CONVENTION

AUSTRALIA

Patents Act 1990

REQUEST FOR A STANDARD PATENT
AND NOTICE OF ENTITLEMENT

648563

The Applicant identified below requests the grant of a patent to the nominated person identified below for an invention described in the accompanying standard complete patent specification.

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[54]Invention Title:
CONTINUOUS RBCOD MEASUREMENT

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[31,33,32] Details of basic application:

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Australia
4 July 1990

Applicant states the following:

1. The nominated person is the assignee of the actual inventor.

2. The nominated person is the applicant of the basic application.

3. The basic application was the first made in a convention country in respect of the invention.

The nominated person is not an opponent or eligible person described in Section 33-36 of the Act.

DATED 25 February 1994

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISAION

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Patent Attorneys
By

Our Ref : IRN 80095/91

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(54) Title
CONTINUOUS RBCOD MEASUREMENT

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(56) Prior Art Documents
DE 2952343
US 4564453
GB 2184110

(57) Claim

1. A method for periodically determining the readily biodegradable chemical oxygen demand (RBCOD) in a wastewater stream or feed comprising:-

i) ~~continuously~~ feeding a sample representative of the real-time wastewater stream or feed to a sample volume whereby the feed rate is controlled to ensure an hydraulic retention time (HRT) in the sample volume sufficient for substantially complete oxidation of the readily biodegradable compounds,

ii) periodically passing air for predetermined periods through the sample volume,

iii) determining the oxygen consumption in the sample volume by measuring a change in the dissolved oxygen content while not passing air through the sample volume, and

.../2

iv) calculating an RBCOD value from each oxygen consumption measurement.

6. Apparatus for monitoring a wastewater stream or feed in real time comprising:

(i) a bio-reactor for containing and maintaining a completely mixed sample volume and for receiving a sample representative of the real-time wastewater stream or feed,

(ii) air injection means for periodically passing air for a predetermined period through a sample in the sample volume in the bio-reactor,

(iii) means for measuring the dissolved oxygen content of a sample within the bio-reactor at predetermined times after the passage of air to determine oxygen consumption of the sample, and

(iv) means for calculating readily biodegradable chemical oxygen demand (RBCOD) from the oxygen consumption of the sample.

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Published
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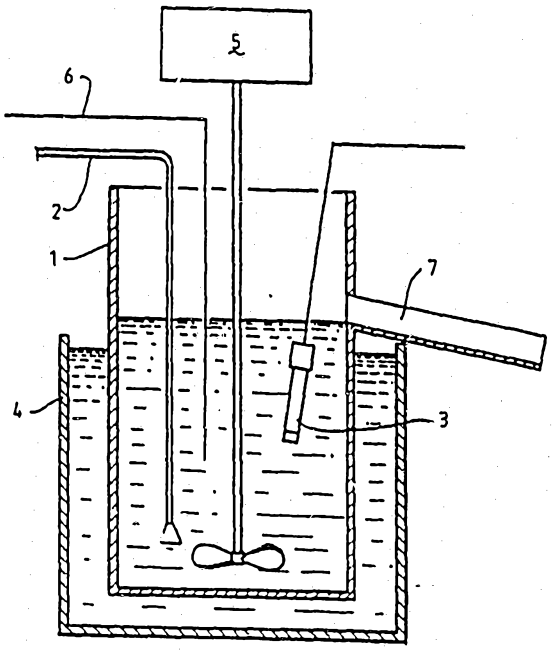
(54) Title: CONTINUOUS RBCOD MEASUREMENT



(57) Abstract

The invention provides a method and apparatus for providing periodical measurements of the real-time readily bio-degradable chemical oxygen demand (RBCOD) of a wastewater stream. The apparatus includes a bio-reactor (1) having an inlet (6) for accepting a continuous feed from the stream and an overflow outlet (7), whereby a sample volume can be maintained within the reactor. A feed rate is chosen to ensure an hydraulic retention time (HRT) in the reactor sufficient for substantially complete oxidation of the readily biodegradable compounds in the feed. Air (2) is periodically passed through the sample volume for set periods and the oxygen up-take (OUR) is determined by measuring the dissolved oxygen content via a probe (3) during the air-off periods. An RBCOD value is then calculated for each OUR value. The invention may be used to monitor the performance of wastewater treatment plants.

CONTINUOUS RBCOD MEASUREMENT

Technical Field

This invention relates to the measurement of readily biodegradable chemical oxygen demand (RBCOD) in an effluent or wastewater. In particular, the invention relates to a method and apparatus for real-time monitoring of RBCOD in a wastewater stream or feed.

The RBCOD of a waste stream is important as it may affect the operation of a process for treating the waste. For example, in biological sewage treatment systems capable of excess phosphorus removal, it has been shown that an appropriate portion of the incoming chemical oxygen demand (COD) needs to be readily biodegradable (Fuhs, G.W. and Chen, M. (1975). "Phosphorus Removal in Activated Sludge Process", Microbial. Ecology, 2, 119-139; Venter, S.L.V., Halliday, J. and Pitman, A.K. (1978). "Optimization of the Johannesburg Olifantzvlei Extended Aeration Plant for Phosphorus Removal", Prog Wat Tech, 10, 279-292). Where the RBCOD portion of the influent is found to be so low as not to achieve biological phosphorus removal, enrichment of the influent with fermentation products, such as volatile fatty acids (VFA) will be necessary. These products may come from solids settled from the sewage or from an external source such as digester sludge, industrial or agricultural waste.

The need for a continuous on-line method of monitoring the RBCOD in the feed to a sewage treatment plant for process control has been recognised. For example H.A. Nichols, C S Stevens and S Deacon in their paper "Full Scale Experimentation: Comparison of Different Control Strategies" published in the Papers of Technology Transfer Symposium "Advances in Biological

Phosphorous Removal by the Activated Sludge Process" 27 October 1988 Water Research Commission of South Africa, state the following:-

"There is an urgent need ... to develop a good and reliable method of monitoring the readily biodegradable COD in the [sewage] feed, so that not only the performance of primary sedimentation tanks can be monitored, but also the performance of the activated sludge process itself."

RBCOD measurements are also useful to monitor the performance of treatment processes, whether or not they have been designed for excess phosphorus removal. Thus there is a need for measurement of the RBCOD of wastewater both up-stream and down-stream of a treatment plant. Furthermore the RBCOD of an effluent stream may assist in characterising that stream for design of a suitable treatment plant therefor.

Knowledge of RBCOD levels is also useful for the control of anaerobic digesters where an increase in RBCOD may indicate microbial imbalance within the digester.

Background Art

Both biological and physical methods are known for measurement of RBCOD. Physical methods involving COD measurement of membrane filtered samples have given poor correlation with biological methods. The three main biological methods are 1) the short sludge age, step fed reactor, 2) the batch aerobic reactor and 3) the batch anaerobic reactor. These are described in some detail by Dold et. al. "Comparison of Measurement Methods for Readily Biodegradable COD Fraction in Municipal Wastewater", IWPC, Durban, South Africa (1985).

The short sludge age step fed reactor method has been reported as not giving consistent results and as being tedious, difficult to operate and unsuitable for the determination of in situ generated RBCOD. Furthermore, to obtain an RBCOD value representative of a 24 hour period, a large refrigerated composite sample would have to be collected each day. Long periods, for example 24 hours, are required for each measurement. Although measurement times can be reduced to about two hours with a batch aerobic reactor, the sampling and sample storage requirements for use of these reactors limit their applicability. The usefulness of anaerobic batch reactors is also limited by their sampling requirements. Furthermore RBCOD measurements based on limited sampling may not provide an accurate profile of the RBCOD of a waste stream because of wide variations over the diurnal cycle. Thus existing biological tests to determine RBCOD are not suitable for on-line or real-time monitoring of the influent to a treatment process or the effluent therefrom because they require a long time (2-24 hours) to obtain a result and the taking and storage of samples.

Disclosure of the Invention

An object of this invention is to provide a method and apparatus allowing relatively quick measurements of the RBCOD of a wastewater stream or feed to be periodically taken.

By virtue of the invention it is possible to obtain almost "real-time" measurements of the RBCOD of a wastewater feed or stream such that the invention may be applied for monitoring, control or other purposes. For example, apparatus according to the invention could be left unattended for a period for relatively frequent data collection.

According to the invention there is provided a method for periodically determining the readily biodegradable chemical oxygen demand (RBCOD) in a wastewater stream or feed comprising:

i) ~~continuously~~ feeding a sample representative of the real-time wastewater stream or feed to a sample volume whereby the feed rate is controlled to ensure an hydraulic retention time (HRT) in the sample volume sufficient for substantially complete oxidation of the readily biodegradable compounds,

ii) periodically passing air for predetermined periods through the sample volume,

iii) determining the oxygen consumption in the sample volume by measuring a change in the dissolved oxygen content while not passing air through the sample volume, and

iv) calculating an RBCOD value from each oxygen consumption measurement.

In accordance with the invention, it is not a requirement that sludge be added to the sample as in prior art RBCOD measurements. Thus the method can be used for monitoring sewers at any point in a sewage network.

~~The invention also provides apparatus for monitoring a~~ wastewater stream or feed comprising:

i) a bio-reactor ~~suitable~~ for maintaining a ~~completely mixed~~ sample volume and for continually ~~receiving~~ a sample representative of the real-time ~~wastewater feed,~~

The invention also provides apparatus for monitoring a wastewater stream or feed in real time comprising:

(i) a bio-reactor for containing and maintaining a completely mixed sample volume and for receiving a sample representative of the real-time wastewater stream or feed,

(ii) air injection means for periodically passing air for a predetermined period through a sample in the sample volume in the bio-reactor,

(iii) means for measuring the dissolved oxygen content of a sample within the bio-reactor at predetermined times after the passage of air to determine oxygen consumption of the sample, and

(iv) means for calculating readily biodegradable chemical oxygen demand (RBCOD) from the oxygen consumption of the sample.

~~ii) air injection means which may be periodically~~ operated to pass air for a predetermined period through a waste water sample when contained in the bio-reactor,

iii) means for measuring the dissolved oxygen content of a sample within the bio-reactor to determine the oxygen consumption of the sample from which the readily biodegradable chemical oxygen demand ~~(RBCOD) is calculable.~~

The bio-reactor (that is, the sample volume of the method aspect of the invention) is completely mixed and as the hydraulic retention time (HRT) is chosen to ensure the RBCOD is substantially oxidised in the reactor, then the concentration of RBCOD within the reactor at any point in time will be close to zero. (There will be some oxygen demand by the bacteria just for them to survive - this is called endogenous oxygen uptake, which in the practice of the invention, may be assumed to be constant.) It follows then that the oxygen consumption at any point in time is due to the incoming feed (plus the assumed constant endogenous demand).

An RBCOD value for each oxygen consumption measurement is calculated by multiplying the oxygen consumption measurement by a constant. Thus, soon after the start of an air-off period a first dissolved oxygen concentration measurement (DO_1) is taken and after a fixed period of time tp a second dissolved oxygen concentration measurement (DO_2) is taken from which the oxygen uptake consumption in the reactor in time t_p is given by:

$$(DO_1 - DO_2) \times V = \Delta DO \times V \text{ mg}$$

where V (litres) is the sample volume.

The RBCOD may be calculated from the change in dissolved oxygen concentration over the set measuring period by multiplying the value obtained by an apparatus constant which may be determined by calculation from the parameters of the system which are held fixed or by calibration using acetate solutions of known concentration as is shown below.

Thus RBCOD = ΔDO x constant.

The value for the constant includes a conversion factor of 3 for converting oxygen consumption to RBCOD (as suggested by Dold et al, supra) and factors relating the oxygen consumption in the bio-reactor over time t_p to oxygen consumption in the quantity of the feed that enters the reactor. These factors include the feed rate into the bio-reactor, a constant measurement period t_p and the bio-reactor volume.

Brief Description of Drawings

The invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a diagrammatic sketch of apparatus according to the invention.

Figures 2 and 3 illustrate O_2 consumption of a batch reactor due to Acetate addition for comparison with and calibration of a reactor according to the invention.

Figures 4 and 5 illustrate O_2 consumption in a reactor according to the invention due to Acetate addition.

Figures 6 and 7 illustrate on-line operation of the method and apparatus of the invention.

Best Mode for Carrying Out the Invention

Figure 1 illustrates example apparatus according to the invention. The apparatus comprises a 1.4 litre bioreactor 1 with an air injection means 2 and dissolved oxygen measuring probe 3. Associated with the bioreactor are temperature control means, in this case a water bath 4 maintained a 20°C, and a stirring means, for example a magnetic stirrer 5. An influent feed line is shown at 6 and overflow at 7. A temperature control means may not be required, for example in applications of the invention where the ambient temperature does not vary widely. Also, the bio-reactor may conveniently include means to clean its internal surface, such as for example, a scraping means which is operable at selected intervals of time.

Apparatus according to the invention may be supplied as a self contained portable unit, which unit may also include a data processing means for providing electrical output signals representative of RBCOD determinations. Optionally, such a portable unit may also include a pump connected to the bio-reactor input for supplying a constant feed thereto.

Experimental Set Up

Two bio-reactors, each of 1.4 litres volume, were set up housed in a water bath at 20°C and continuously fed by a peristaltic pump. The reactors were stirred at about 60 rpm. Since no attempt was made to retain solids, they acted as completely mixed reactors with the sludge age equal to the hydraulic retention time (HRT) which was around six hours. Air was applied in a 15 minute on, 15 minute off cycle at a rate chosen to prevent oxygen saturation occurring. (Any suitable on and off period for the air supply may be chosen, for example an

on and off cycle of between 1 and 30 minutes may be chosen.) Measurement of dissolved oxygen (DO) was made by polarographic electrode connected to a flat bed chart recorder. This method and apparatus by which relatively quick periodical measurements of RBCOD may be taken is referred to herein as a "continuous" method or "continuous" reactor.

Care must be taken that the DO electrode's response rate is very much greater, ~~than~~ and its oxygen consumption rate ~~and~~ very much smaller than the maximum and minimum oxygen uptake rates to be measured. The electrodes used were Titron 500MB with a response rate of around 2000mg/l/hr and a consumption rate of <0.1mg/l/hr. Maximum and minimum oxygen uptake rates in the reactors were in the order of 20 to 2 mg/l/hr.

So as to maintain a low endogenous oxygen uptake rate (OUR) in the reactor, cleaning of bio-film from all surfaces within the reactor was carried out once a day. The DO electrodes were likewise cleaned and calibrated to maintain their accuracy. Alternatively or additionally, the bio-reactor may include a cleaning means as has been described above.

Calibration of the reactors. To calibrate the oxygen uptake response of the continuous reactors, a comparison was made with an established batch method (ref. Lindrea et al - see below) by the addition of sodium acetate, expressed as acetic acid, to both the continuous reactors and a batch reactor. Plots of oxygen consumption rates following additions of acetate are shown for the batch method in Figures 2 and 3, and for the continuous method in Figures 4 and 5.

Sequential additions of acetate to both batch and continuous reactors result in similar shaped peaks in so

much as the consumption rate increases with time. This may indicate that the population of bacteria is increasing to meet the available substrate or the bacterial population is being "switched on" due to the stimuli of the substrate. The area under the curve, or oxygen consumption, is similar for sequential additions to both types of reactor. A surprising feature was the low rate of degradation of the acetate substrate in the batch reactor, considering that it had a high biomass content compared to the continuous reactor.

The measured oxygen consumption for each peak is shown in Table 1 as a percentage of the theoretical chemical oxygen demand of the acetate added. No allowance has been made in the calculation for the acetate lost due to wash out from the continuous reactor, estimated to be between 10 and 15% of the acetate added.

TABLE 1 % of Chemical Oxygen Demand of Acetate

	Batch			Continuous	
	Area 1	Area 2		Area 1	Area 2
Fig 2	29%	29%	Fig 4	29%	31%
Fig 3	29%	31%	Fig 5	30%	

The above figures are in excellent agreement with each other, and when converted to RBCOD using the factor of 3 recommended by Dold et. al. (supra) give a result similar to that reported by Lindrea et. al. (1988) "The Determination of the Readily Biodegradable COD Fraction of Wastewater", Australian Water and Wastewater Association, 13th Federal Convention, Canberra, March 6-10, pp.294-298.

The possibility existed that oxygen adsorption from the atmosphere may be occurring through the open top continuous reactors during the air off period. This would result in lower oxygen uptake readings, although the acetate addition results did not suggest this. Tight fitting closed cell foam disks were pressed into the reactors down to liquid surface level. No measurable difference was found in the oxygen consumption rate and as the discs only increase the surface area to volume ratio for biofilm growth, they may be dispensed with.

It was felt that these results were sufficiently encouraging for the apparatus to be used for the measurement of RBCOD in the influent and effluent streams of an activated primary tank (APT) of a 5.3m^3/day pilot sewage treatment plant operated by CSIRO at its Lower Plenty Research Station (Bayly et al "The Effect of Primary Fermentation on Biological Nutrient Removal" Australian Water and Wastewater Association, 13th Federal Convention, Canberra, March 6-10, 1989, pp. 162-166). Excess phosphorous removal was associated with the pretreatment of the pilot plant feed by the APT, the purpose of which is to increase the concentration of influent RBCOD.

Continuous In Situ Measurement of RBCOD

One reactor was fed with raw screened sewage continuously pumped from the feed stream to the APT, the other with APT effluent which is used to feed the Bio-P removal pilot plant.

The data shown in Figure 6 is typical of that collected during November 1989 when the APT was operating as a clarifier, the settled solids being drawn off once a day to give a sludge age of approximately one day. Under

these conditions it appears that very little if any RBCOD was being generated, the average oxygen consumption values are, 37mgO_2/l of influent and 33mgO_2/l of effluent. In contrast Figure 7 is typical of data collected during January 1990 when settled solids were being built up in the APT to obtain a sludge age of approaching 30 days. The average influent oxygen consumption for Figure 7 is 26mgO_2/l and effluent 51mgO_2/l.

The diurnal pattern of raw sewage oxygen consumption can be clearly seen in Figure 7. Typically a very low value occurs at about 6 to 7am followed by an initial peak at about mid-day, a plateau or trough, then a second usually higher peak around 10pm. The minimum diurnal value is in the region of 4 to 5mgO_2/l and the maximum value between 40 and 60mgO_2/l.

The effluent pattern is damped and moved in time by the APT hydraulic retention time HRT, which is variable with the diurnal feed rate. Also the feed rate to the APT dictates the degree of dilution of soluble substrates being produced from the accumulated settled solids. The dip in the curves at around 8am is caused by flow cessation for routine reactor cleaning.

The continuous fed reactor returns similar oxygen uptake results to the batch method when calibrated by acetate addition. The method of the invention provides a convenient investigative adjunct to the well established batch method and provides a clearer picture of diurnal and day to day RBCOD variations. This information could be used to predict the performance of an operating process with or without an APT or be used for design of new plants.

Those skilled in the art will appreciate that the invention described herein is susceptible to variations and modifications other than those specifically described. It is therefore to be understood that the invention includes all such variations and modifications which fall within its spirit and scope.

CLAIMS

1. A method for periodically determining the readily biodegradable chemical oxygen demand (RBCOD) in a wastewater stream or feed comprising:-

i) ~~continuously~~ feeding a sample representative of the real-time wastewater stream or feed to a sample volume whereby the feed rate is controlled to ensure an hydraulic retention time (HRT) in the sample volume sufficient for substantially complete oxidation of the readily biodegradable compounds,

ii) periodically passing air for predetermined periods through the sample volume,

iii) determining the oxygen consumption in the sample volume by measuring a change in the dissolved oxygen content while not passing air through the sample volume, and

iv) calculating an RBCOD value from each oxygen consumption measurement.

2. A method as claimed in claim 1 wherein the sample volume is maintained at a substantially constant temperature.

3. A method as claimed in claim 1 wherein the sample volume is continuously stirred.

4. A method as claimed in claim 1 wherein the predetermined period for each periodical passage of air through the sample volume together with the air-off period is within the range of between 1 to 30 minutes.

5. A method as claimed in claim 4 wherein the predetermined period plus the air-off period is between 10 to 15 minutes.

6. Apparatus for monitoring a wastewater stream or feed in real time comprising:

(i) a bio-reactor for containing and maintaining a completely mixed sample volume and for receiving a sample representative of the real-time wastewater stream or feed,

(ii) air injection means for periodically passing air for a predetermined period through a sample in the sample volume in the bio-reactor,

(iii) means for measuring the dissolved oxygen content of a sample within the bio-reactor at predetermined times after the passage of air to determine oxygen consumption of the sample, and

(iv) means for calculating readily biodegradable chemical oxygen demand (RBCOD) from the oxygen consumption of the sample.

7. Apparatus as claimed in claim 6 including means to maintain a sample volume at a substantially constant temperature.

8. Apparatus as claimed in claim 6 or claim 7 including means for stirring the bio-reactor contents.

9. Apparatus as claimed in anyone of claims 6 to 8 wherein the bio-reactor includes an inlet and an overflow outlet, the inlet being connectable to receive a wastewater feed.

10. Apparatus as claimed in claim 6 wherein the bio-reactor includes means to clean the internal surface of the reactor.

11. Apparatus as claimed in claim 10 wherein the inlet is connected to receive a continual wastewater feed.

12. A self contained portable unit for measuring RBCOD comprising apparatus as claimed in anyone of claims 6 to 10 housed within the unit together with a data processing means for providing electrical output signals representative of RBCOD determinations.

13. A self contained portable unit as claimed in claim 12 also including a pump, for supplying a feed to the bio-reactor, housed within the unit.

14. A method for periodically determining the readily biodegradable chemical oxygen demand (RBCOD) in a wastewater stream or feed substantially as hereinbefore described with reference to the drawings.

15. Apparatus for monitoring a wastewater stream or feed substantially as hereinbefore described with reference to the drawings.

DATED: 25 February 1994

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800951/91

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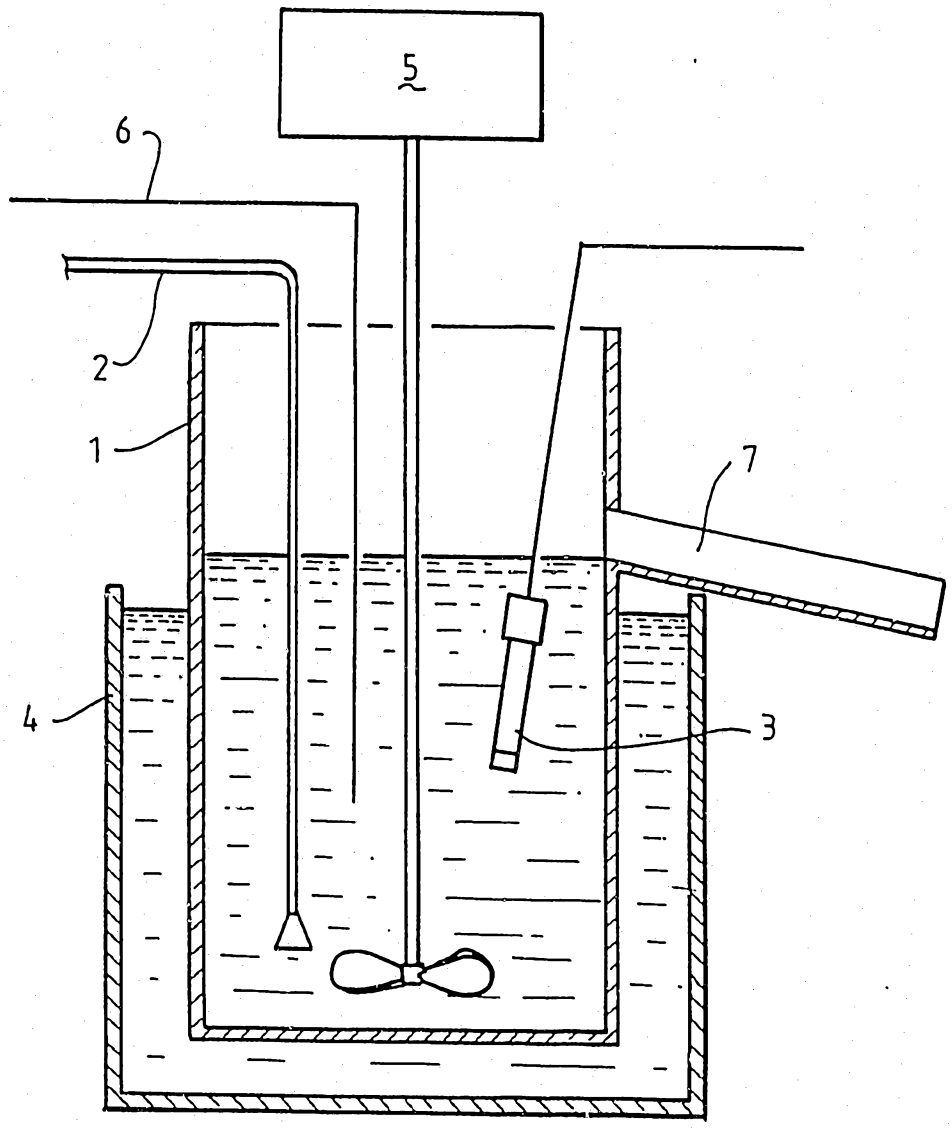
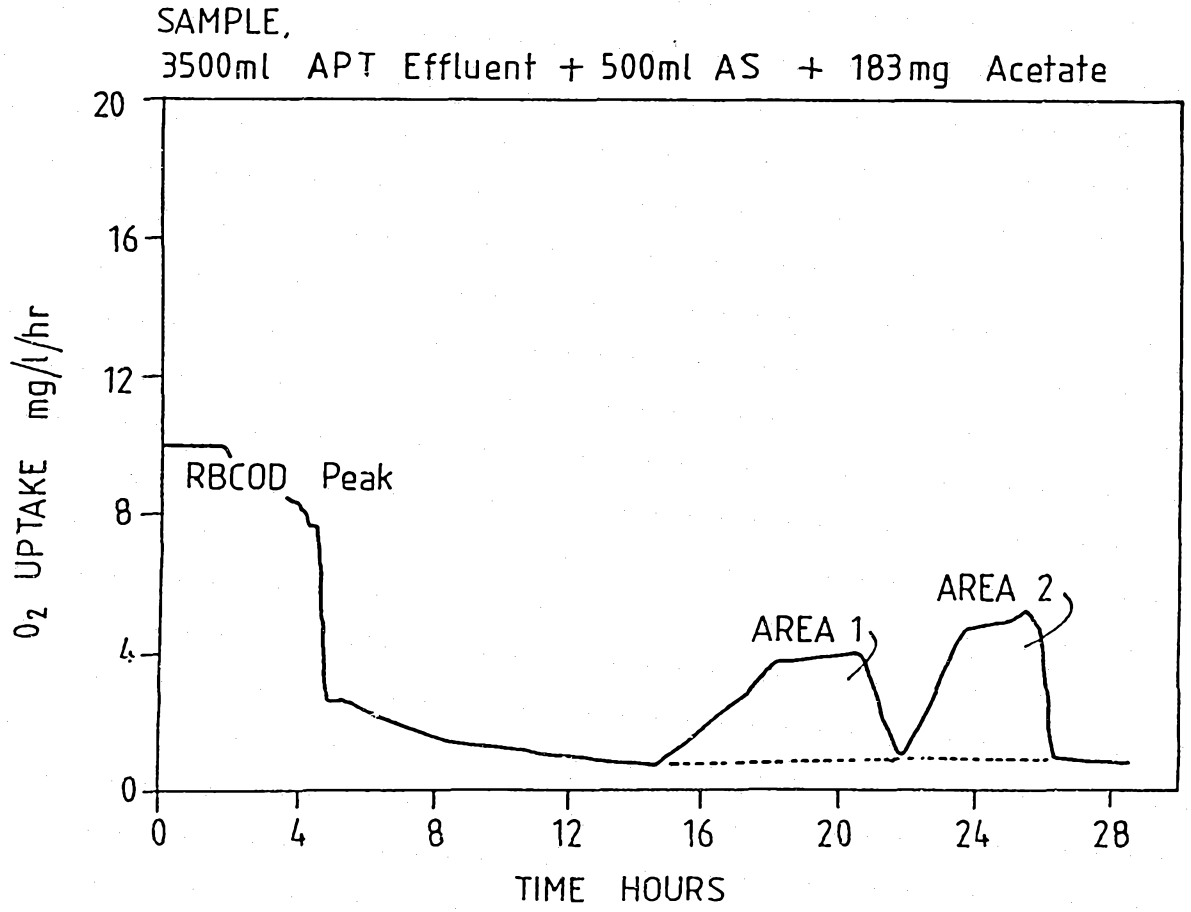


FIG. 1.



O_2 Uptake due to Acetate Addition

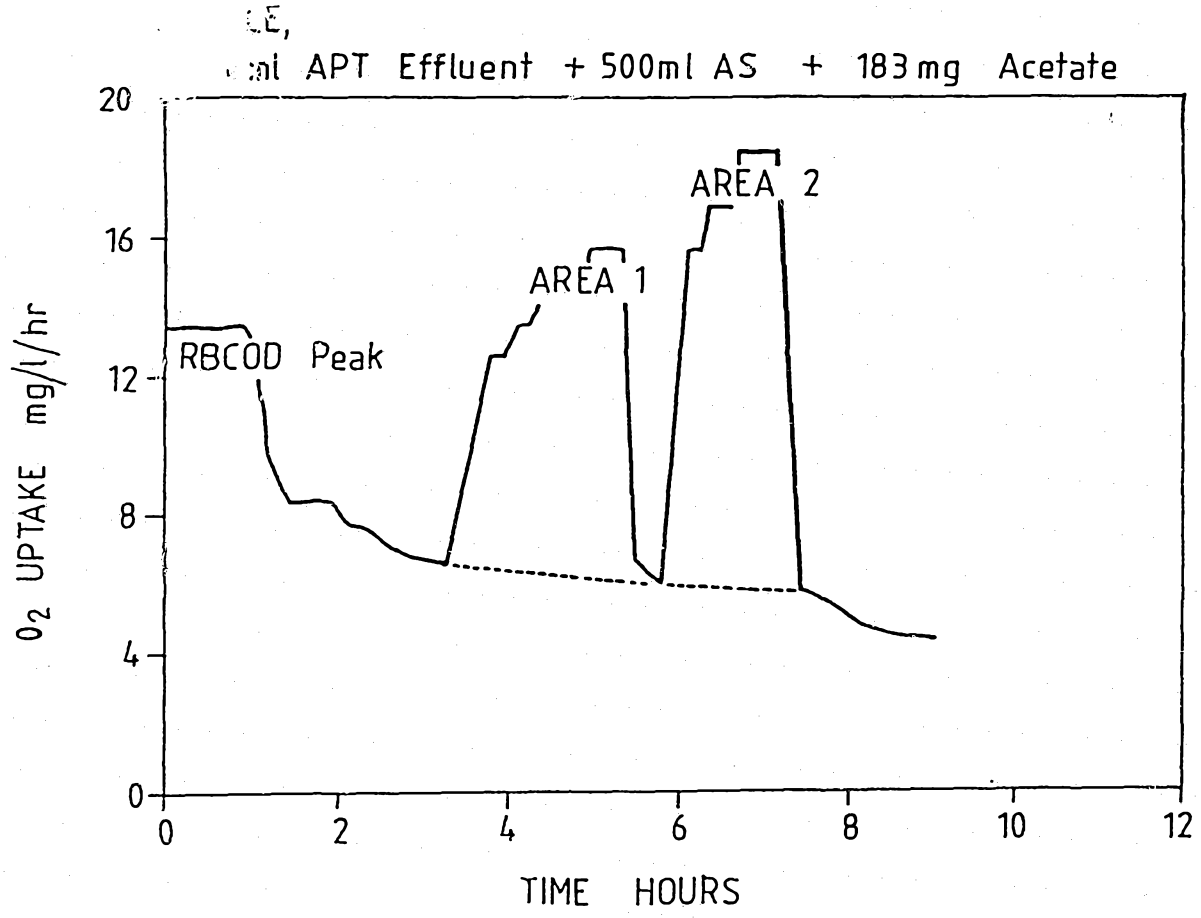
AREA 1 = 58mg

AREA 2 = 56 mg

AS = 1 Hour Settled Activated Sludge

FIG. 2.

OXYGEN UPTAKE in BATCH REACTOR due to ACETATE ADDITION



O_2 Uptake due to Acetate Addition

AREA 1 = 57mg

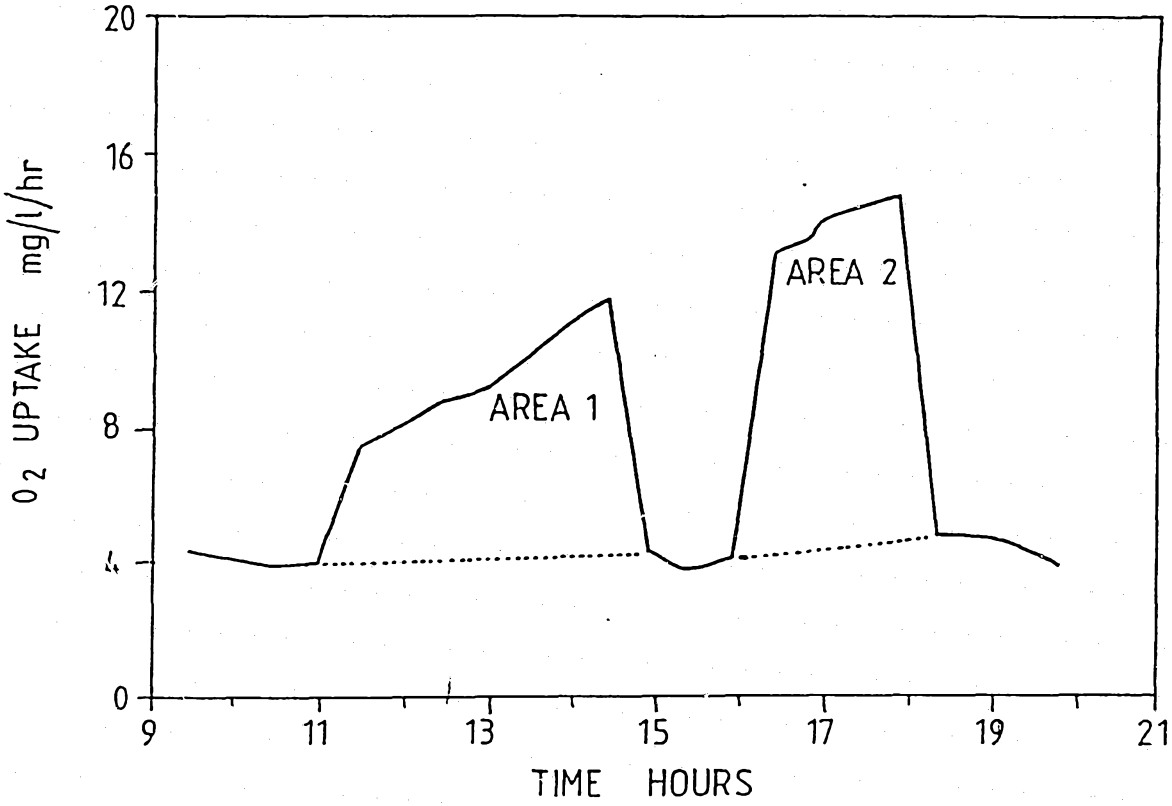
AREA 2 = 59mg

AS = 1 Hour Settled Activated Sludge

FIG. 3.

OXYGEN UPTAKE in BATCH REACTOR due to ACETATE ADDITION

FEED, APT Effuent + 60mg/l Acetate added to Reactor



O_2 Uptake due to Acetate Addition

AREA 1 = 27 mg

AREA 2 = 28 mg

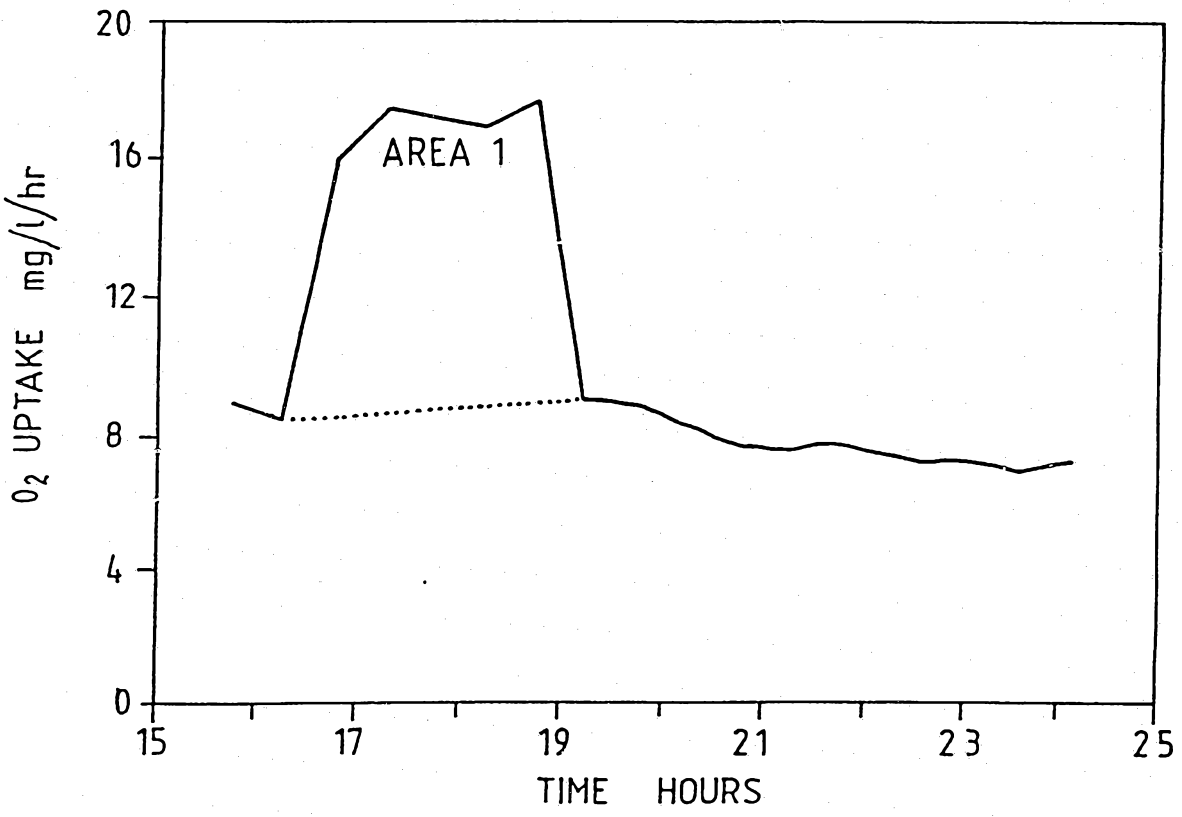
Reactor Vol. 1.4l

Feed Flow 3.9l/min

FIG. 4.

OXYGEN UPTAKE in CONTINUOUS REACTOR due to ACETATE ADDITION

FEED, APT Effuent + 60mg/l Acetate Added to Reactor



O_2 Uptake due to Acetate Addition

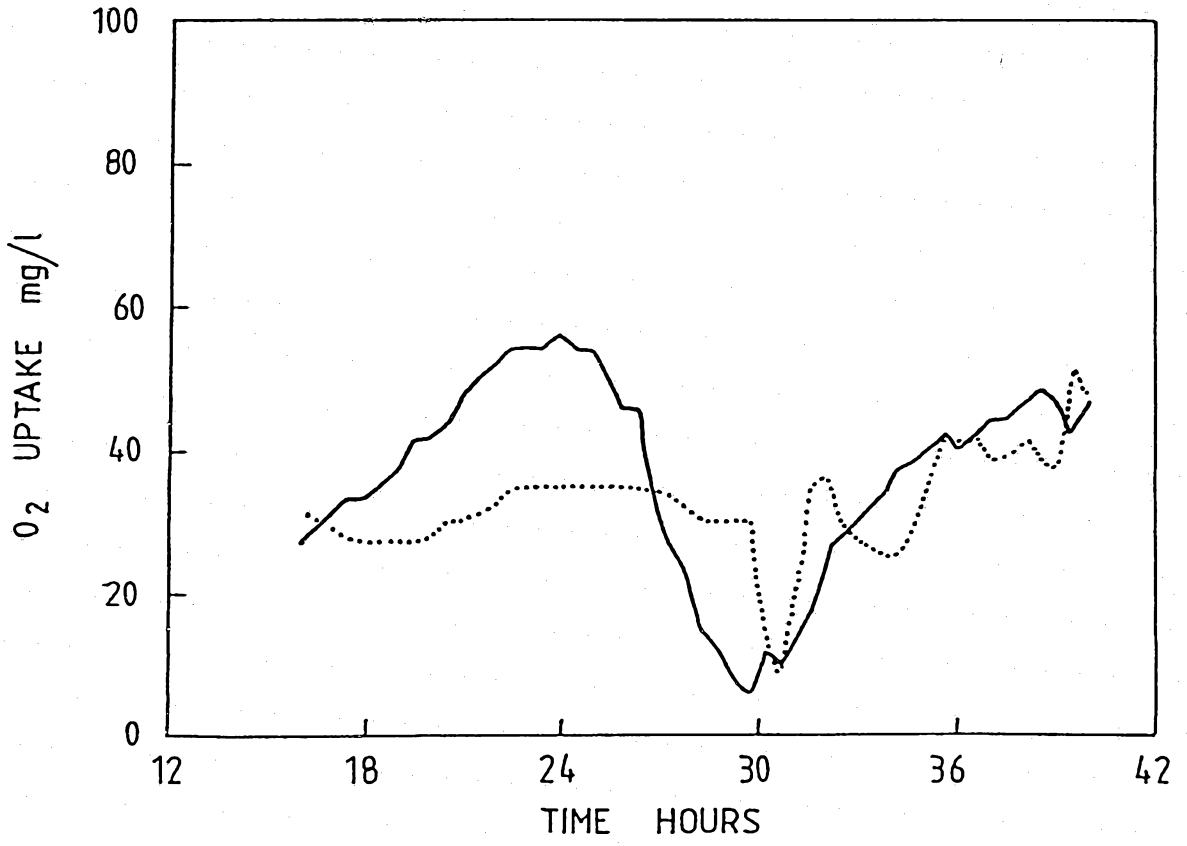
AREA 1 = 28mg

Reactor Vol. 1.4l

Feed Flow 2.4l/min

Fig. 5.

OXYGEN UPTAKE in CONTINUOUS REACTOR due to ACETATE ADDITION



[November 89 Sludge Age = 1 Day]

FIG. 6.

OXYGEN UPTAKE of APT INFLUENT and EFFLUENT

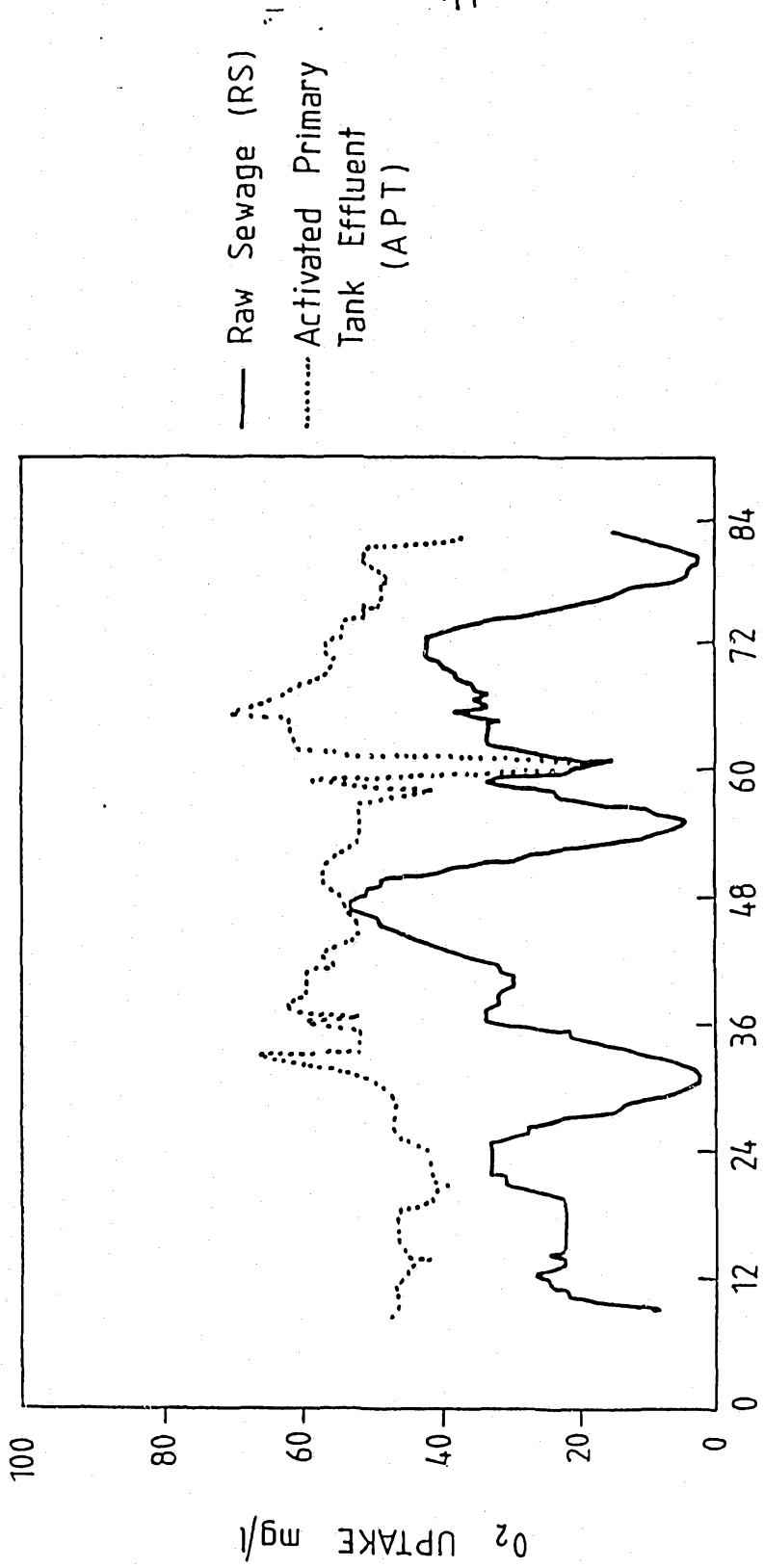


FIG. 7.

OXYGEN UPTAKE of APT INFLUENT and EFFLUENT

[January 90 Sludge Age = 30 Days]

INTERNATIONAL SEARCH REPORT

International Application No. PCT/AU 91/00287

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) 6

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl.[5] G01N 33/18 // C02F 3/02, G01N 27/48

II. FIELDS SEARCHED

Minimum Documentation Searched 7

Classification System	Classification Symbols
IPC	G01N 33/18

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched 8

AU : IPC as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT 9

Category*	Citation of Document, 11 with indication, where appropriate, of the relevant passages 12	Relevant to Claim No 13
X	US,A, 4564453 (COPLOT et al) 14 January 1986 (14.01.86)	(6,8-9)
Y	See col 3 line 55 - col 4 line 29, Fig 1	(11)
X	DE,A, 2952343 (LINDE A.G.) 25 June 1981 (25.06.81) See figures	(6,8-9)
Y		(11)
X	GB,A, 2184110 (THE BOC GROUP PLC) 17 June 1987 (17.06.87)	(6,9)
Y	See page 2 lines 11-40, Fig 1	(11)
X	Patents Abstracts of Japan, P-305, page 47, JP,A, 59-99353	(6-8,10)
Y	(KOGYO GIJUTSUIN) 8 June 1984 (08.06.84)	(11)
X	Patents Abstracts of Japan, P-156, page 153, JP,A, 57-135357 (TOKYO SHIBAURA DENKI K.K.) 20 August 1982 (20.08.82)	(6-9)

(continued)

* Special categories of cited documents: 10

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
5 September 1991 (05.09.91)	12 September 91
International Searching Authority	Signature of Authorized Officer
Australian Patent Office	M S Haynes M.S. HAYNES

Form PCT/ISA/210 (second sheet) (January 1985)

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

X Y	Patents Abstracts of Japan, P-58, page 60, JP,A, 56-12546 (AJINOMOTO K.K.) 6 February 1981 (06.02.81)	(6-7,9) (11)
X	Patents Abstracts of Japan, P-89, page 164, JP,A, 56-108951 (NITSUSHIN DENKI K.K.) 28 August 1981 (28.08.81)	(6-8)
X	Patents Abstracts of Japan, P-511, page 102, JP,A, 61-129567 (SHUKUJI ASAKURA) 17 June 1986 (17.06.86)	(6-8)
X	M.A. Winkler "Biological Treatment of Waste-Water", published 1981, Ellis Horwood Ltd (Chichester), see pages 160-161, Fig 5.6	(6)

V. [ ] OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE 1

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.[ ] Claim numbers ..., because they relate to subject matter not required to be searched by this Authority, namely:

2.[ ] Claim numbers , because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3.[ ] Claim numbers ..., because they are dependent claims and are not drafted in accordance with the second and third sentences of PCT Rule 6.4 (a):

VI. [ ] OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING 2

This International Searching Authority found multiple inventions in this international application as follows:

1.[ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2.[ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3.[ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. [ ] As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

[ ] The additional search fees were accompanied by applicant's protest.

[ ] No protest accompanied the payment of additional search fees.

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL APPLICATION NO. PCT/AU 91/00287

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Members
US 4564453	EP 114780, FR 2539875
DE 2952343	
GB 2184110	JP 62254897, ZA 8608928

END OF ANNEX