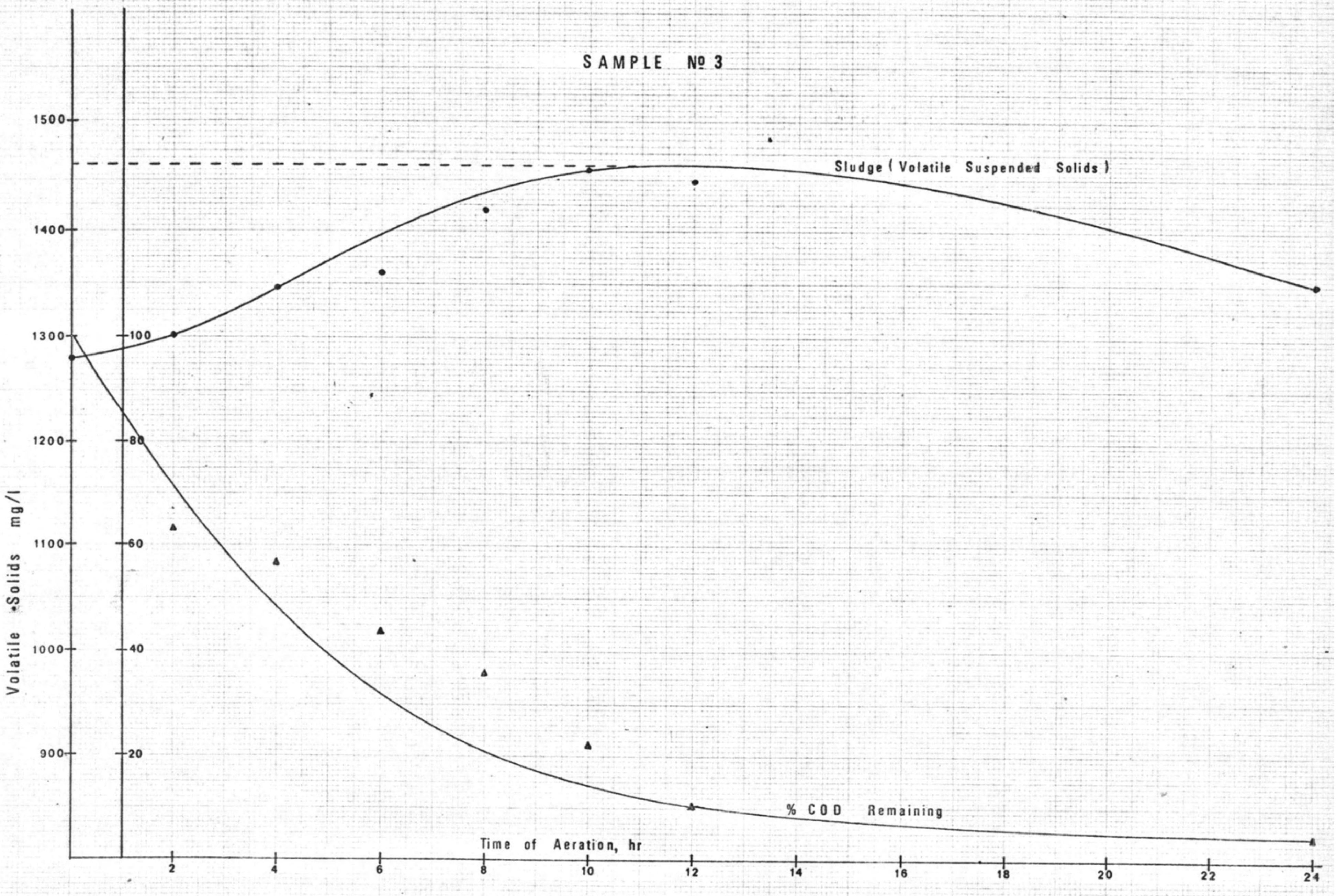


Fig 15 COD Remaining and Sludge Growth Relationship

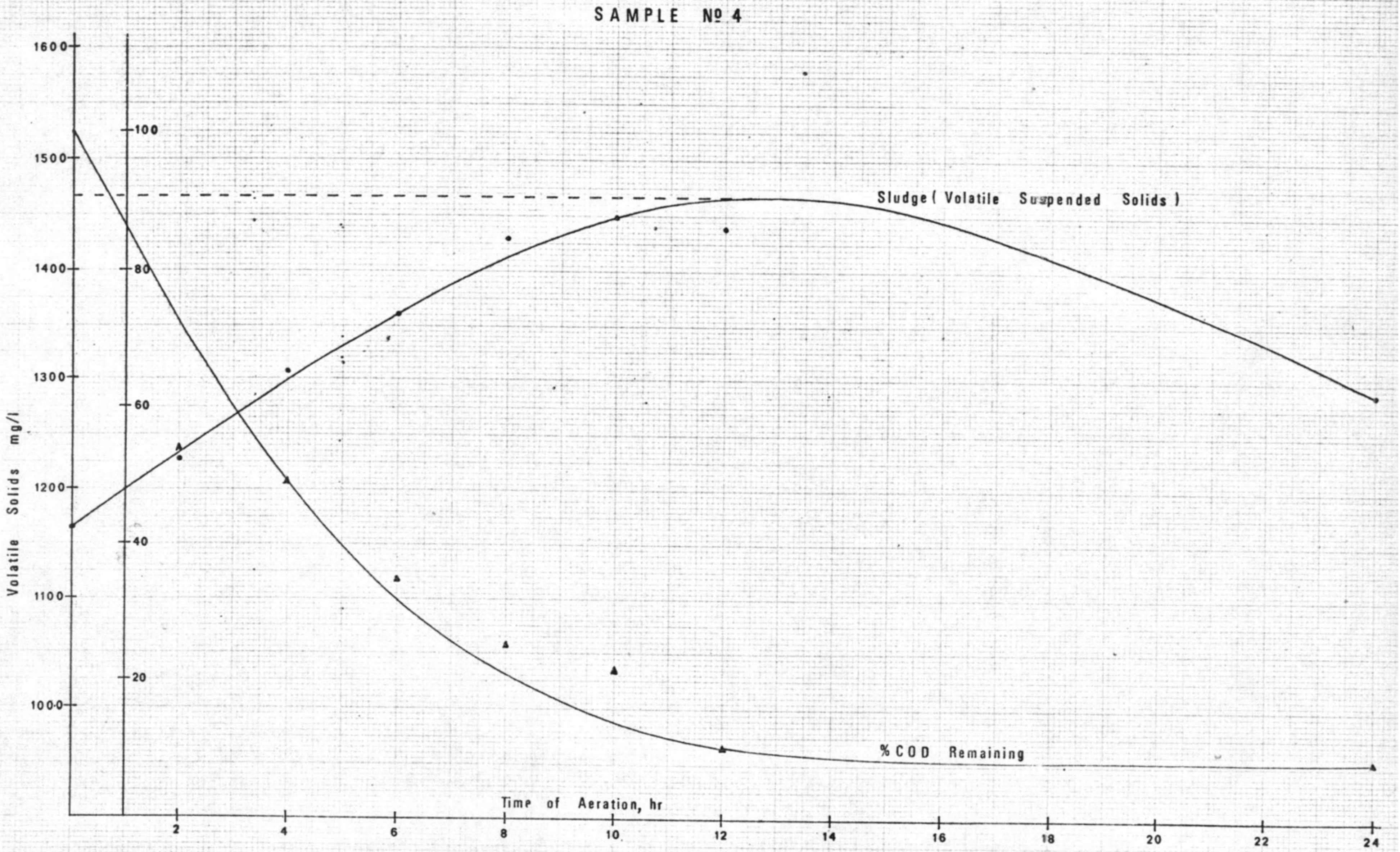


Fig 16 COD Remaining and Sludge Growth Relationship

SAMPLE № 1

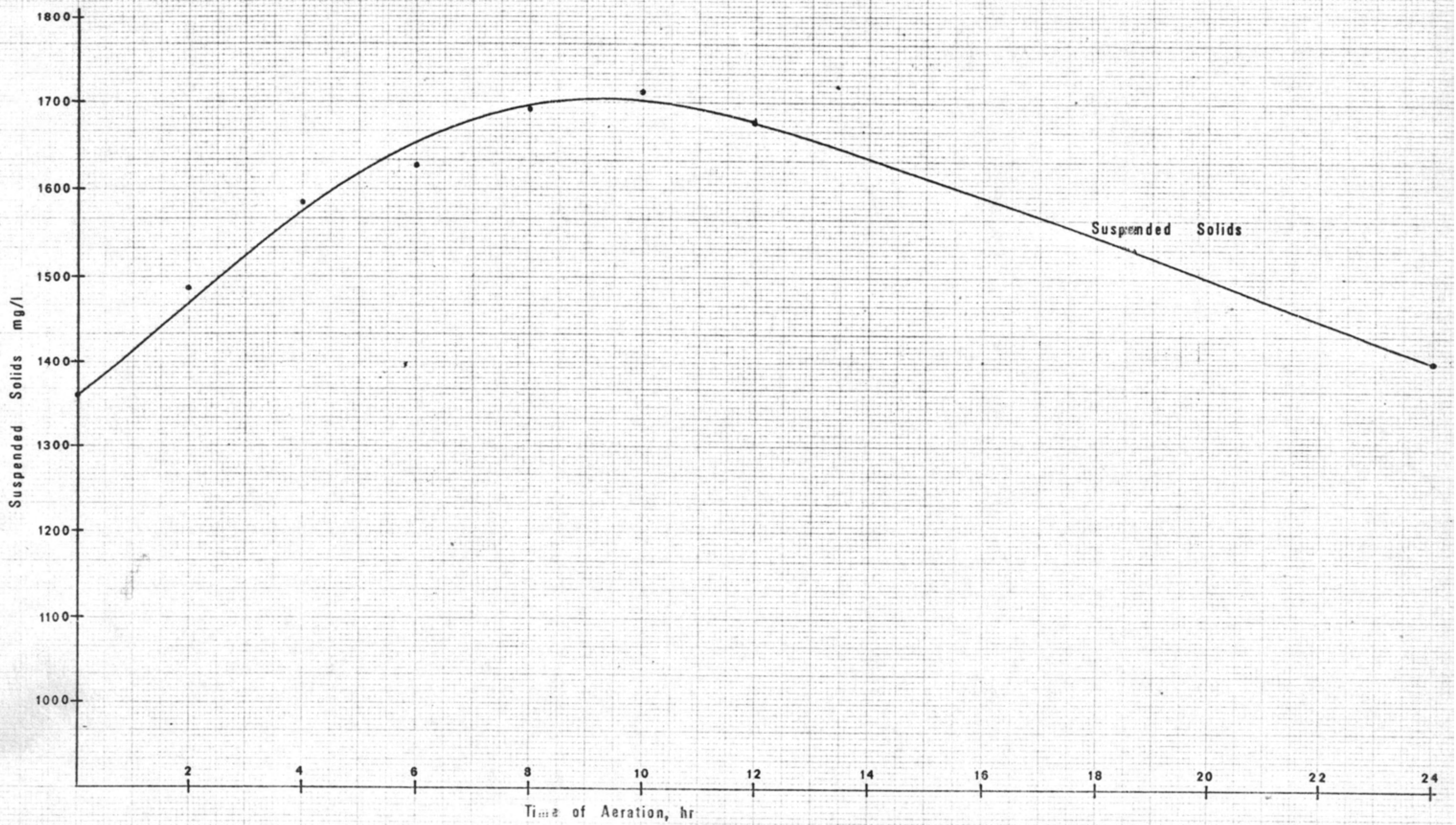


Fig 17 Solid Production Characteristic

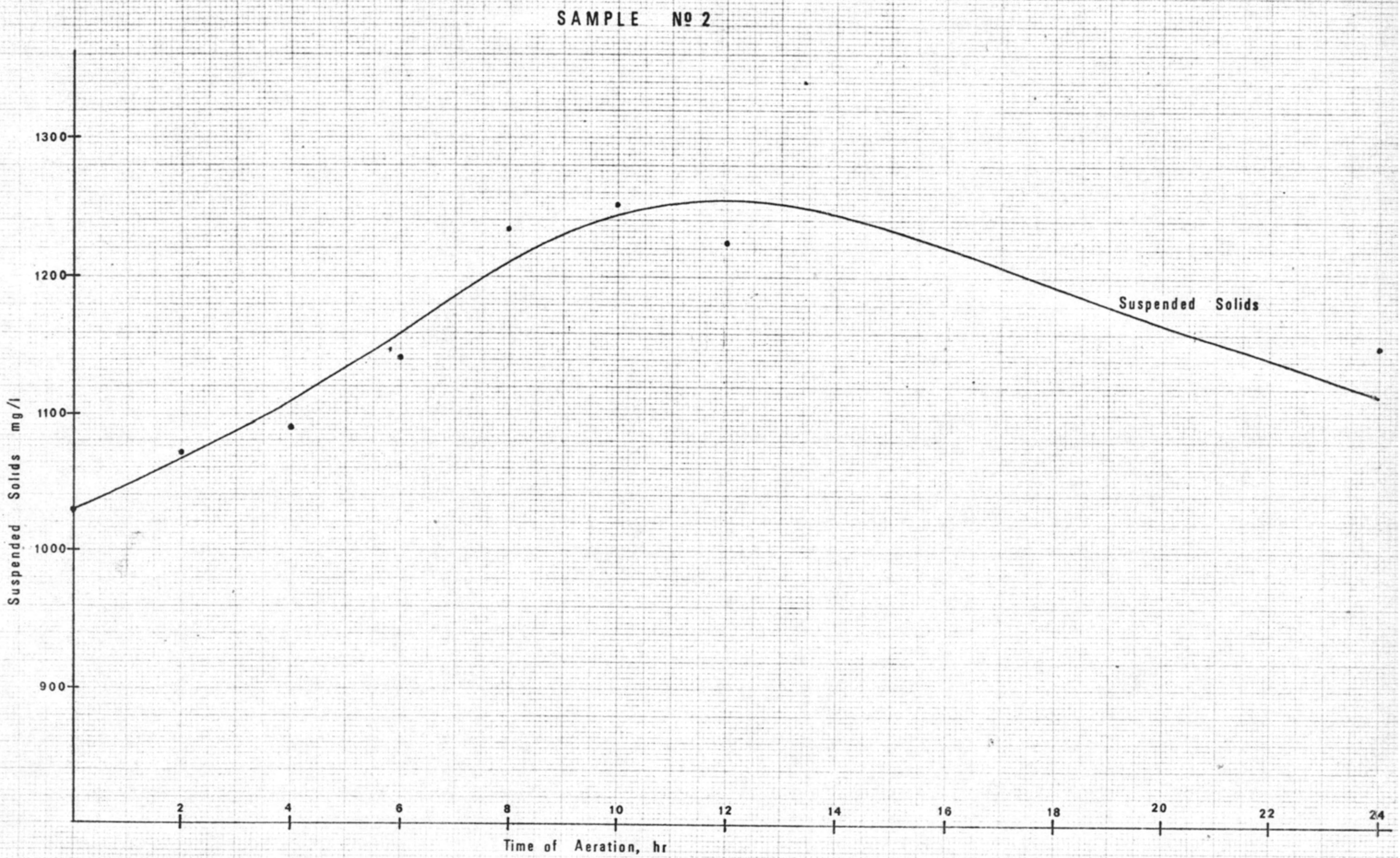


Fig 18 Solid Production Charateristic

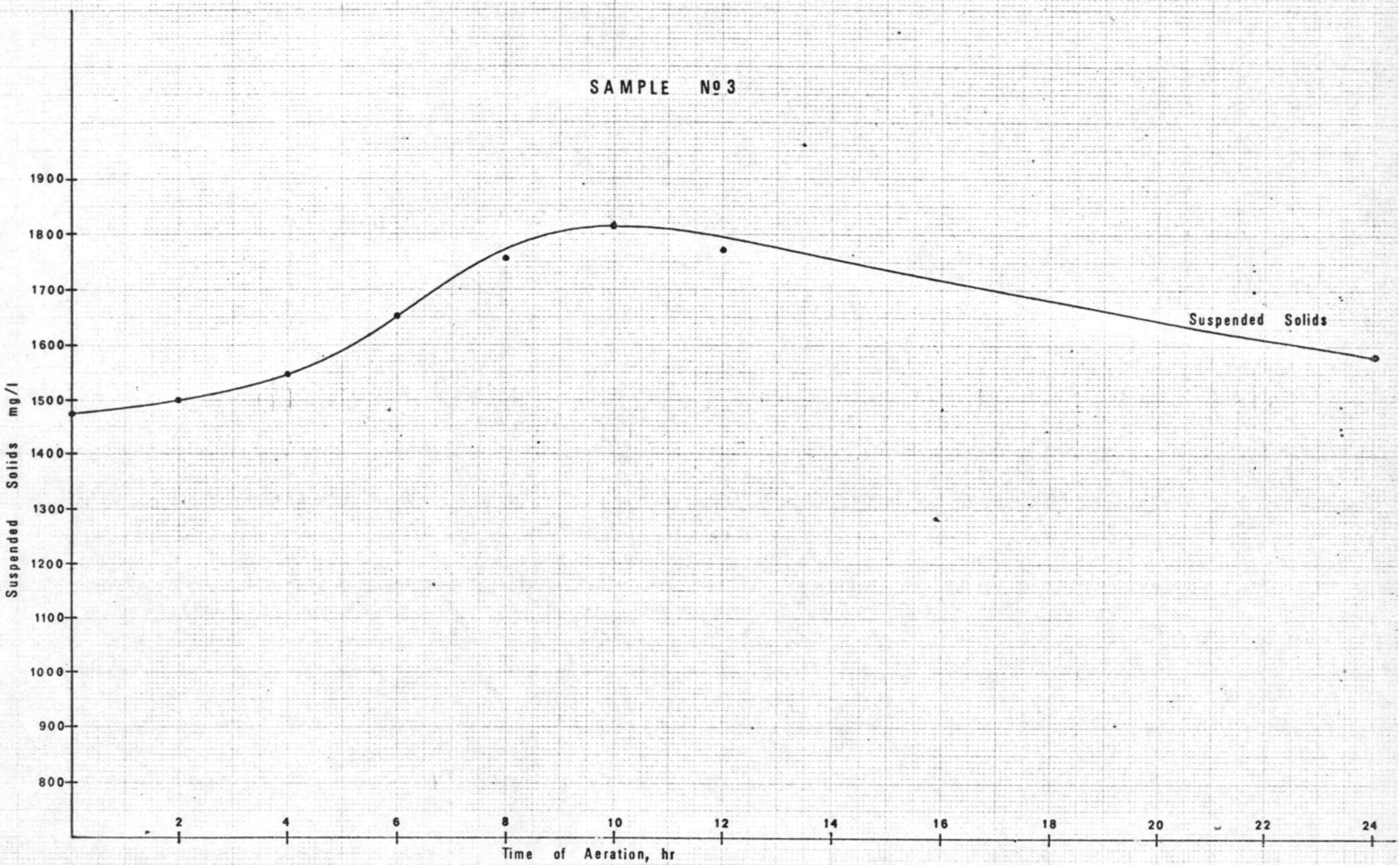


Fig 19 Solid Production Characteristic

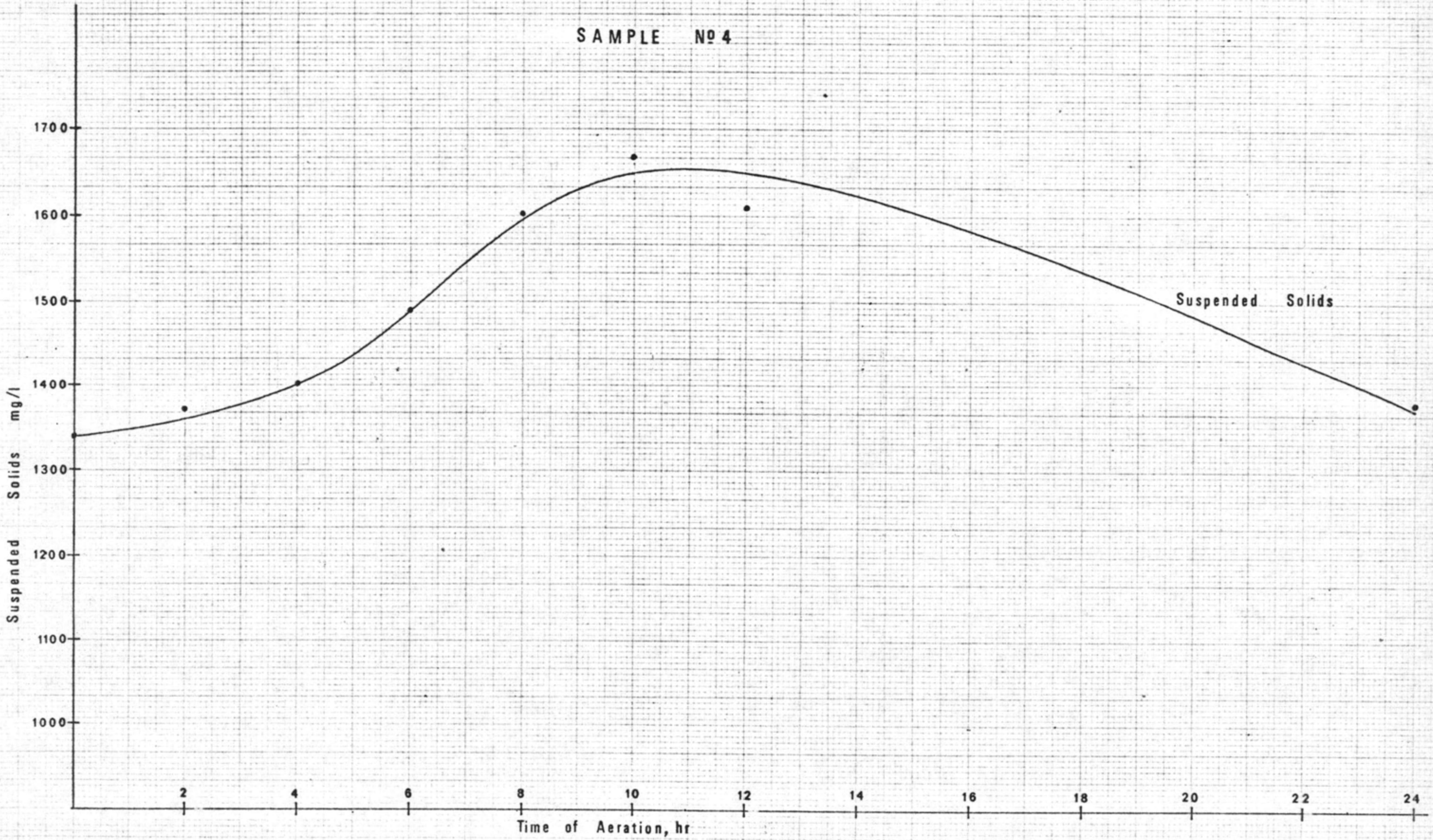


Fig 20 Solid Production Characteristic

Table 17.

DETERMINATION OF NITROGEN REQUIREMENTS BASE ON COD

SAMPLE NO 1

Time hr.	COD mg/1	COD_r	NH_3- N	NH_3-Nr	100 $\frac{NH_3\text{-}Nr}{COD_r}$	% COD Removal
0	950		308			
2	472	478	293	15	3.13	50.32
4	268	682	284	24	3.51	71.79
6	245	705	282	25	3.54	74.21
8	204	746	279	29	3.88	78.53
10	139	811	274	34	4.19	85.37
12	118	832	267	41	4.92	87.58
24	72	878	261	47	5.35	92.42

COD_r = COD Removal, mg/l

NH_3- N = Ammonia - Nitrogen, mg/l as N

NH_3- Nr = Ammonia - Nitrogen Removal, mg/l as N

Time = Time of Aeration, hr.

From Fig 21

Ammonia - Nitrogen Requirements = 5.17 lb N/100 lb. COD Removed

Table 18.

DETERMINATION OF NITROGEN REQUIREMENTS BASE ON COD

SAMPLE NO 2

Time hr.	COD mg/l	COD_r	NH_3- N	NH_3- Nr	100 NH_3-Nr / COD_r	% COD Removal
0	612		212			
2	305	307	202	10	3.25	50.16
4	286	326	200	12	3.68	53.27
6	235	377	197	15	3.97	61.60
8	152	460	193	19	4.13	75.16
10	95	517	189	23	4.44	84.48
12	80	532	186	26	4.88	86.93
24	55	557	181	31	5.56	91.01

COD_r = COD Removal, mg/l

NH_3-N = Ammonia - Nitrogen, mg/l as N

NH_3-Nr = Ammonia - Nitrogen Removal, mg/l as N

Time = Time of Aeration, hr.

From Fig 22

Ammonia - Nitrogen Requirements = 5.45 lb N/100 lb. COD Removed

Table 19

DETERMINATION OF NITROGEN REQUIREMENTS BASE ON COD

SAMPLE NO 3

Time hr.	COD mg/l	COD_r	NH_3 - N	NH_3 - Nr	100 $\frac{NH_3 - Nr}{COD_r}$	% COD Removal
0	1150		302			
2	728	422	288	14	3.31	36.21
4	657	492	285	17	3.45	42.80
6	515	635	279	23	3.62	55.22
8	423	727	274	28	3.85	63.15
10	258	892	265	37	4.14	68.99
12	115	1035	254	48	4.63	89.99
24	56	1044	246	56	5.11	95.25

COD_r = COD Removal, mg/l

NH_3 - N = Ammonia - Nitrogen, mg/l as N

NH_3 - Nr = Ammonia - Nitrogen Removal, mg/l as N

Time = Time of Aeration, hr.

From Fig 23.

Ammonia - Nitrogen Requirements = 5.53 lb N/100 lb COD Removed

Table 20

DETERMINATION OF NITROGEN REQUIREMENTS BASE ON COD

SAMPLE NO 4

Time hr.	COD mg/1	COD_r	NH_3 - N	NH_3 - Nr	$\frac{100\ NH_3\_Nr}{COD_r}$	% COD Removal
0	1145		347			
2	615	530	330	17	3.20	46.28
4	523	622	326	21	3.37	54.32
6	401	744	320	27	3.62	64.97
8	303	842	314	33	3.91	73.53
10	260	885	310	37	4.18	77.29
12	117	1028	302	45	4.37	89.78
24	97	1048	295	52	4.96	91.52

COD_r = COD Removal, mg/1

NH_3 - N = Ammonia - Nitrogen, mg/1 as N

NH_3 - Nr = Ammonia - Nitrogen Removal, mg/1 as N

Time = Time of Aeration, hr.

From Fig 24.

Ammonia - Nitrogen Requirements = 5.03 lb N/100 lb COD Removed

SAMPLE Nº1

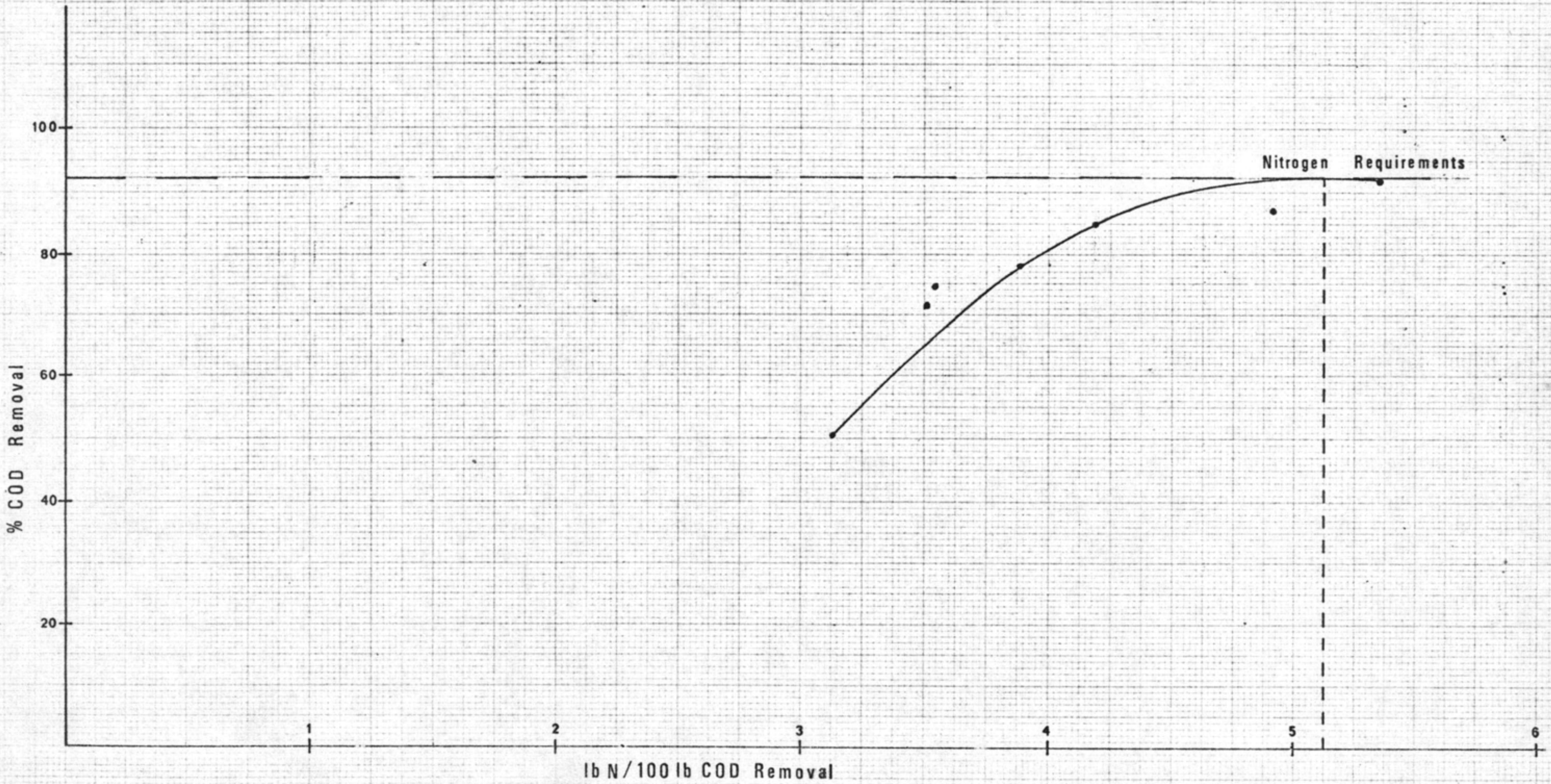


Fig 21 Relationship between COD Removal & Nitrogen Requirements

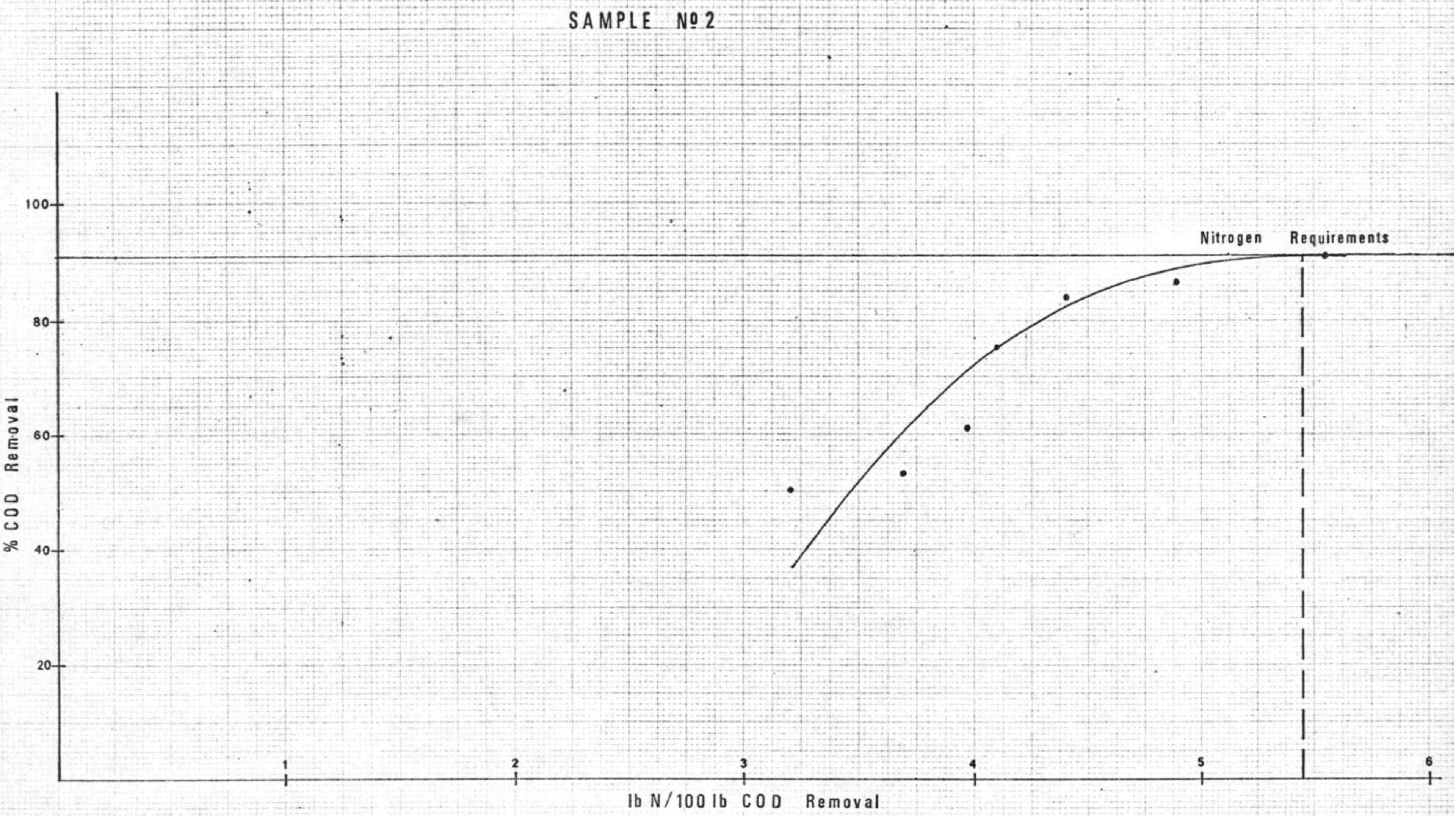


Fig 22 Relationship between COD Removal & Nitrogen Requirements

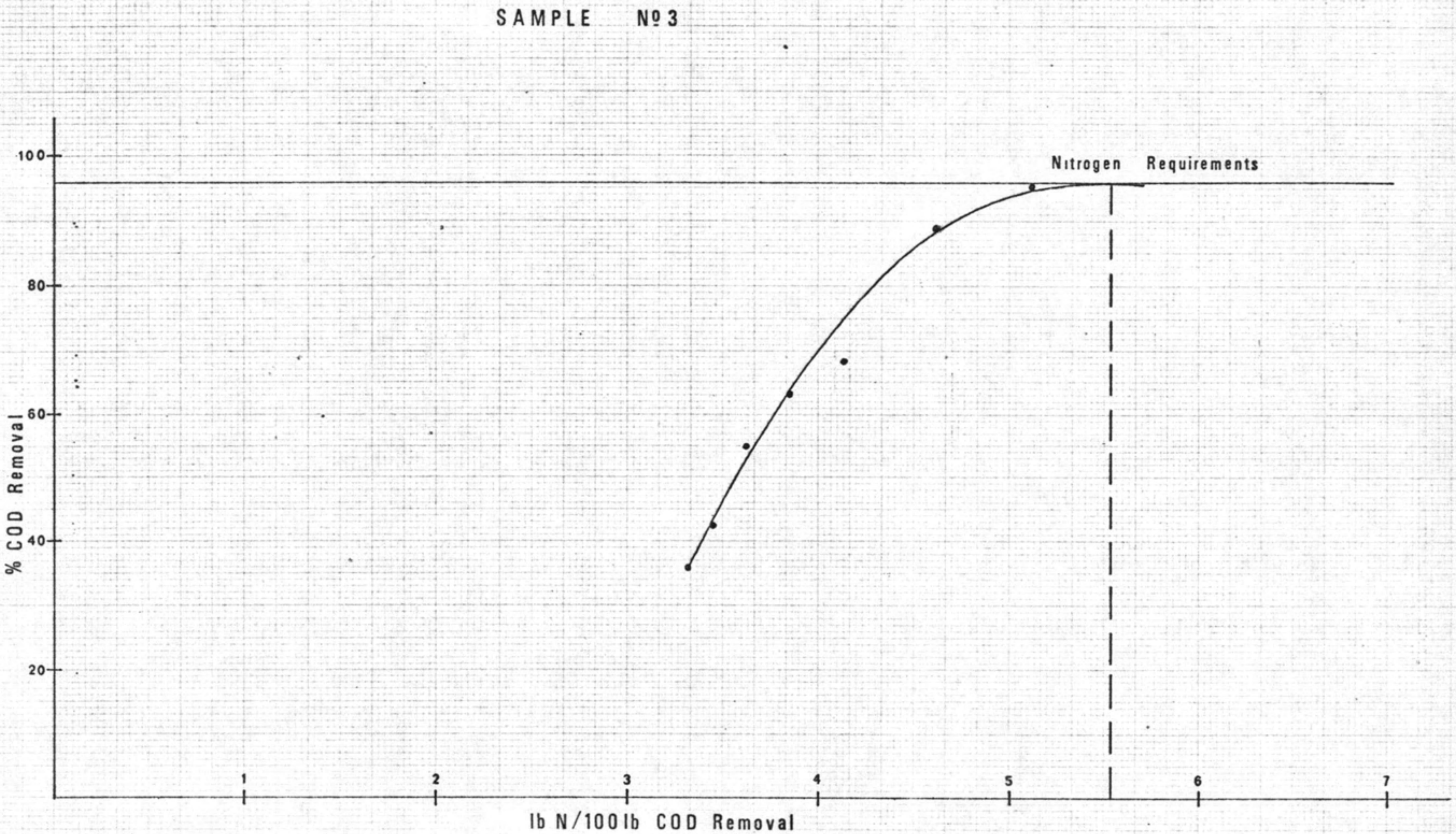


Fig 23 Relationship between COD Removal & Nitrogen Requirements

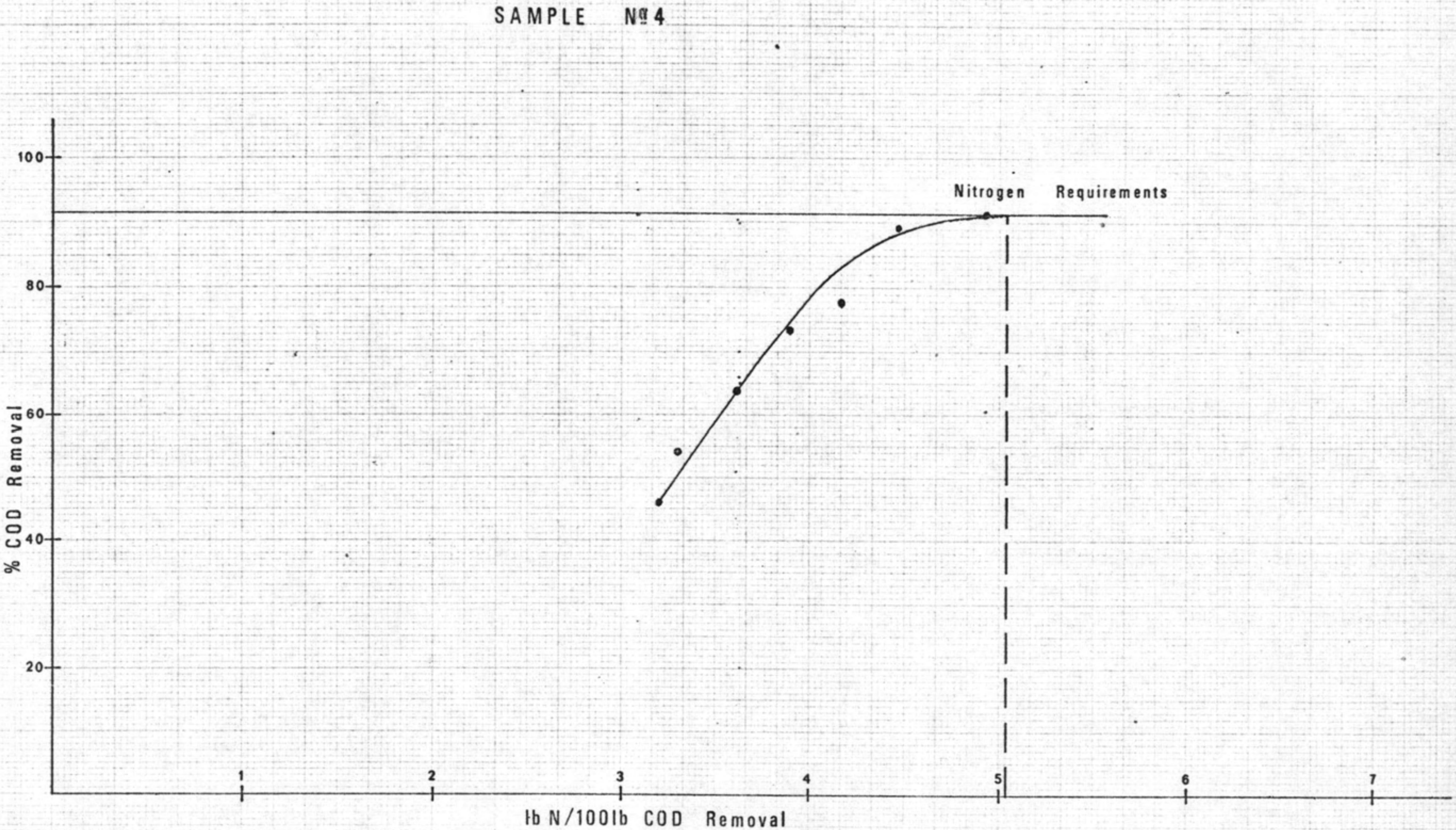


Fig 24 Relationship between COD Removal & Nitrogen Requirements

Table 21 ..

DETERMINATION OF NITROGEN REQUIREMENTS BASE ON BOD

SAMPLE NO 1

Time hr.	BOD mg/l	BOD_r	NH_3 - N	NH_3 - Nr	100 $\frac{NH_3 - Nr}{BOD_r}$	% BOD Removal
0	362		308			
2	185	177	293	15	8.47	48.90
4	92	270	284	24	8.88	74.59
6	84	278	282	25	8.99	76.80
8	76	286	279	29	10.13	79.01
10	63	299	274	34	11.37	82.60
12	46	316	267	41	12.97	87.29
24	31	331	261	47	14.19	91.44

BOD_r = BOD Removal, mg/l

NH_3 - N = Ammonia - Nitrogen, mg/l as N

NH_3 - Nr = Ammonia - Nitrogen Removal, mg/l as N

Time = Time of Aeration, hr

From Fig 25.

Ammonia - Nitrogen Requirements = 13.8 lb N/100 BOD_5 Removed

.Table 22.

DETERMINATION OF NITROGEN REQUIREMENTS BASE ON BOD

SAMPLE NO 2

Time hr.	BOD mg/l	BOD_r	NH3-N	NH_3- Nr	100 NH_3-Nr / BOD_r	% BOD Removal
0	237		212			
2	118	119	202	10	8.40	50.21
4	104	133	200	12	9.02	56.12
6	87	150	197	15	10.00	63.29
8	58	179	193	19	10.61	75.53
10	35	202	189	23	11.38	85.23
12	29	208	186	26	12.50	87.76
24	17	220	181	31	14.09	92.83

BOD_r = BOD Removal, mg/l

NH_3-N = Ammonia - Nitrogen, mg/l as N

NH_3-N = Ammonia - Nitrogen Removal, mg/l as N

Time = Time of Aeration, hr.

From Fig 26.

Ammonia - Nitrogen Requirements = 14.28 lb N/100 lb BOD_5 Removed

Table 23.

DETERMINATION OF NITROGEN REQUIREMENTS BASE ON BOD

SAMPLE NO 3

Time hr.	BOD mg/1	BOD_r	NH_3 - N	NH_3 - Nr	100 $\frac{NH_3\text{-}Nr}{CODr}$	% BOD Removal
0	437		302			
2	275	162	288	14	4.86	37.10
4	240	197	285	17	5.96	45.08
6	183	254	279	23	8.24	58.12
8	151	286	274	28	9.79	65.45
10	108	329	265	37	11.24	75.29
12	71	366	254	48	13.11	83.75
24	25	412	246	56	13.59	94.28

BOD_r = BOD Removal, mg/1

NH_3 - N = Ammonia - Nitrogen, mg/1 as N

NH_3 - Nr = Ammonia - Nitrogen Removal, mg/1 as N

Time = Time of Aeration, hr.

From Fig 27.

Ammonia - Nitrogen Requirements = 15.8 lb N/100 lb BOD_5 Removed

Table 24.

DETERMINATION OF NITROGEN REQUIREMENTS BASE ON BOD

SAMPLE NO 4

Time hr.	BOD mg/l	BOD_r	NH_3 - N	NH_3 - Nr	100 NH_3 Nr	% BOD Removal
0	480		347			
2	234	246	330	17	6.91	51.25
4	201	279	326	21	7.52	58.12
6	168	312	320	27	8.66	65.00
8	117	363	314	33	9.09	75.62
10	99	381	310	37	9.71	79.37
12	48	432	302	45	10.41	90.00
24	36	444	295	52	11.71	92.50

BOD_r = BOD Removal , mg/l

NH_3 - N = Ammonia - Nitrogen , mg/l as N

NH_3 - Nr = Ammonia - Nitrogen Removal , mg/l as N

Time = Time of Aeration, hr

From Fig 28.

Ammonia - Nitrogen Requirements = 13.5 lb N/100 lb BOD_5 Removed

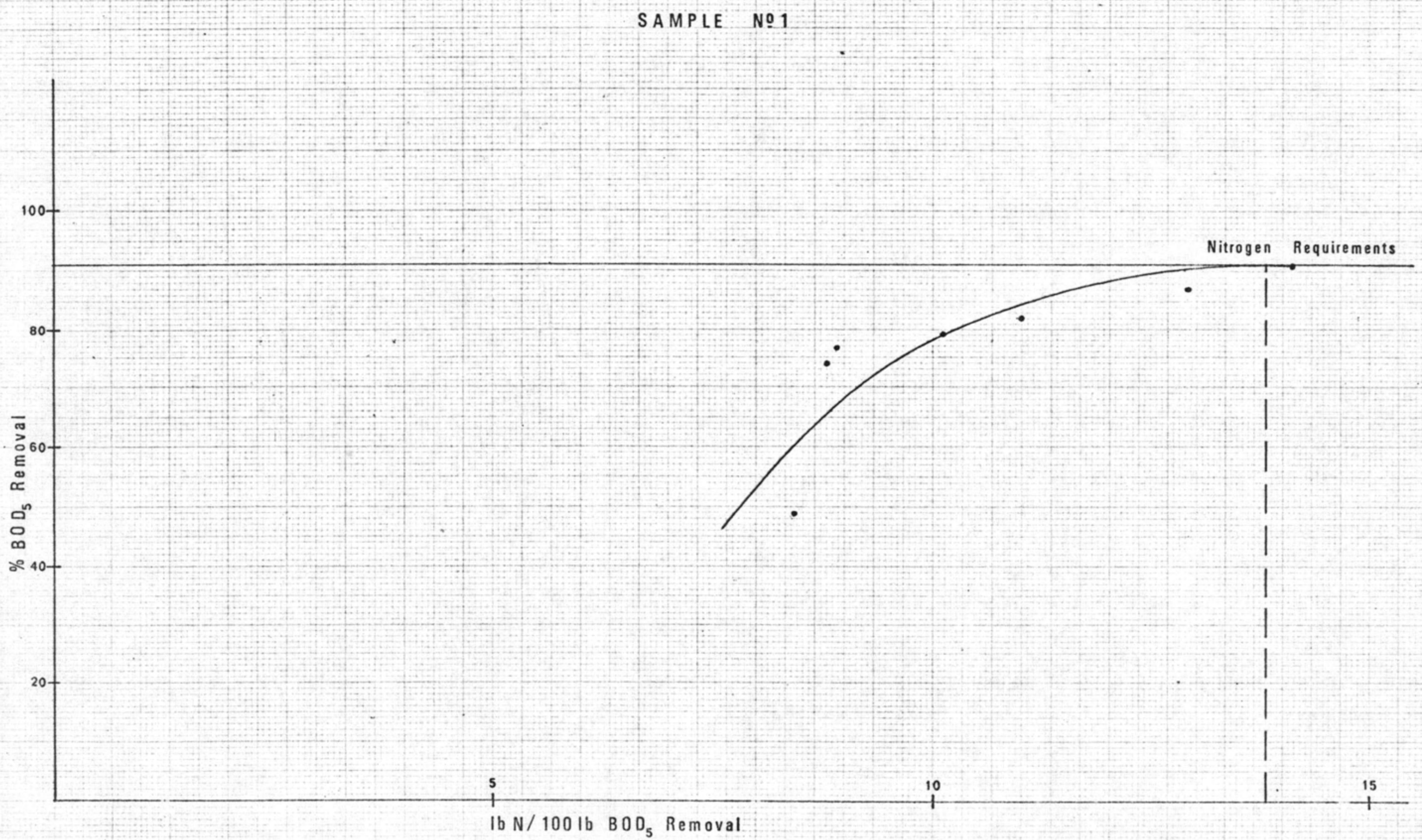


Fig 25 Relationship between BOD_5 Removal & Nitrogen Requirements

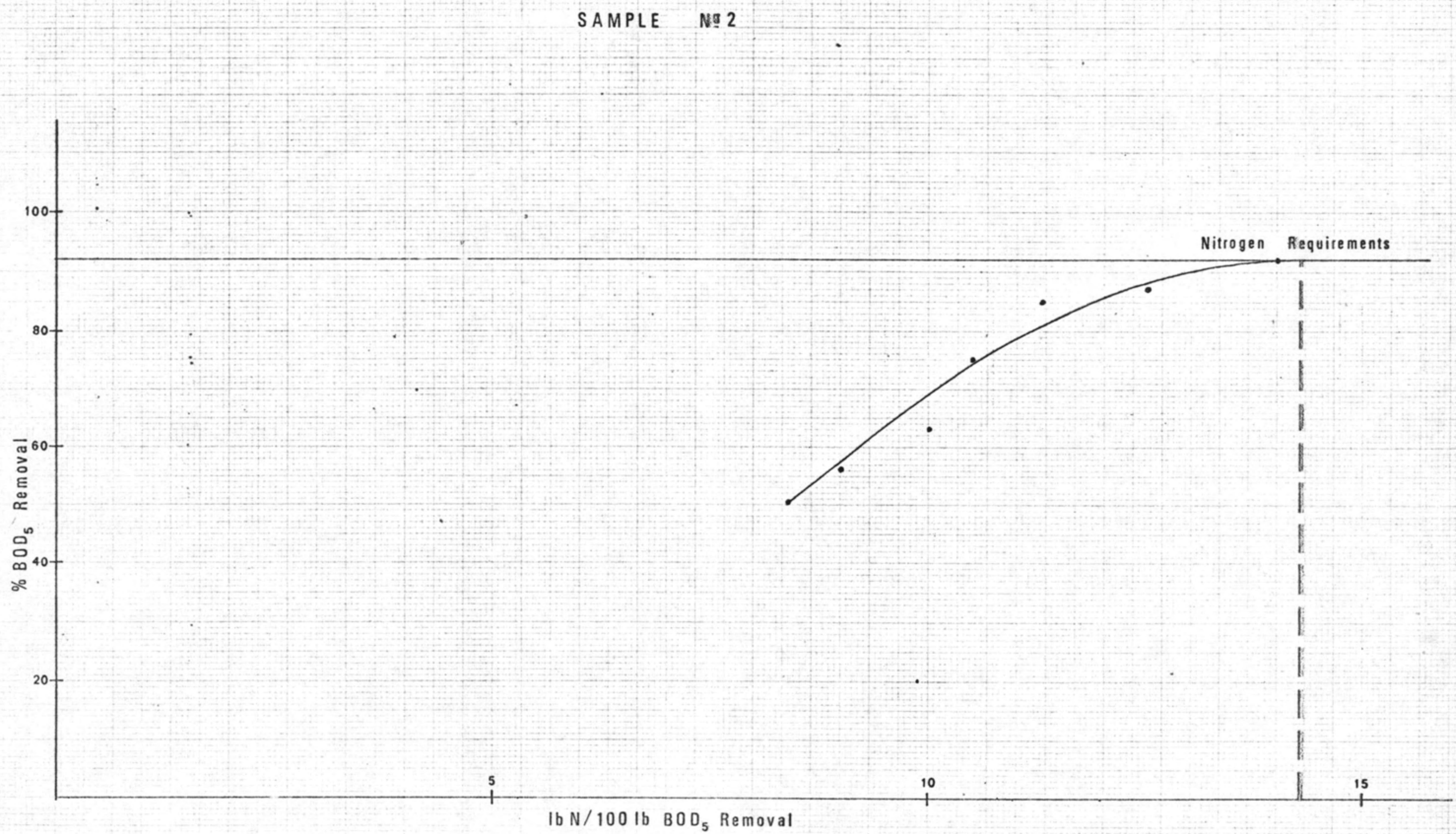


Fig 26 Relationship between BOD_5 Removal & Nitrogen Requirements

SAMPLE Nº 3

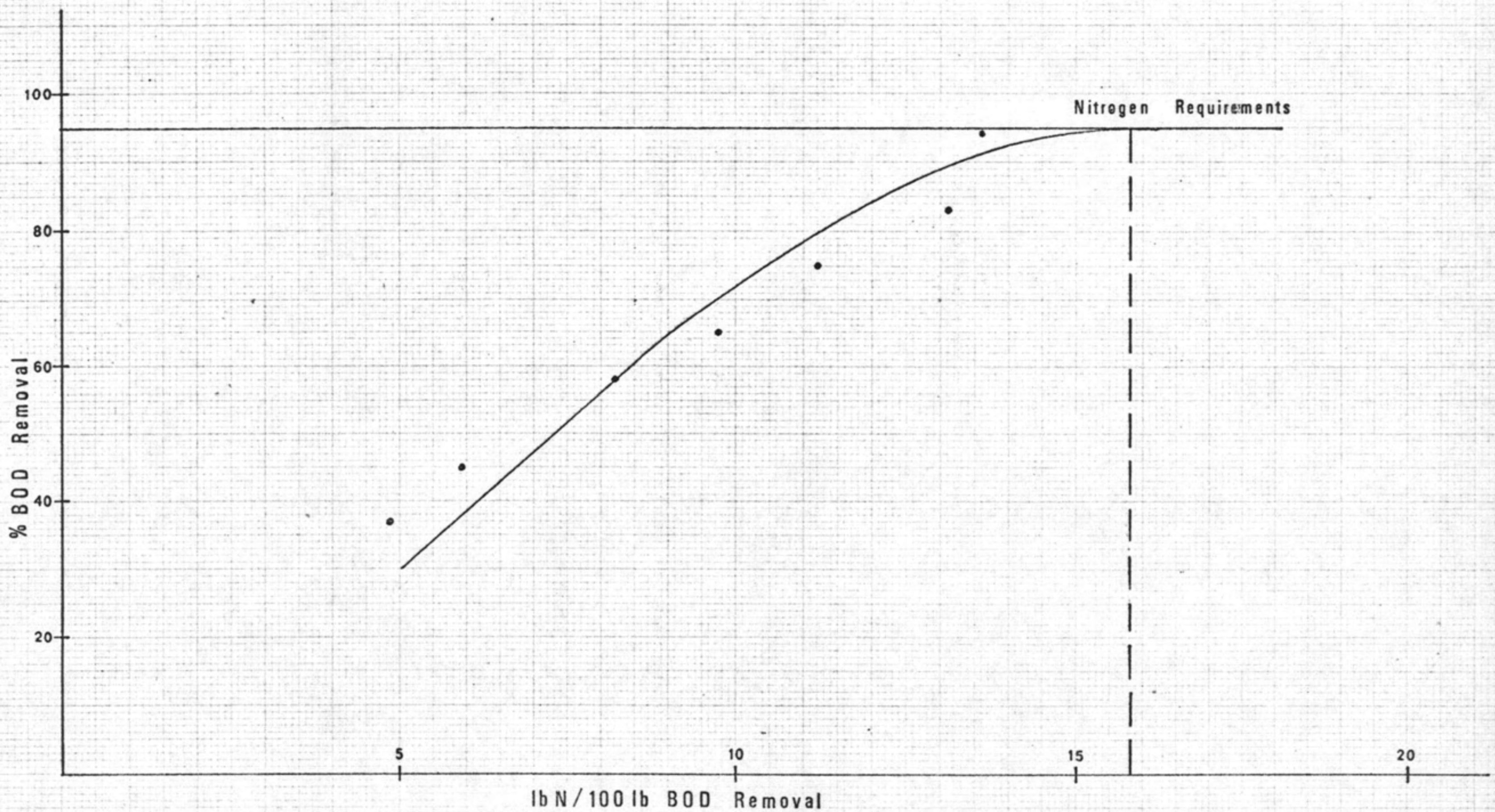


Fig 27 Relationship between BOD Removal & Nitrogen Requirements

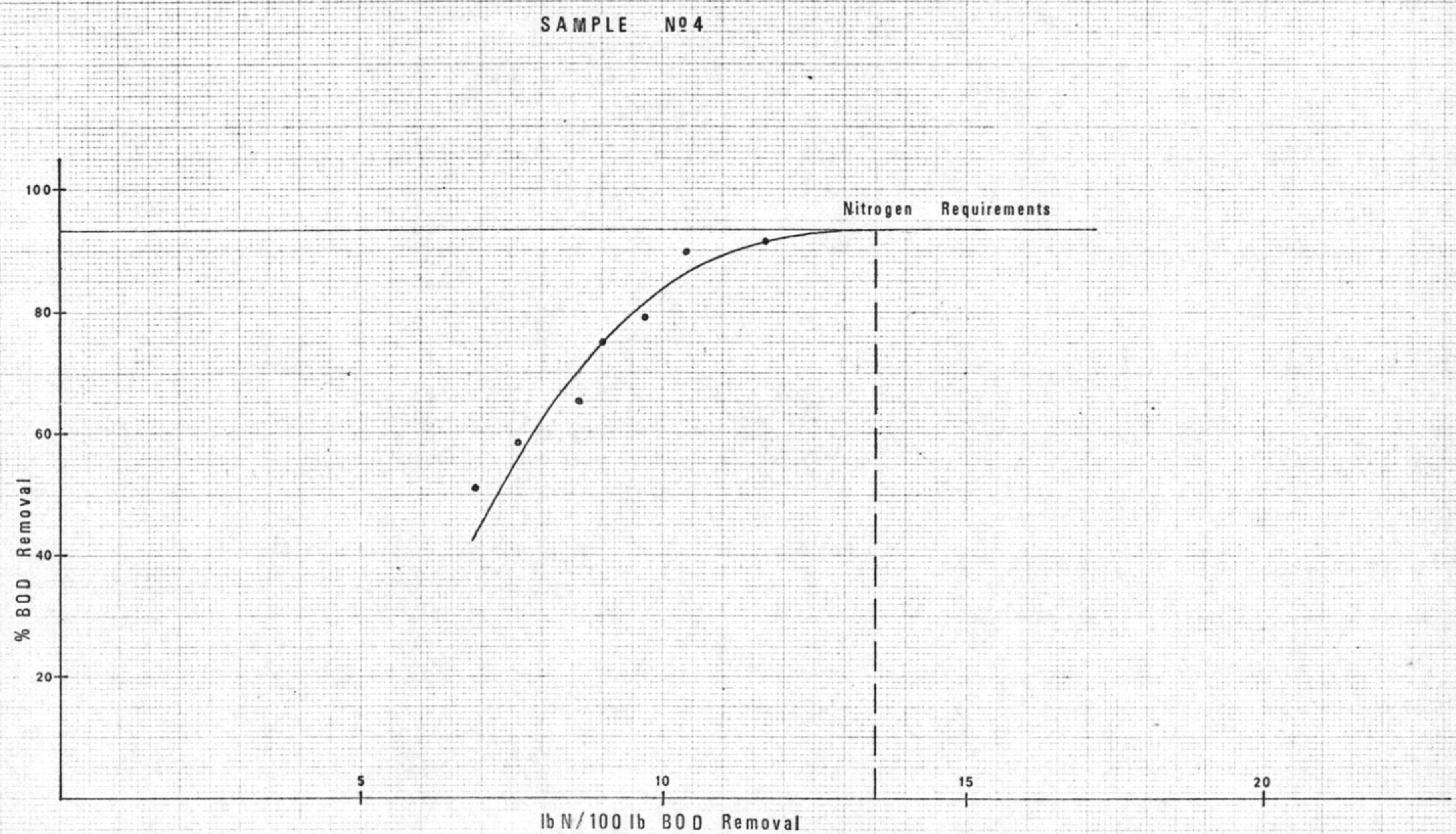


Fig 28 Relationship between BOD Removal & Nitrogen Requirements

Table 25

AMMONIA - NITROGEN AND NITRATE - NITROGEN

SAMPLE NO 1

Time of Aeration hr.	Ammonia - Nitrogen mg/l	Nitrate - Nitrogen mg/l
0	308	6.8
2	293	7.1
4	284	7.5
6	282	8.7
8	279	13.6
10	274	15.0
12	267	17.0
24	261	20.0

Table 26.

AMMONIA - NITROGEN AND NITRATE - NITROGEN

SAMPLE NO 2

Time of Aeration hr.	Ammonia - Nitrogen mg/l as N.	Nitrate - Nitrogen mg/l as N.
0	212	6.2
2	202	6.5
4	200	7.0
6	197	7.5
8	193	8.4
10	189	10.9
12	186	13.2
24	181	16.2

Table 27

AMMONIA - NITROGEN AND NITRATE - NITROGEN

SAMPLE NO 3

Time of Aeration hr.	Ammonia - Nitrogen mg/l	Nitrate - Nitrogen mg/l
0	302	2.8
2	288	3.5
4	285	6.0
6	279	7.2
8	274	9.12
10	265	12.5
12	254	15.5
24	246	21.15

Table 28.

AMMONIA - NITROGEN AND NITRATE - NITROGEN

SAMPLE NO 4

Time of Aeration hr.	Ammonia - Nitrogen mg/l	Nitrate - Nitrogen mg/l
0	347	8.3
2	330	9.
4	326	10.3
6	320	11.4
8	314	12.6
10	310	13.4
12	302	15.5
24	295	19.9

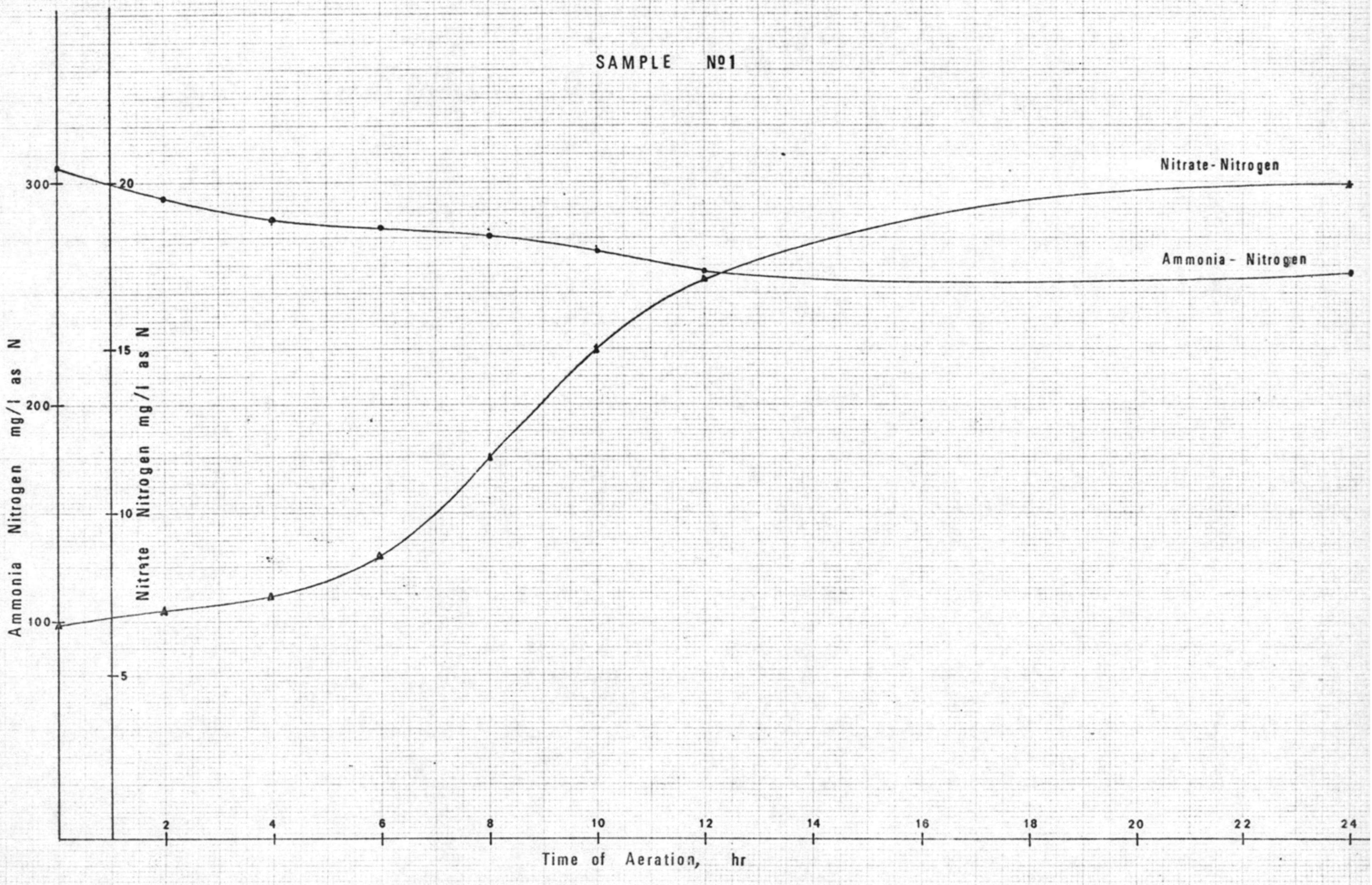


Fig 29 Nitrogen Relationship between Ammonia Nitrogen & Nitrate Nitrogen

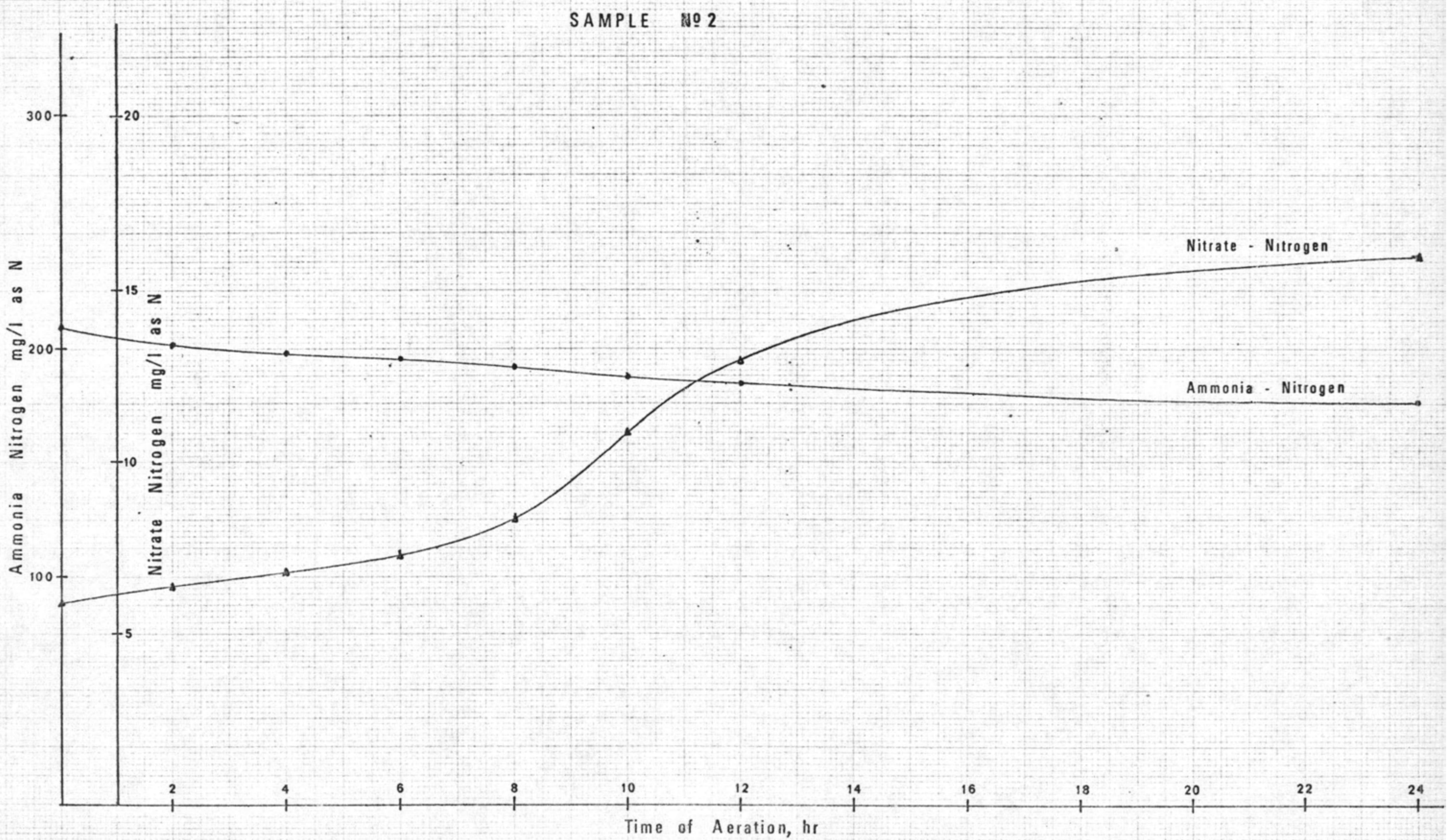


Fig 30 Nitrogen Relationship between Ammonia Nitrogen & Nitrate Nitrogen

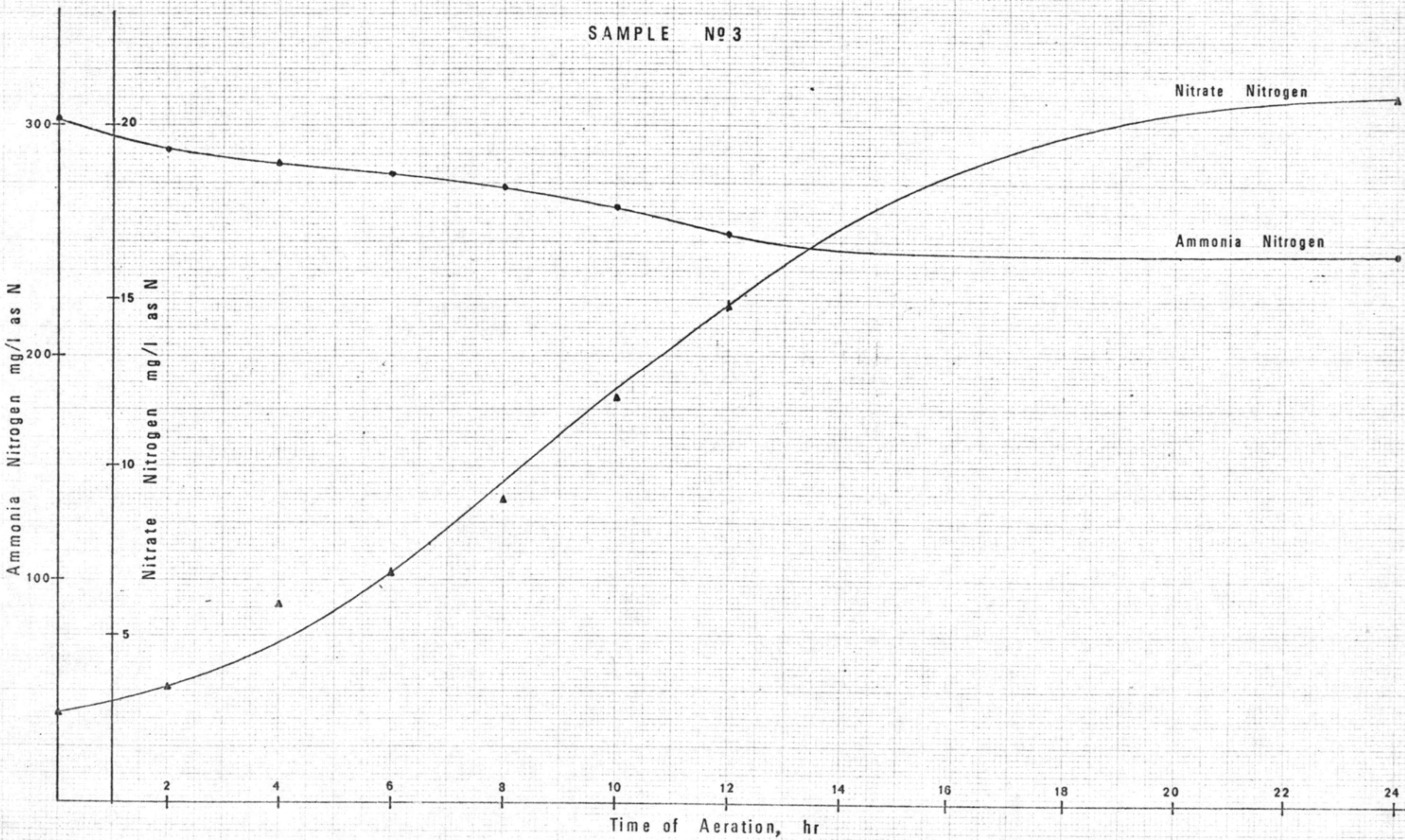


Fig 31 Nitrogen Relationship between Ammonia Nitrogen & Nitrate Nitrogen

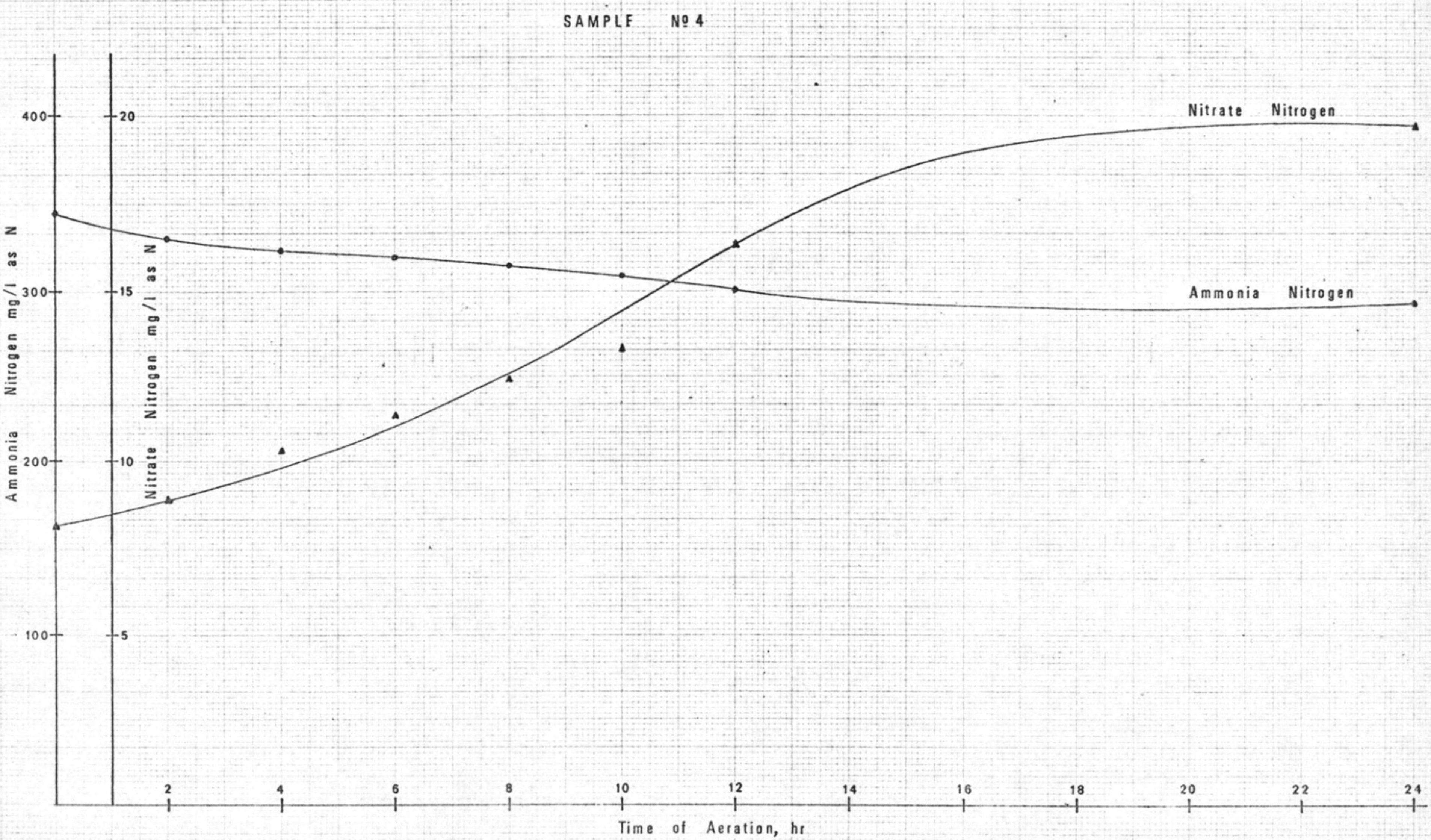


Fig 32 Nitrogen Relationship between Ammonia Nitrogen & Nitrate Nitrogen

Table 29.

DISSOLVED OXYGEN DURING PERIOD OF AERATION

SAMPLE NO 1

Time of Aeration hr.	Dissolved oxygen mg/l
0	0
2	4.7
4	5.1
6	5.4
8	5.7
10	6.2
12	6.8
24	6.8

Table 30.

DISSOLVED OXYGEN DURING PERIOD OF AERATION

SAMPLE NO 2

Time of Aeration hr.	Dissolved oxygen mg/l
0	0.1
2	3.9
4	4.8
6	5.3
8	5.6
10	6.2
12	6.6
24	6.6

Table 31.

DISSOLVED OXYGEN DURING PERIOD OF AERATION

SAMPLE NO 3

Time of Aeration hr.	Dissolved oxygen mg/l
0	0
2	4.9
4	5.2
6	5.6
8	5.8
10	6.2
12	6.5
24	6.8

Table 32.

DISSOLVED OXYGEN DURING PERIOD OF AERATION

SAMPLE NO 4

Time of Aeration hr.	Dissolved oxygen mg/1
0	0
2	3.8
4	4.7
6	5.4
8	5.6
10	6.0
12	6.2
24	6.5

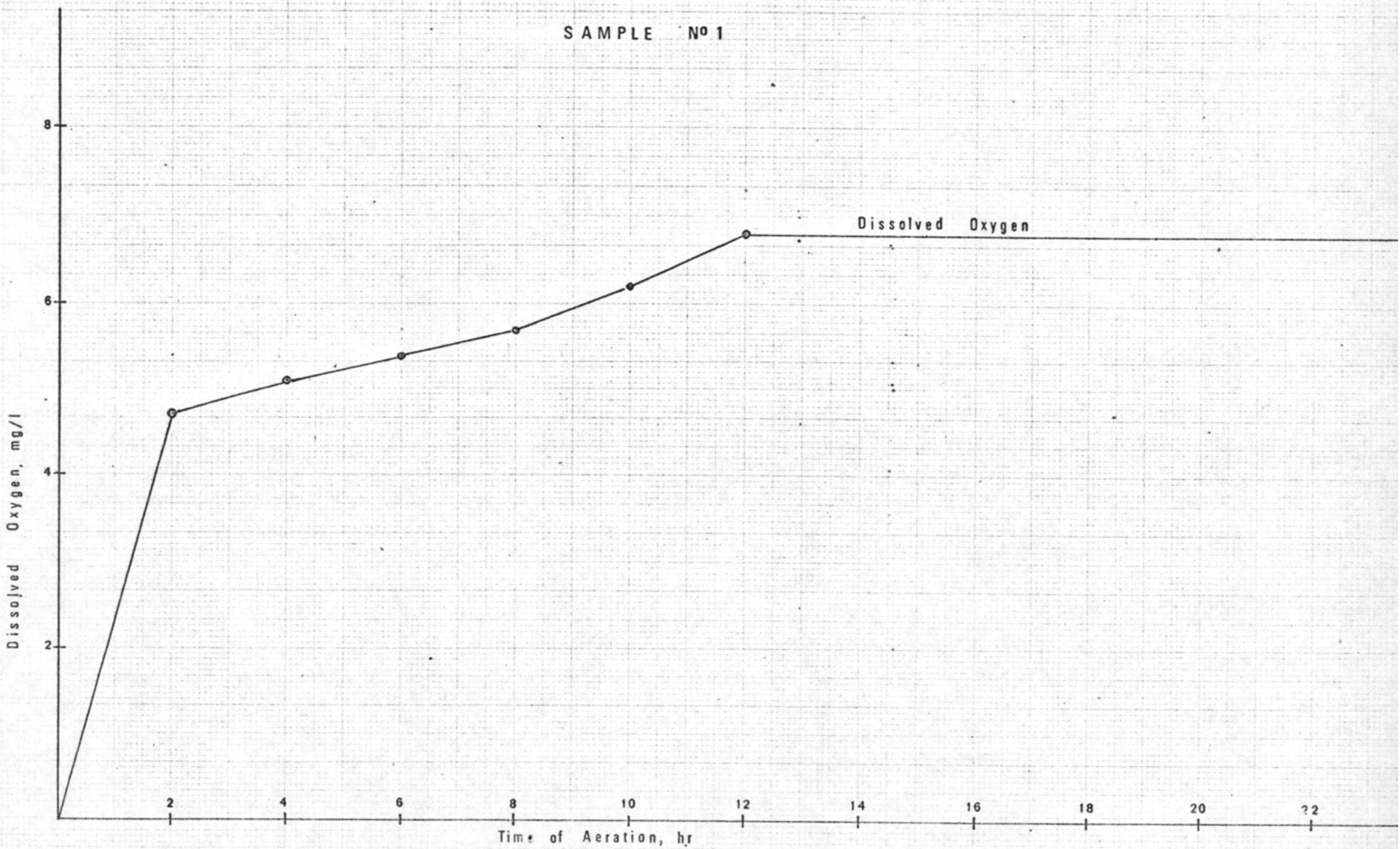


Fig 33 Dissolved Oxygen During Period of Aeration

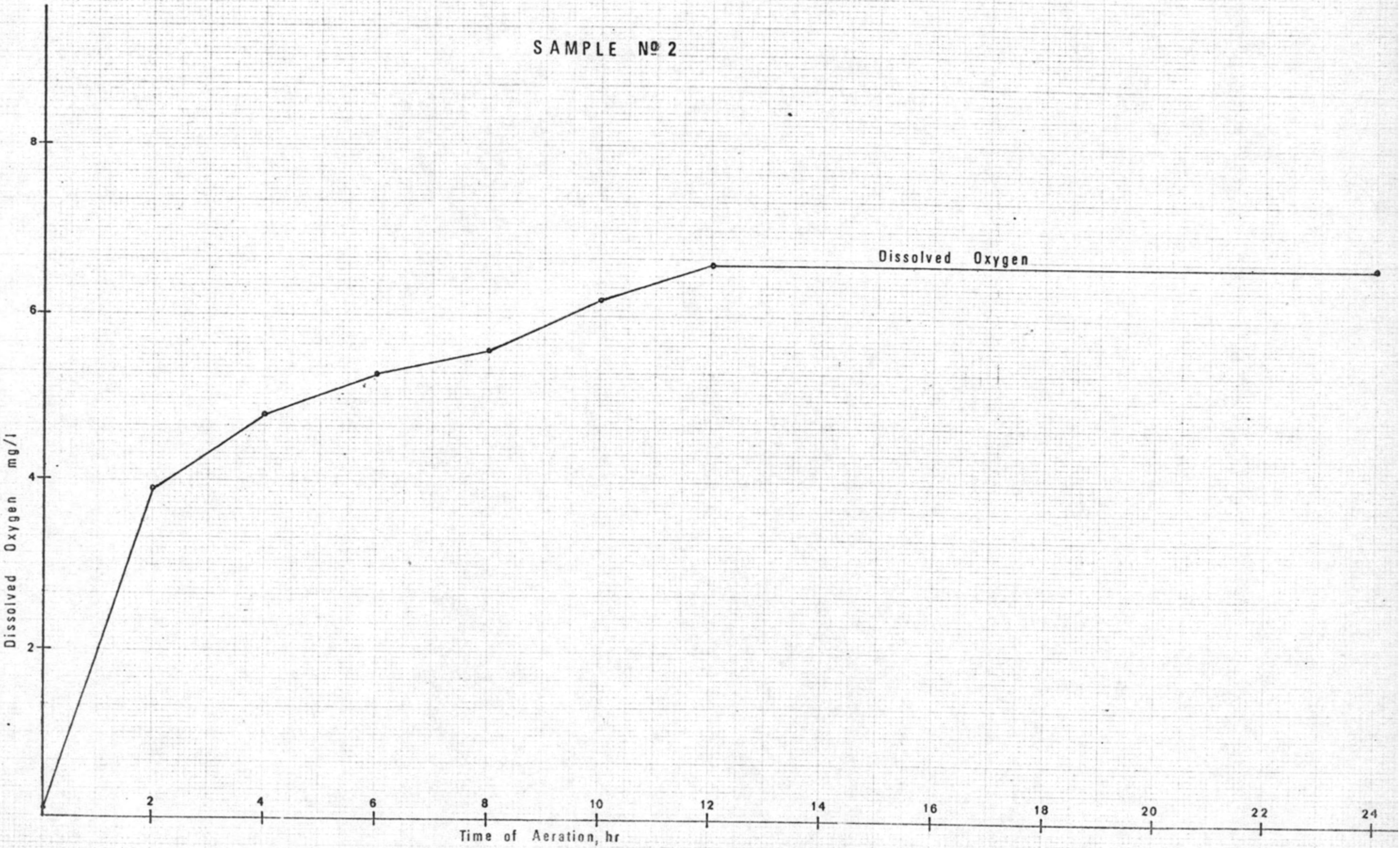


Fig 34 Dissolved Oxygen During Period of Aeration

SAMPLE № 3

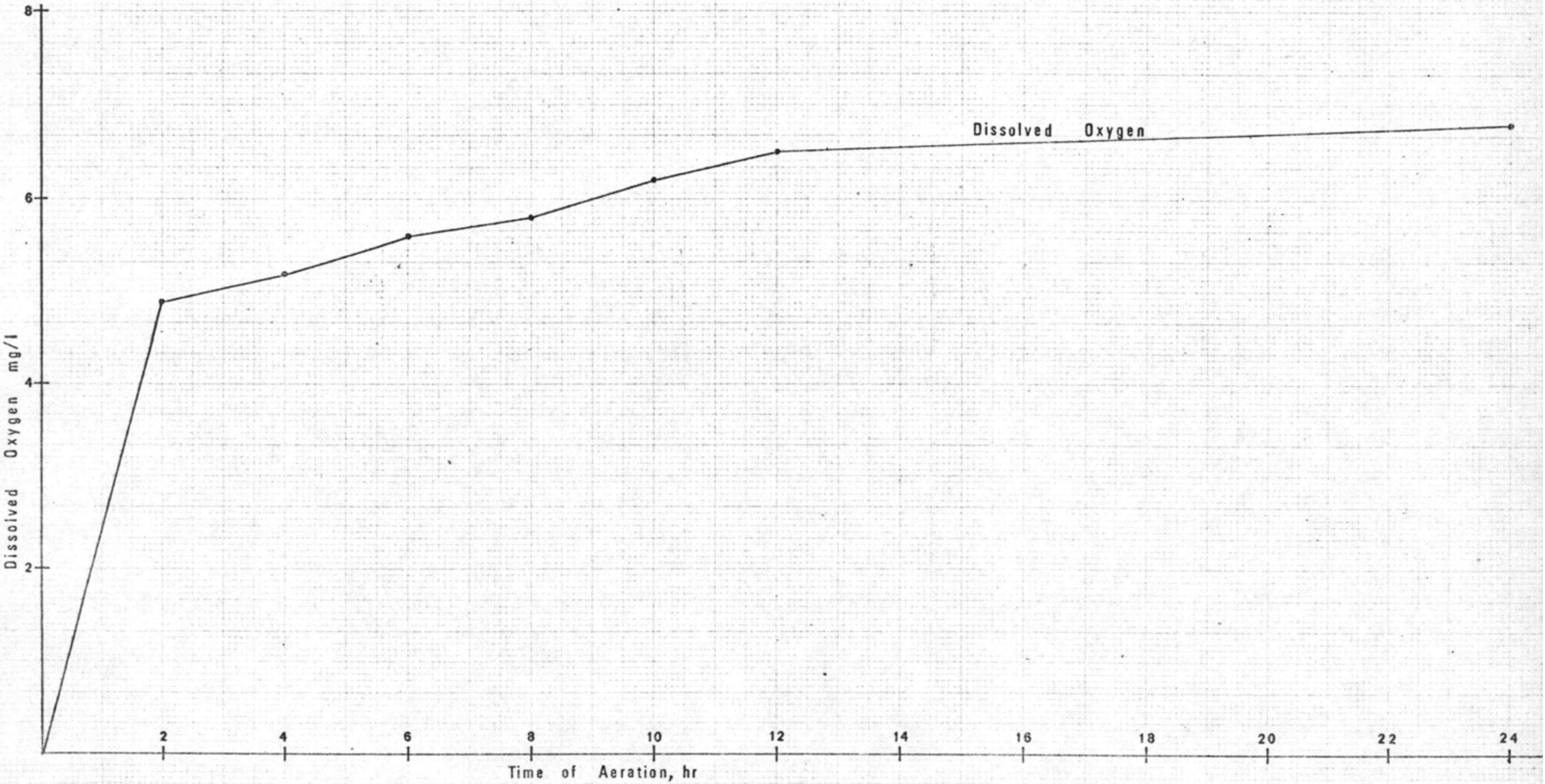


Fig 35 Dissolved Oxygen During Period of Aeration

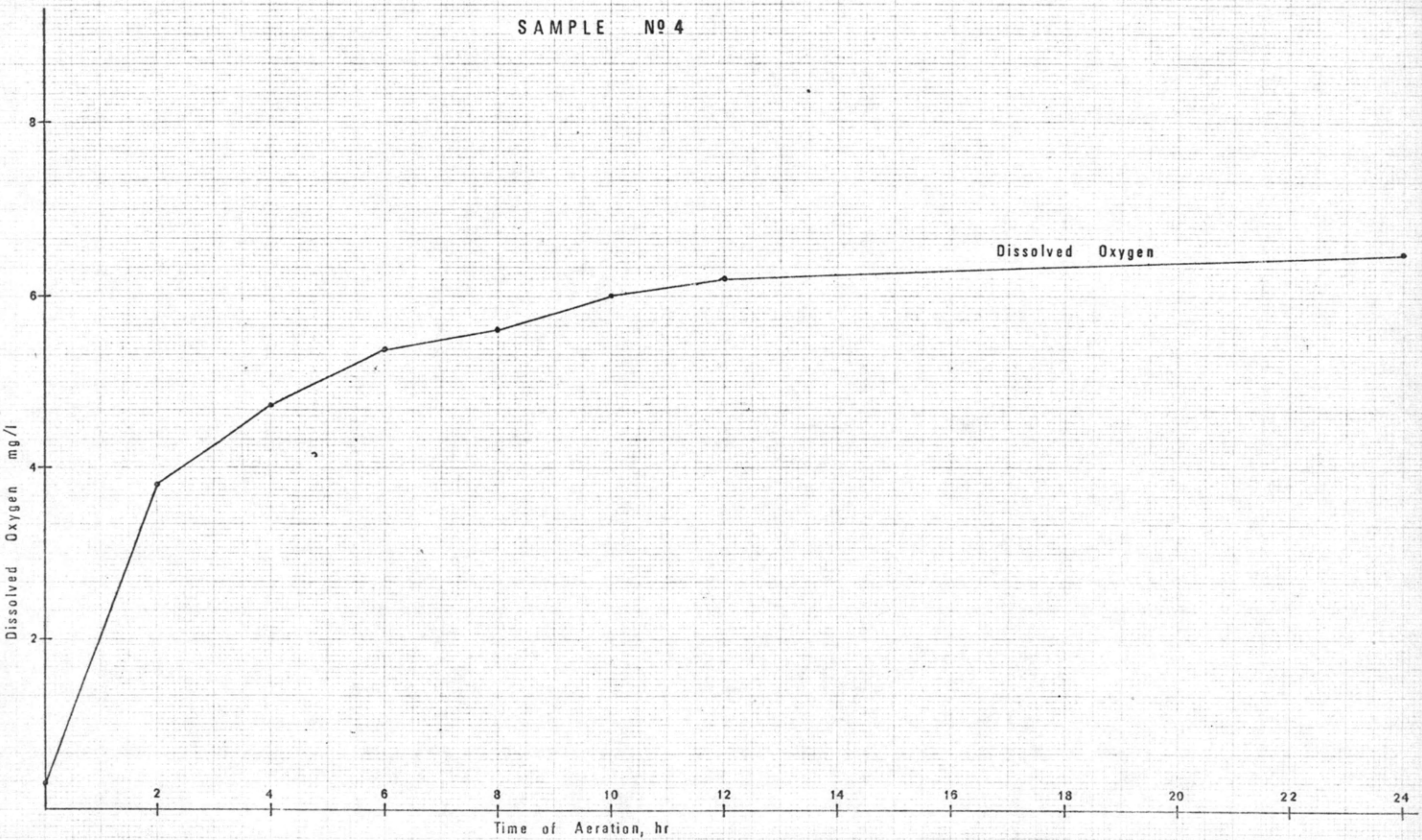


Fig 36 Dissolved Oxygen During Period of Aeration

Table 33.

DETERMINATION OF BOD_5 : COD AT 28°C.

SAMPLE NO 1. NO 2. NO 3. NO 4.

Sample No	1	Σx	=	3.098
	2	Σx	=	2.926
	3	Σx	=	3.315
	4	Σx	=	3.148
		Total	=	12.487

$$\text{Average} = \frac{12.487}{32} = 0.39$$

CHAPTER V

CONCLUSIONS

From the experiment in this study. The following conclusions may be drawn.

1. The COD of Slaughterhouse waste used as design creteria is 950 mg/1 to 1150 mg/1 with 80 % to 85 % of chance.

2. The relationship between BOD_5 / COD ratio obtained the mean value of 0.390.

3. The value of COD and BOD and suspended solids was reduced at 28 ^{o}C. The value decreased was related to the length of time.

4. By mean of the activated sludge in the batch process, the COD removal was in excess of 90 % after 24 hour of aeration.

5. The value of pH during experiment was 6.8 to 7.0. The value obtained without adding any chemical reagent. It was probably due to the characteristic of waste which have the neutral value in itself.

6. Nitrogen requirements base on COD expressed as the NH_3 - N varied from 5.03 lb N/100 lb COD removal to 5.53 lb N/100 lb COD removal.

7. Nitrogen requirements based on BOD_5 expressed as the $NH_3 - N$ varied from 13.5 lb N/100 lb BOD_5 removal to 15.8 lb N/100 lb BOD_5 removal.

8. The value of dissolved oxygen is 6.7 mg/l. in 24 hours of aeration.

9. The ammonia - nitrogen of dairy waste was high enough and sufficient for micro - organisms requirements.

10. The oxygen supply was sufficient to ensure adequate oxygen utilization through the aeration tank.

CHAPTER VI

RECOMMENDATIONS FOR FUTURE WORKS

From this research there are many problem in this review will give some direction to future studies. The following items of future works are recommended.

1. Measure the flow rate in order to calculate the dimension for designing the parameter of Aeration Tank.

2. To study about the detention period and precipitation of solids in order to design the sedimentation unit.

3. Another method should be studied in stead of this process.

4. To study the microbial sludge employed in bio - oxidation processes.

5. The oxygen up tak rate should be studied in order to compute oxygen utilization and sludge growth.

6. To study about the logarithmic growth rate, declining growth rate, endogeneous growth rate, in order to calculate the constant value of K_1 , K_2 , and K_3.

7. Another unit should be constructed for the experiment in the scope of the pilot plant.