Refinery BREF related environmental parameters for aqueous discharges from refineries in Europe

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Brussels
April 2010

ABSTRACT

This report is prepared as part of the Industry input to the revision process for the Refinery Best Available Technique (BAT) Reference Document (BREF) that is being undertaken by the European IPPC Bureau.

Five effluent parameters were selected for consideration on the basis that these are addressed in the current refinery BREF. These are Total Hydrocarbon Content (THC), Total Nitrogen (TN), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Total Suspended Solids (TSS). The data are presented in this report document as cumulative frequency plots of the measured concentrations (mg/l), as reported and where possible the associated determined loads in grammes per tonne of Crude oil processed.

The analysis reveals that there is no obvious correlation between concentrations and loads of these five parameters and type of wastewater treatment process. Further analysis indicates that the level of complexity of a refinery (as characterised by the industry standard Nelson Complexity Index) have no bearing on the quality of the final effluent.

It is, therefore, concluded that it is not possible, from this set of data, to specify a level of effluent quality that can be achieved or be expected from these two aspects of refinery technology. It is more likely that effluent quality is determined by a complex combination of operational process and waste-stream management parameters and that management of these on a site-specific basis is likely to present the most effective way of meeting effluent quality objectives.

KEYWORDS

Refinery effluent quality, Total Petroleum Hydrocarbon Content, Oil in Water, Total Petroleum Hydrocarbons, BOD, COD, Total Suspended Solids, Nelson Complexity Index.

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SUMMARY

This document has been prepared in response to feedback received from the European IPPC Bureau on an earlier internal CONCAWE document [1] that was prepared as input to the process of revising the Best Available Techniques (BAT) Reference Document (BREF) for refineries that is being carried out by the Bureau. The document provides a factual reflection of data for five oil refinery effluent quality parameters from data obtained in a 2006 CONCAWE survey of 100 of its members. The survey included all refineries in the EU-27 countries and those in Norway and Switzerland and concerned data for the year 2005.

The parameters covered by this and the earlier document are Total Hydrocarbon Content (THC), Total Nitrogen (TN), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Total Suspended Solids (TSS).

The aforementioned document presented the data for the parameters as a series of cumulative frequency plots that provided the information on the average yearly measured concentrations in mg/l and, where possible, the average parameter load in gram per tonne of feedstock processed for each effluent stream.

In response to comments received from the European IPPC Bureau, the same data are now re-presented in such a way that the significance of two refinery-specific variables on the concentration and load data can be assessed. The two variables considered are:

- The type of waste-water treatment process that is applied to the effluent prior to discharge to the environment – as characterised by five process descriptions
- The complexity of the refinery – as defined based on the industry standard Nelson Complexity Index (NCI).

Presenting the data in this way has revealed that there does not appear to be any direct or simple correlation between concentrations and loads of the five parameters and the type of waste-water treatment process and that the level of complexity of a refinery does not have any bearing on the quality of the final effluent. Thus, technologies applied to the treatment of wastewater in refineries do not currently guarantee comparable performances between sites.

Based on these results, it is concluded that it is not currently possible to specify a level of effluent quality that can be achieved or be expected from these two aspects of refinery technology. It is more likely that effluent quality is determined by a complex combination of operational process and waste-stream management parameters and the application of these on a site-specific basis is likely to present the most effective way of meeting effluent quality objectives.

Moreover, the analytical methods and the measurement frequency are another source of variability in the dataset. Each expected level of performance referred to in the BREF should be related to a standard analytical method and to an appropriate averaging period. Monthly average values must not be derived from annual average data as some parameters can vary more than others from one month to another. Daily values can cover an even wider range depending on the stability of the operation and operating events.

The scope of the survey did not extend to the provision of information on site-specific operational and waste-stream management processes. Consequently, it did not provide sufficient data or information that could be used to correlate these variables with the quality of the final effluent and the type of wastewater treatment technique applied.

1. INTRODUCTION

An earlier internal CONCAWE document [1] was prepared as input to the process of revising the Best Available Techniques (BAT) Reference Document (BREF) for refineries that is being carried out by the European IPPC Bureau. The document provided a factual reflection of data for five oil refinery effluent quality parameters from data obtained in a 2006 CONCAWE survey of 100 of its members. The survey included all refineries in the EU-27 countries and those in Norway and Switzerland.

Data for five parameters were presented; Total Hydrocarbon Content (THC), Total Nitrogen (TN - as the sum of organic nitrogen, ammonia, nitrite and nitrate nitrogen), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Total Suspended Solids (TSS). These endpoints were selected for consistency with those cited in the 'Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques for Mineral Oil and Gas Refineries' [2]. The parameters also reflect the main representative pollutants mentioned in "Best Available Techniques to Reduce Emissions from Refineries" [3].

In response to comments received from the Bureau, CONCAWE undertook to present the data in such a way that the significance of two refinery-specific variables on the concentration of and load-data could be assessed. The two variables to be considered were:

- The type of waste-water treatment processes that are applied to the effluent – as characterised by five process descriptions
- The complexity of the refinery – as defined based on the industry standard Nelson Complexity Index [4, 5, 6, 7, 8 & 9].

This document presents the data in formats that are consistent with these requirements.

The data reflect returns from all responding refineries. However, because not all refineries reported data for all parameters and some refineries reported data for more than one discharge, the total number of observations for each parameter in the data plots does not equal the aforementioned total number of refineries.

2. DATA COLLATION, ANALYSIS AND PRESENTATION

The processes by which the survey data were obtained and the results were collated are described in the earlier document [1]. The database is included again in this report as **Appendix 1**. The data were presented in the form of 'S' shaped cumulative frequency distribution curves with the magnitude of the parameter on the 'X' axis (logarithmic scale) and the cumulative percentage frequency of observations on the 'Y' axis (linear scale). Separate plots were presented for the data expressed in terms of concentration (mg/l) and load (g/tonne of crude oil or feedstock processed). Where applicable, separate plots were also presented that included and excluded data relating to effluents sent to off-site waste-water treatment facilities prior to discharge.

The data sets are now re-presented in amended formats to illustrate the significance of:

- the type of waste-water treatment processes that are applied to the effluent and
- the complexity of the refinery.

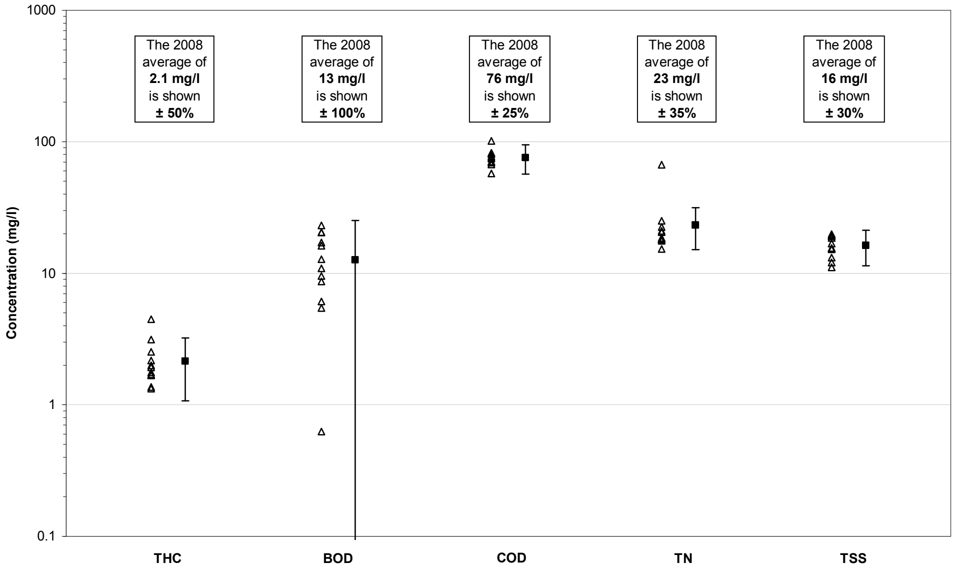
In determining the quality of the discharged effluent and the relationship between the achieved quality and criteria specified in the 'Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques for Mineral Oil and Gas Refineries [2], hereafter, referred to as the BREF document.

The cumulative frequency distribution plots of concentration and load for each parameter now show values corresponding to the 10^{th}, 50^{th} and 90^{th} percentile points on the distributions. These values have been included to provide an approximate screen for data which are not representative (analytical or reporting errors can be suspected) of the overall distribution pattern.

The upper and lower values of specific load for the parameters (g/tonne of crude) that are specified in the BREF document are also shown. The BAT associated emission values from the BREF, expressed as concentrations (mg/l), are not shown; it is not appropriate to compare monthly BREF emission ranges with the annual survey average concentrations.

Due to the varying operational conditions at a refinery, the monthly average effluent concentrations can fluctuate significantly, as demonstrated in **Figure 1**. The figure is based upon a recent evaluation of the effluent stream from CONCAWE member refinery sites. The data are presented using a logarithmic concentration axis to facilitate visual comparison. The same data is also presented in **Appendix 2** as individual plots with linear concentration axes. Tabulated data are also shown in this appendix for additional sites.

Figure 1 2008 - Monthly and Annual Average THC, BOD, COD, TN and TSS concentrations (mg/l)



Therefore, as advocated in CONCAWE report 4/03 [10], CONCAWE remains of the opinion that BREF emission ranges should reflect annual averages, as these are less prone to variability in operational conditions and the ranges must be based upon sufficiently robust data sets. Furthermore, interpreting annual average values, as provided in this report, with reference to monthly average BAT-associated emission ranges is inappropriate.

2.1. SIGNIFICANCE OF TYPE OF WASTE-WATER TREATMENT PROCESS

A new set of ‘S’ curves have been produced that are based on the originals but within which data points relating to particular types of waste-water treatment processes applied to the refinery effluents are differentiated. The types of treatment are defined as follows in Table 1.

Table 1 Type of wastewater treatment processes

Treatment type	Description
G	Gravity separation, e.g. API separators, plate interceptors, tank separation
GA	Advanced treatment, e.g. flocculation, gas flotation, sedimentation, filtration
GB	Biological treatment, e.g. bio-filters, activated sludge, aerated ponds
GAB	Gravity + advanced treatment + biological treatment
GABP	Biological treatment followed by additional polishing treatment

These treatment type definitions are a minor adaptation of the definition used in the last report on trends in oil discharged with aqueous effluents from oil refineries in Europe [11].

The plots in chapter 3 exclude data points relating to effluents sent to off-site treatment facilities.

A further set of plots showing the same data sets have been produced with the load and concentration data for each parameter plotted on the 'Y' axis against type of wastewater treatment process on the 'X' axis.

If the wastewater treatment process will be a significant factor determining concentration of and load-data for a parameter, it would be expected that this would be reflected in clustering of data points around particular regions of both types of plot.

2.2. SIGNIFICANCE OF REFINERY COMPLEXITY

The Nelson Complexity Index [4, 5, 6, 7, 8 & 9] provides a standard measure of the complexity of a refinery. The NCI assigns a complexity factor to each major piece of refinery equipment based on its complexity and cost in comparison to crude distillation, which is assigned a complexity factor of 1.0. The complexity of each piece of refinery equipment, then, is calculated by multiplying its complexity factor by its throughput ratio as a percentage of crude distillation capacity. A refinery's NCI is obtained by summing the complexity values for each piece of equipment, including crude distillation.

For the analysis presented in this document the NCI values shown in **Appendix 3** have been used. The values were derived from the Oil and Gas Journal refining capacity and layout listing of December 2004 (Data as of January 1, 2005 [12]). No attempt has been made to verify these NCIs with the CONCAWE Membership due to changes in ownership and the fact that today's lay-out may have altered due to changing strategies and major investments that have taken place.

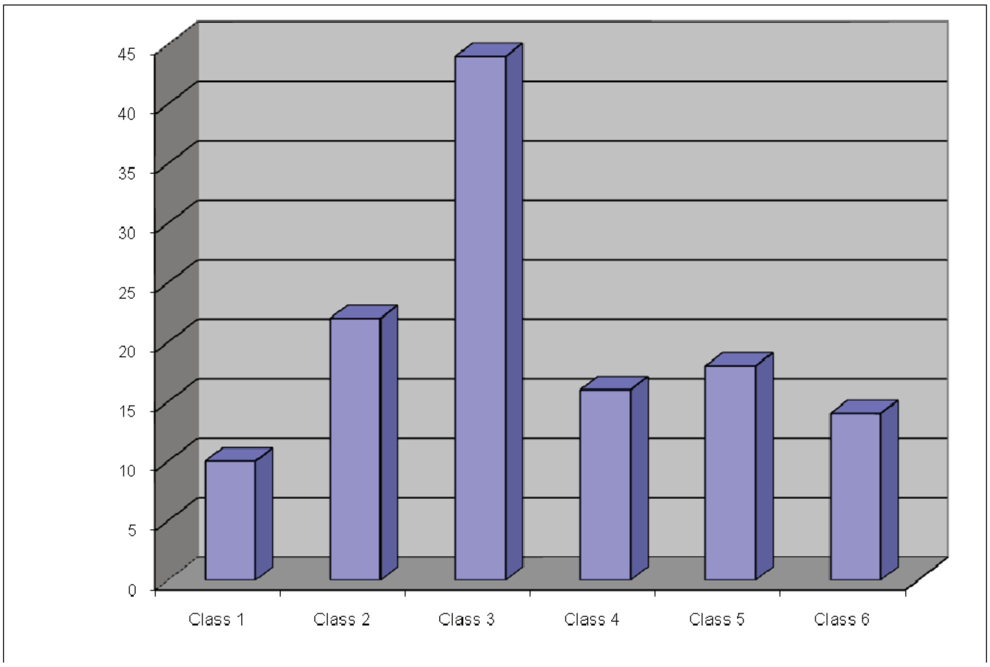
For the purpose of this report, CONCAWE has derived the following six classes of refineries based on NCI that are shown in Table 2.

Table 2 NCI Refinery classifications

Refinery Class	**NCI ranges**
Class 1	NCI < 4
Class 2	4 < NCI ≤ 6
Class 3	6 < NCI ≤ 8
Class 4	8 < NCI ≤ 10
Class 5	NCI >10
Class 6	Specialised Refineries for Lubes and Bitumen production.

The 2005 NCI classification for all EU-27 based refineries, as derived from the aforementioned Oil & Gas Journal information, is shown in **Figure 2**.

Figure 2 2005 Nelson Complexity Index (NCI) classification for all EU-27 based refineries



The figure shows that the European refineries differ with respect to their complexity and the operations and installations that are present on-site. These differences could also have an impact on the waste water streams that end up in the final treatment facility and, hence, the effluent composition. Therefore, in chapter 3, for the purposes of this document the load and concentration values for each parameter have been plotted on the 'Y' axis against the absolute NCI values that have been calculated for each refinery on the 'X' axis. The resulting data points have been further differentiated by highlighting those that relate to effluents subject to the particular types of wastewater treatment process described in Section 2.1.1. Once again, the plots exclude data points relating to effluents sent to off-site treatment facilities.

If waste-water treatment process is a significant factor determining concentration and load data for a parameter it would be expected that this would again be reflected in clustering of data points around particular regions of the plots.

2.3. SIGNIFICANCE OF SITE SPECIFIC OPERATING PRACTICES

Differences in the quality of final effluent from sites applying the same type of treatment technique could be associated with differences in site-specific process practices that impact the composition of wastewater, hydraulic loading and pollutant mass loading to the waste water treatment system. The scope of the survey did not include sufficient data or information that could be extracted for this document to evaluate site-specific operational process and waste-stream management parameters. Therefore, correlations to the quality of the final effluent and the type of wastewater treatment technique applied could not be obtained.

3. RESULTS

The results are presented in **Figures 3** to **32**. The types of wastewater treatment process are indicated in the relevant figures by different coloured symbols.

The raw data from which the cumulative frequency distributions (the 'S' curves) were derived are contained in **Appendix 1**.

3.1. TOTAL HYDROCARBON CONTENT (THC)

The data are presented in **Figures 3** to **8**.

THC concentrations reported in the survey were determined using the range of methods indicated in **Appendix 4**. These included gravimetric methods, infra-red (IR) spectrometry or gas chromatography (GC). The Limit of Detection (LOD) values for the methods were in the range 0.0005 to 2 mg/l.

The use of different methods will have introduced systematic differences in the total oil concentrations reported in this survey. Furthermore, the inclusion or removal of intermediate sample clean-up or concentration steps and the use of different extraction media, such as Freon or n-hexane, are also likely to have introduced variation in results obtained using ostensibly the same approach. In addition, some analytical methods include work-up procedures that remove all polar hydrocarbons. These differences in analytical approach and methods can result in reported values differing by up to 4 orders of magnitude, when compared to a data set that was analysed by a single method. It is therefore important that methods of measurements be associated with BAT emission ranges.

Figure 3[1] shows that 80% of the refineries reported annual average THC concentrations higher than 0.15 mg/l and lower than 6 mg/l. In comparison, the current lower value of the BAT range[2] (not shown in the figure) is a monthly average (rather than an annual average) of 0.05 mg/l. For most of the refineries, this value cannot be measured given the LOD values of the methods that are being used.

Figure 4 shows that approximately 50% of the refineries reported annual average THC loads that were lower than the upper value of the BAT range of 0.75 g/t and approximately 99% reported loads that were above the lower value of the BAT range of 0.01 g/t.

Figures 5 and **6** show that, although there is a wide range of concentrations for each class of treatment, lower average concentration of THC can be reached with biological treatments that are able to remove a part of soluble HC. Nevertheless, based on this survey, the presence of a biological step (classes 3, 4 and 5) does not guarantee lower average concentrations or loads compared to gravity separation or advanced gravity treatment.

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[1] With reference to Figure 3 the BREF document notes that there is some disagreement on the analytical methods used to assess hydrocarbons. Specifically "One Member State and Industry claim that 3 mg/l as upper value is representative of actual operations data of existing refinery facilities in Europe with 3-step Waste Water Treatment Plant currently in place. One Member State proposed an upper value of 5 based on current observed performances in existing facilities in their country." The value of 3 mg/l (expressed as a monthly average) was proposed by CONCAWE (CONCAWE 2003: report 4/03) [10].

[2] In this report "BAT range" always refers to the BAT-associated emission range indicated in the February 2003 version of the Refinery BREF [2].

Figures 7 and **8** show no clustering of data around particular regions of the plots of NCI versus THC concentration or load. The NCI of a refinery does not therefore determine with the THC content of its wastewater.

Figure 3 2005 Yearly Average THC concentrations shown as a cumulative frequency plot

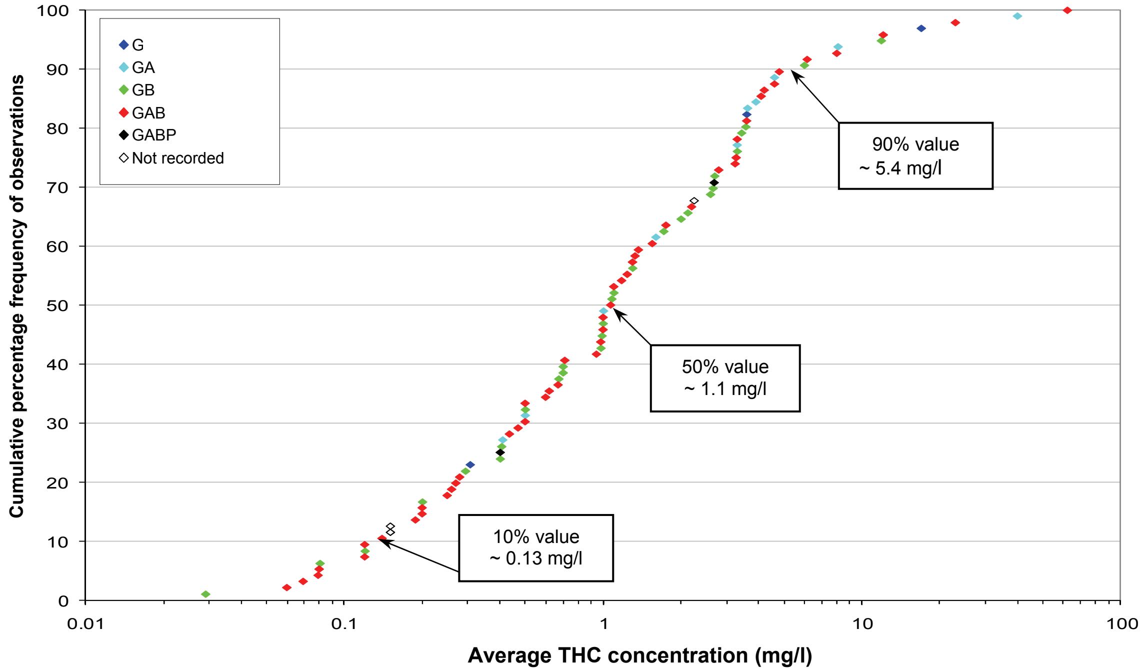


Figure 4 2005 Yearly Average THC loads shown as a cumulative frequency plot

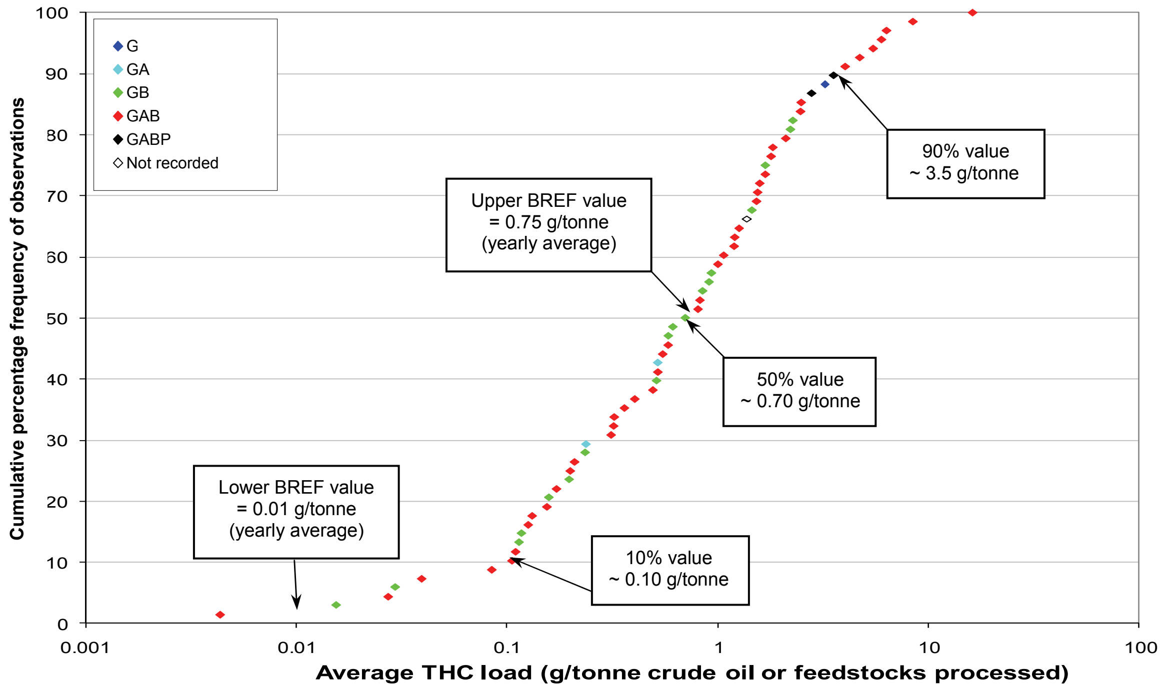


Figure 5 2005 Yearly Average THC concentrations differentiated by type of waste-water treatment process

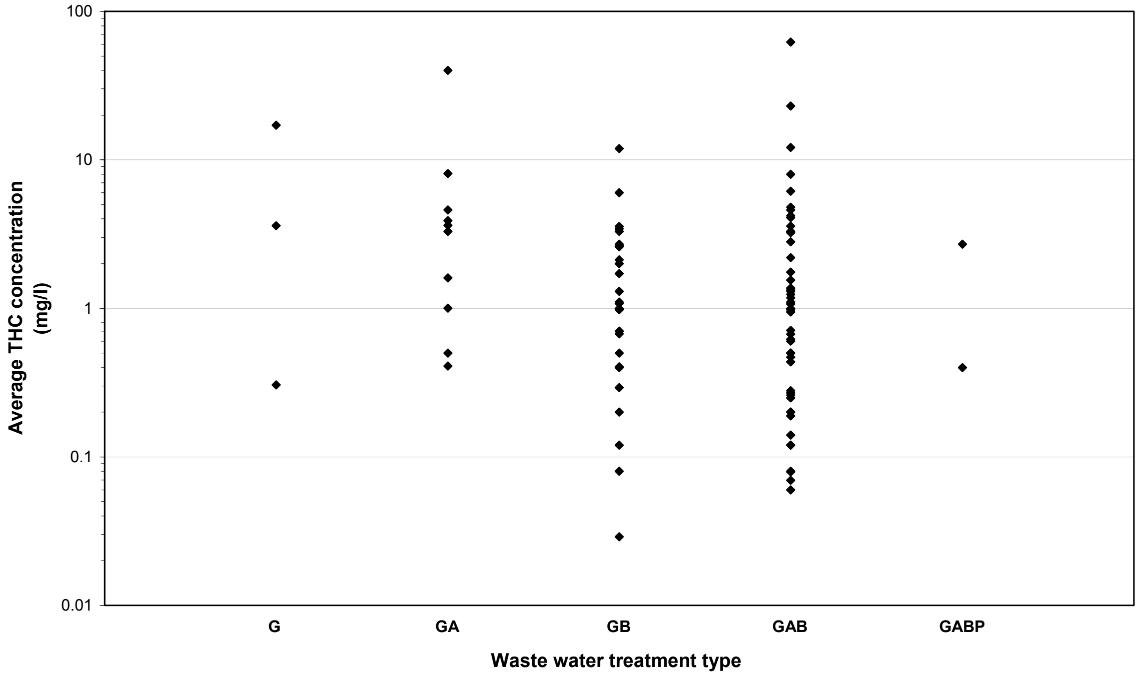


Figure 6 2005 Yearly Average THC loads differentiated by type of waste-water treatment process

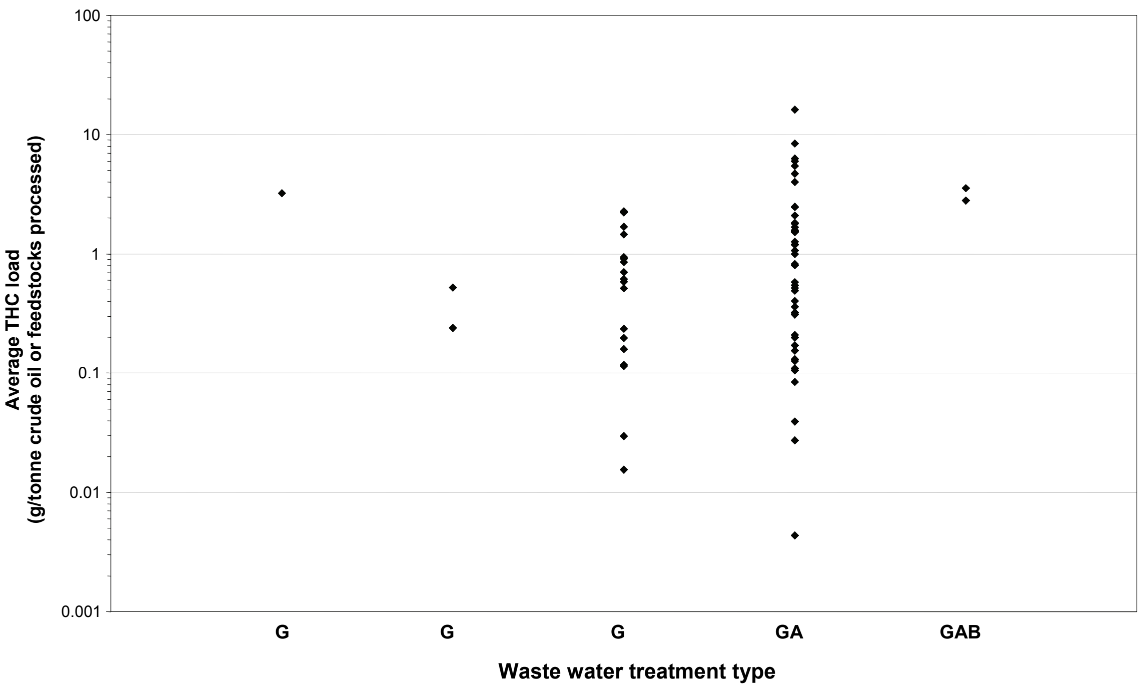


Figure 7 2005 Yearly Average THC concentrations shown as a function of the NCI

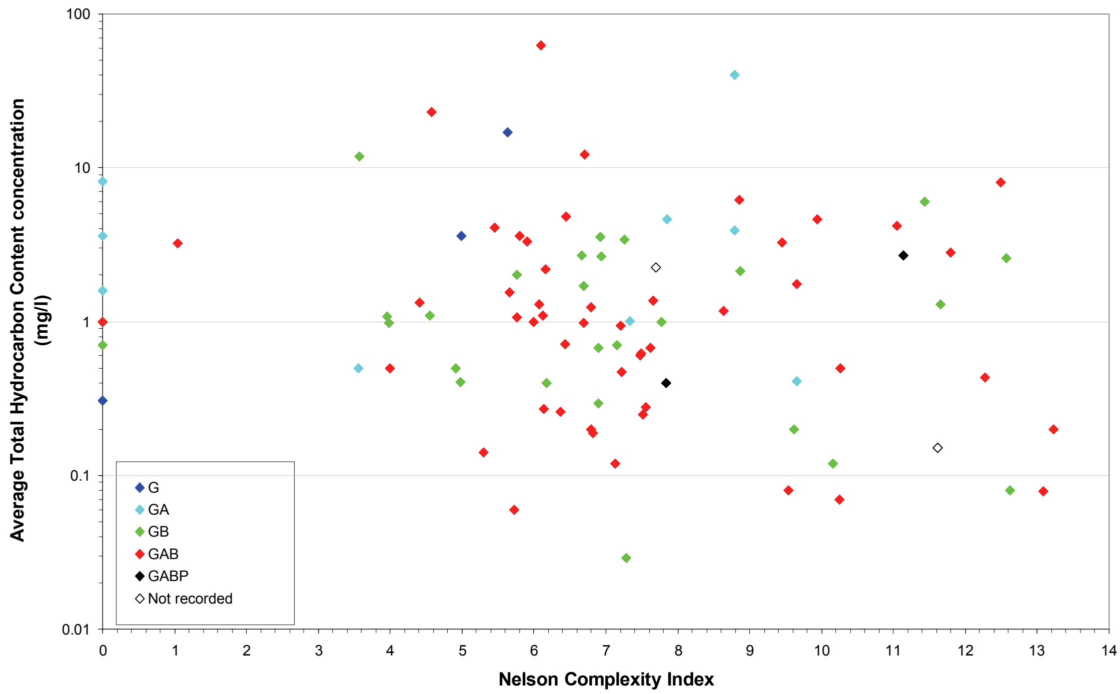
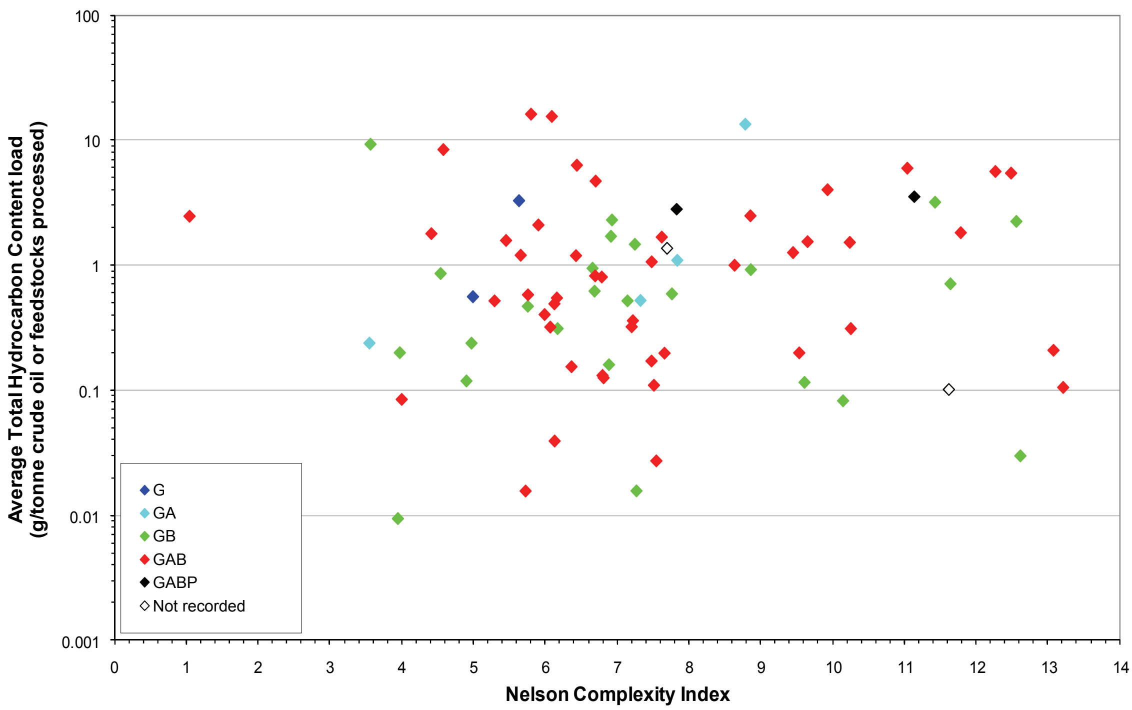


Figure 8 2005 Yearly Average THC loads shown as a function of the NCI



3.2. BIOCHEMICAL OXYGEN DEMAND (BOD)

The data are presented in **Figures 9** to **14**.

BOD concentrations reported in the survey were determined using the range of methods indicated in **Appendix 4**. The Limit of Detection (LOD) values for the methods were in the range 0.5 to 15 mg/l.

BOD was generally measured over a 5-day period although three refineries reported a value determined over 7 days. The test is reliant upon the use of a microbial inocculum (activated sludge) obtained from a sewage treatment plant. Variation in the exposure history of the micro-organisms present in the inocculum to substances present in an effluent can have a significant effect on the result of the test.

Figure 9 shows that 80% of the refineries reported annual average BOD concentrations in the range 3 to 35 mg/l. In comparison, the current lower and upper values of the BAT range (not shown in the figure), which are monthly averages and not annual averages, are 2 and 20 mg/l.

Figure 10 shows that approximately 60% of the refineries reported annual average BOD loads that were lower than 11 g/t crude oil or feedstock processed (upper value of the BAT range) and approximately 98% reported loads that were above 0.5 g/t (lower value of the BAT range).

Figure 11 shows that, although a wide range of BOD concentrations were reported for each class of treatment, lower average BOD concentrations could be achieved using biological treatments. However the incorporation of a biological treatment stage (classes 3, 4 and 5) does not guarantee lower average BOD concentrations or loads (**Figure 12**) compared with gravity separation or advanced gravity treatment.

Figures 13 and **14** show no clustering of data around particular regions of the plots of NCI versus BOD concentration or load. The NCI of a refinery does not, therefore, correlate with the BOD content of its wastewater.

Figure 9 2005 Yearly Average BOD concentrations shown as a cumulative frequency plot

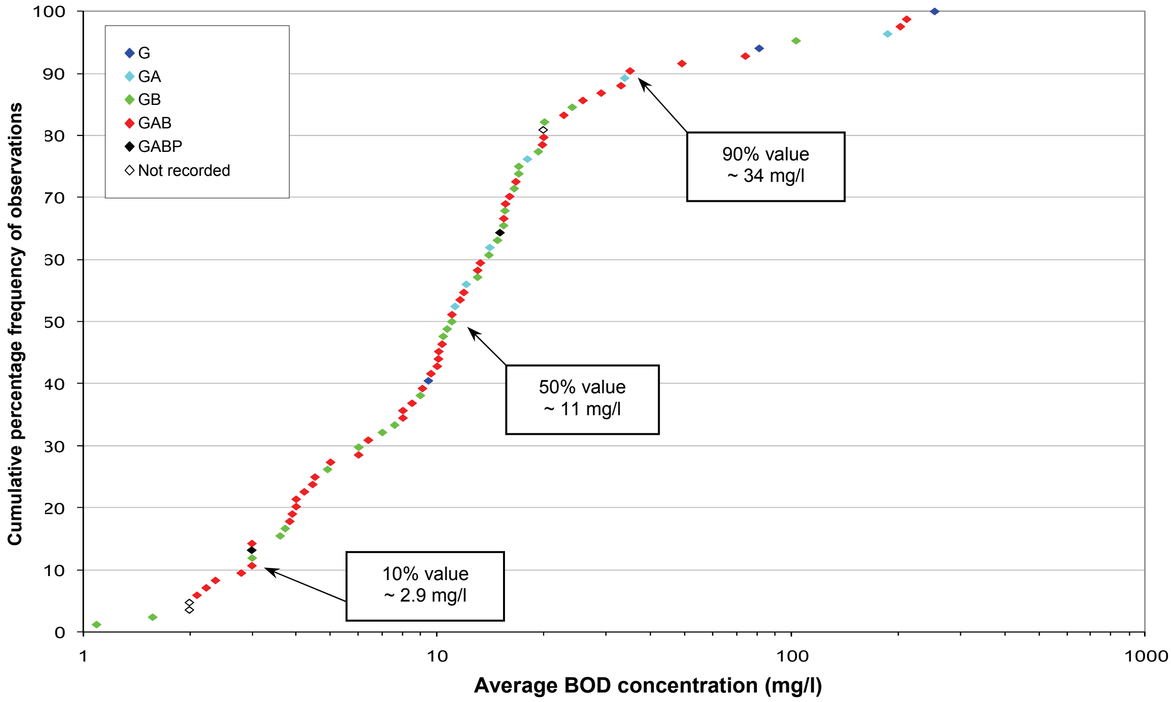


Figure 10 2005 Yearly Average BOD loads shown as a cumulative frequency plot

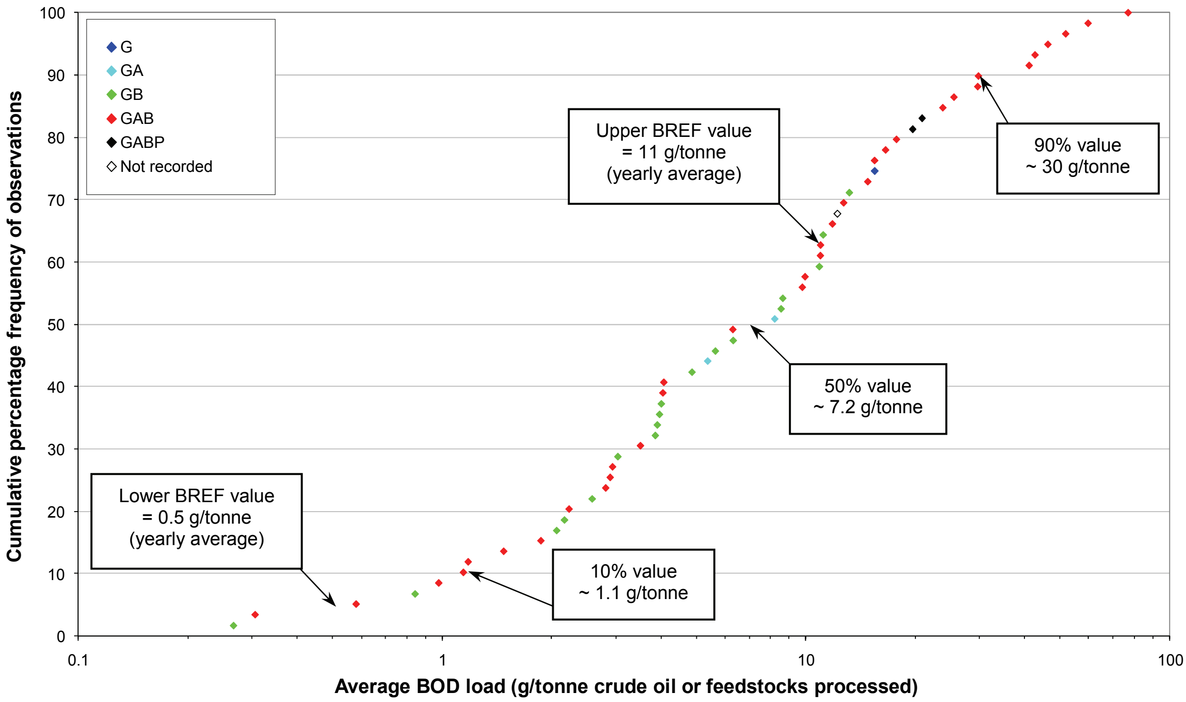


Figure 11 2005 Yearly Average BOD concentrations differentiated by type of waste-water treatment process

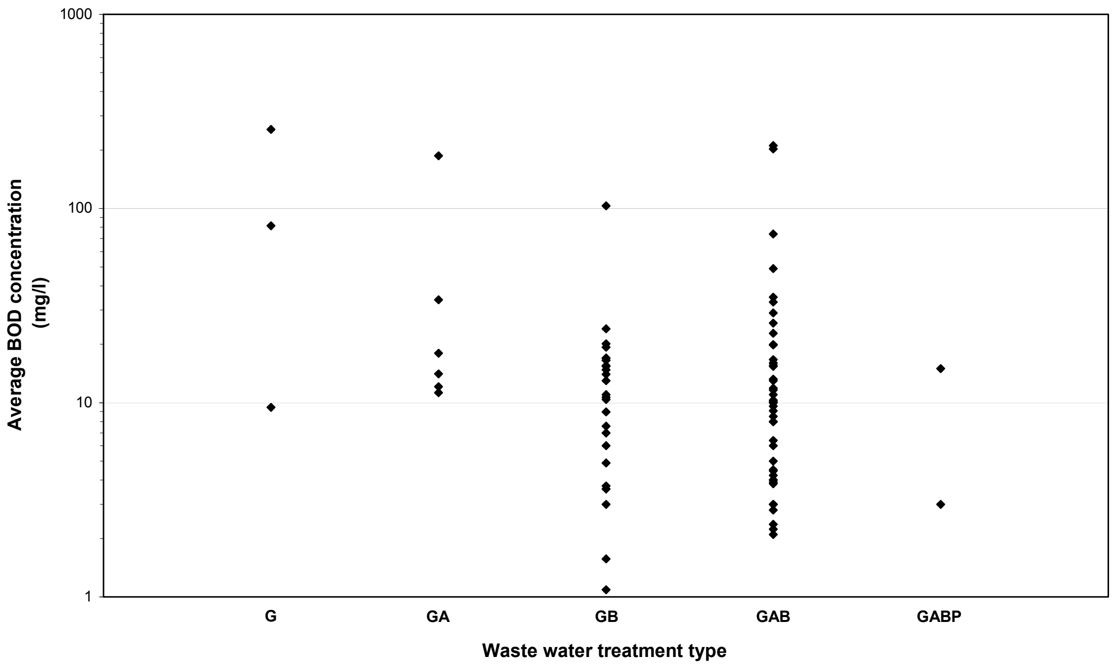


Figure 12 2005 Yearly Average BOD loads differentiated by type of waste-water treatment process

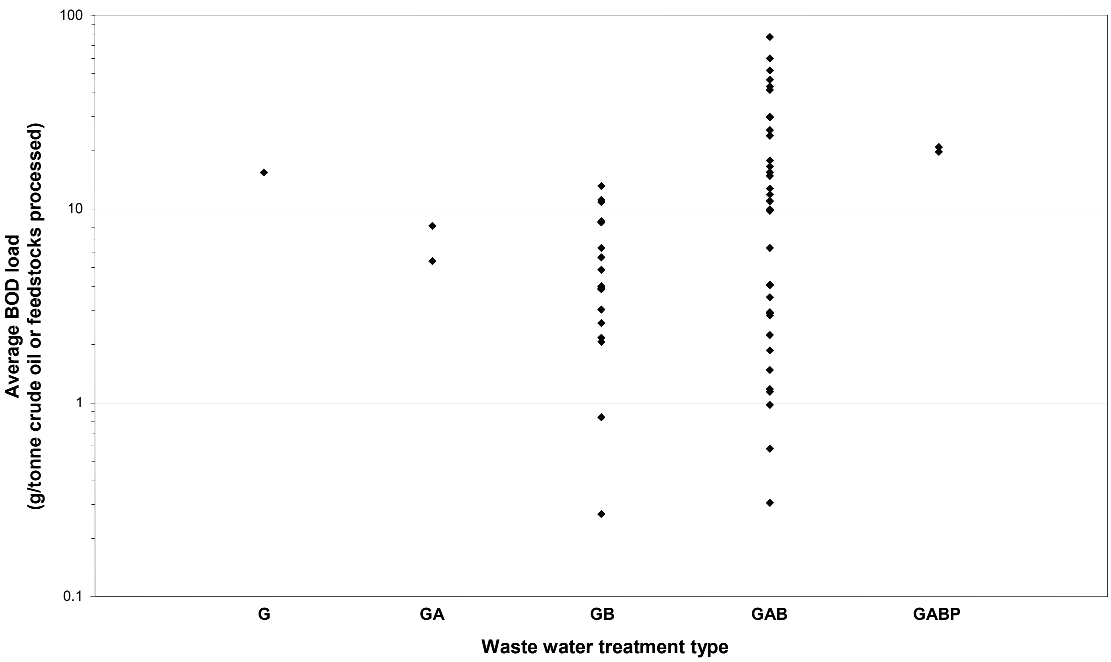


Figure 13 2005 Yearly Average BOD concentrations shown as a function of the NCI

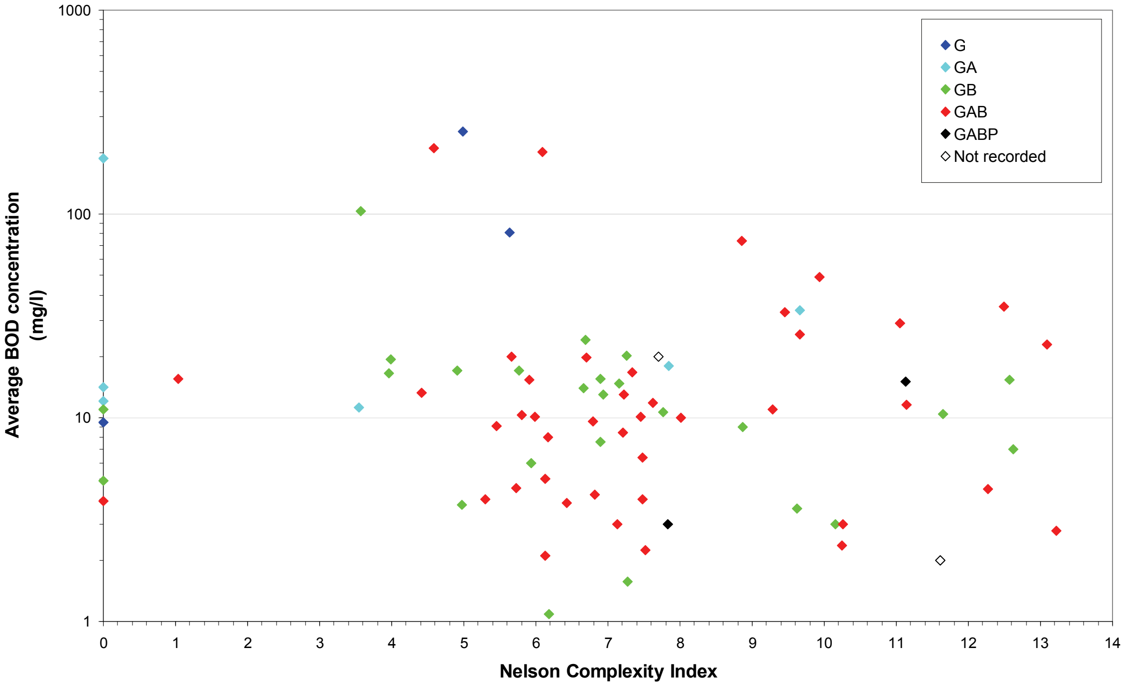
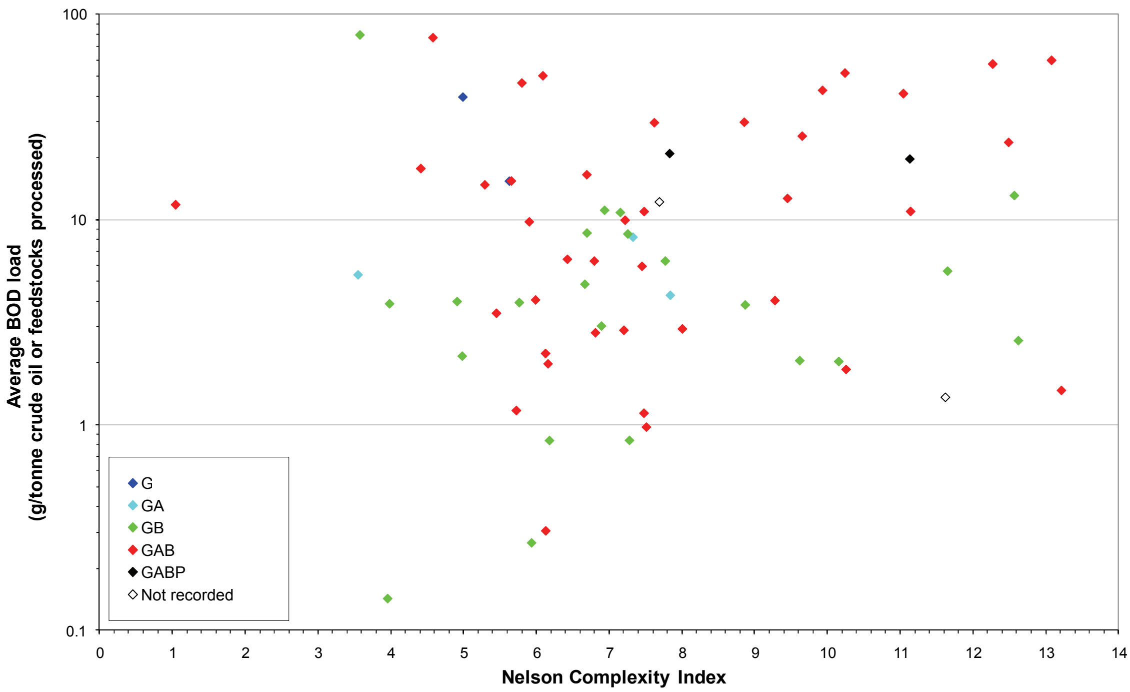


Figure 14 2005 Yearly Average BOD loads shown as a function of the NCI



3.3. CHEMICAL OXYGEN DEMAND (COD)

The data are presented in **Figures 15** to **20**.

Both BOD and COD are indicators of wastewater quality indicative of the impact it might have on the receiving environment. The COD test directly measures the amount of organic compounds in water. However, COD is less specific, as it measures all oxidisable organic and inorganic compounds rather than just levels of biodegradable organic matter.

COD concentrations reported in the survey were determined using the range of methods indicated in **Appendix 4**. The Limit of Detection (LOD) values for the methods were in the range 0.01 to 100 mg/l.

Figure 15 shows that 80% of the refineries reported annual average COD concentration between 25 mg/l and 150 mg/l. In comparison, the current lower and upper value of the BAT range (not shown in the figures), which are monthly averages and not annual average values, are 30 and 125 mg/l.

Figure 16 shows that approximately 80% of the refineries reported annual average COD loads that were lower than 70 g/t crude oil or feedstock processed (upper value of the BAT range) and approximately 98% reported loads that were above 3 g/t (lower value of the BAT range).

Figure 17 shows that, although a wide range of COD concentrations were reported for each class of treatment, lower average COD concentrations could be achieved using biological treatments. However, the incorporation of a biological treatment stage (classes 3, 4 and 5) does not guarantee lower average COD concentrations or loads (**Figure 18**) compared with advanced gravity separation or advanced treatment.

Figures 19 and **20** show no clustering of data around particular regions of the plots of NCI versus COD concentration or load. The NCI of a refinery does not, therefore, correlate with the COD content of its wastewater.

Figure 15 2005 Yearly Average COD concentrations shown as a cumulative frequency plot

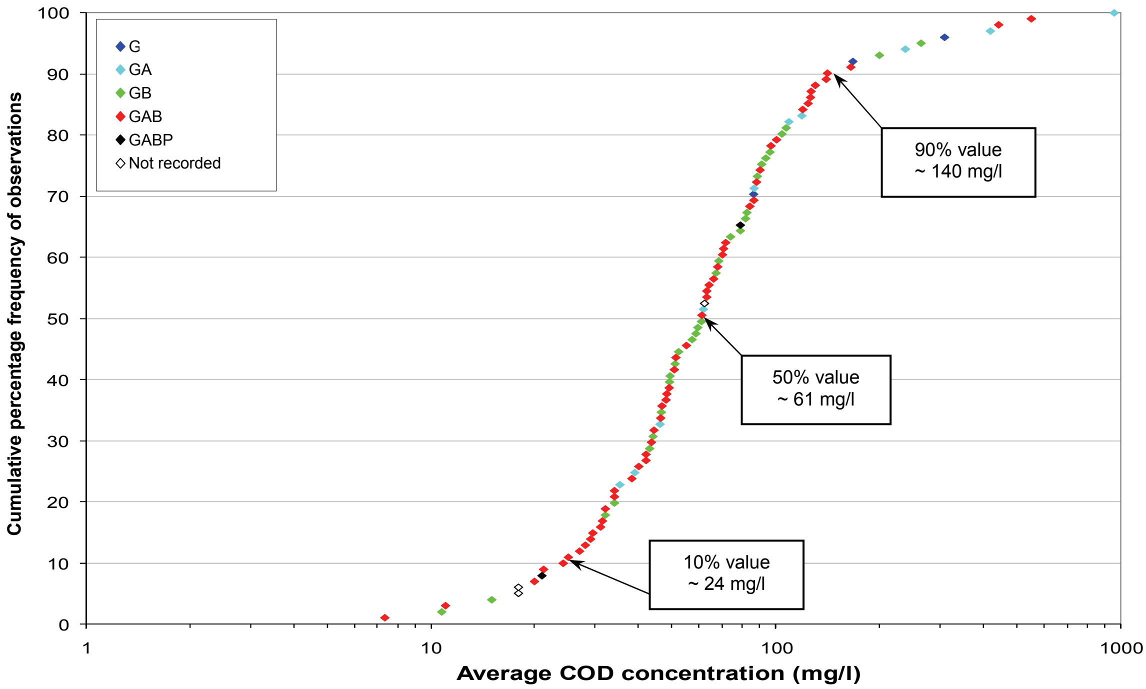


Figure 16 2005 Yearly Average COD loads shown as a cumulative frequency plot

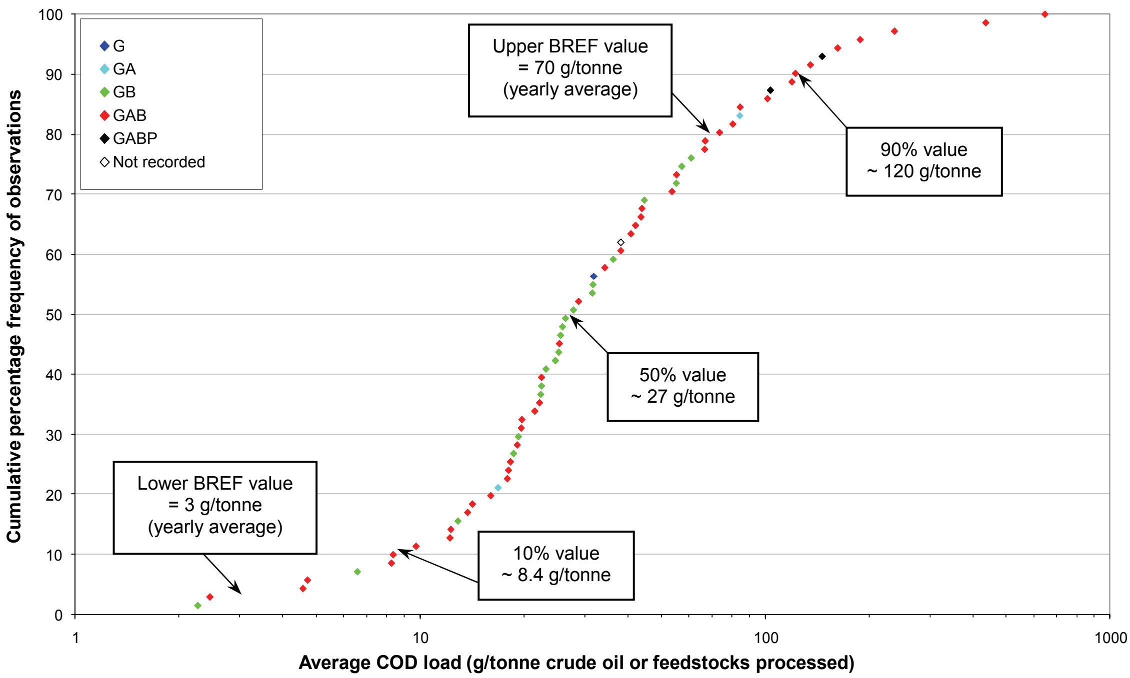


Figure 17 2005 Yearly Average COD concentrations differentiated by type of waste-water treatment process

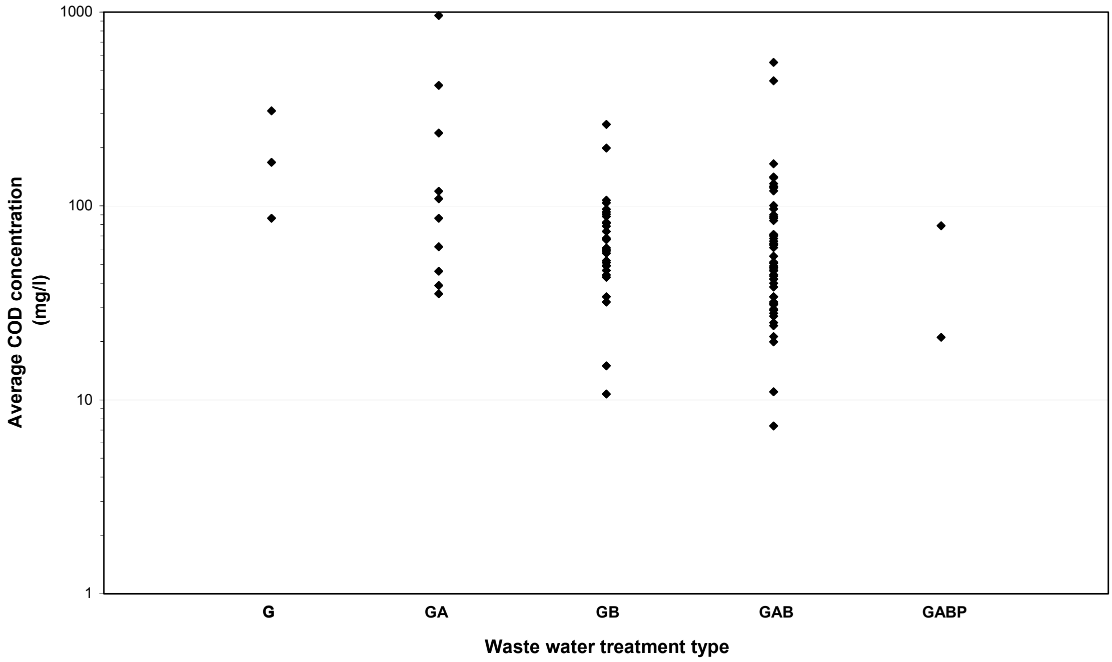


Figure 18 2005 Yearly Average COD loads differentiated by type of waste-water treatment process

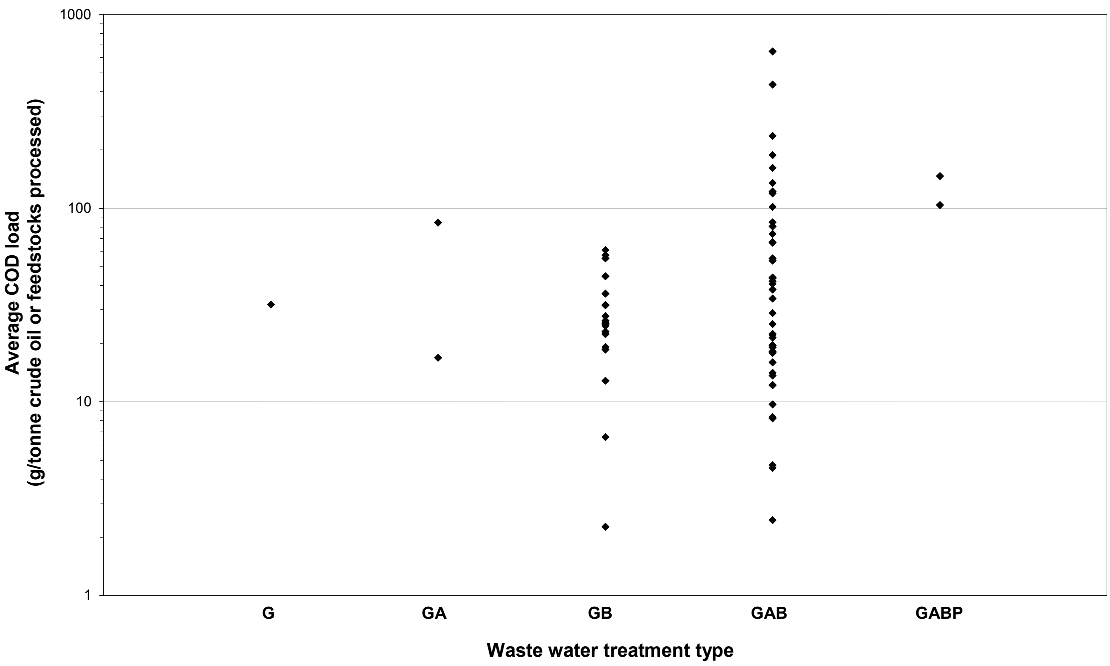


Figure 19 2005 Yearly Average COD concentrations shown as a function of the NCI

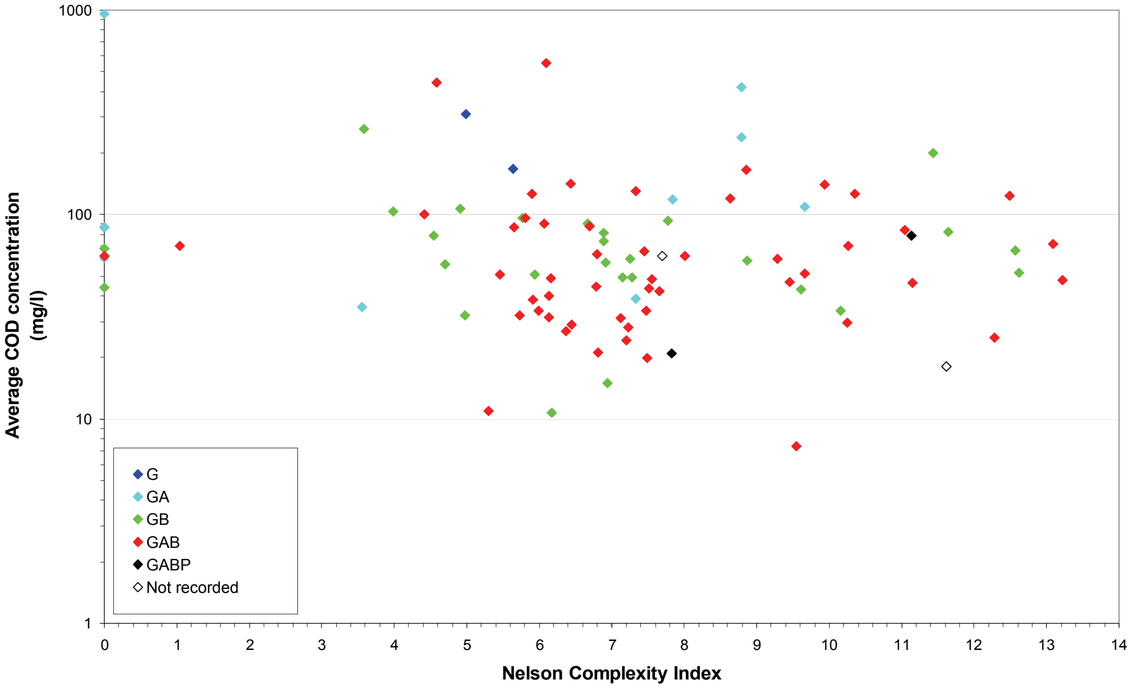
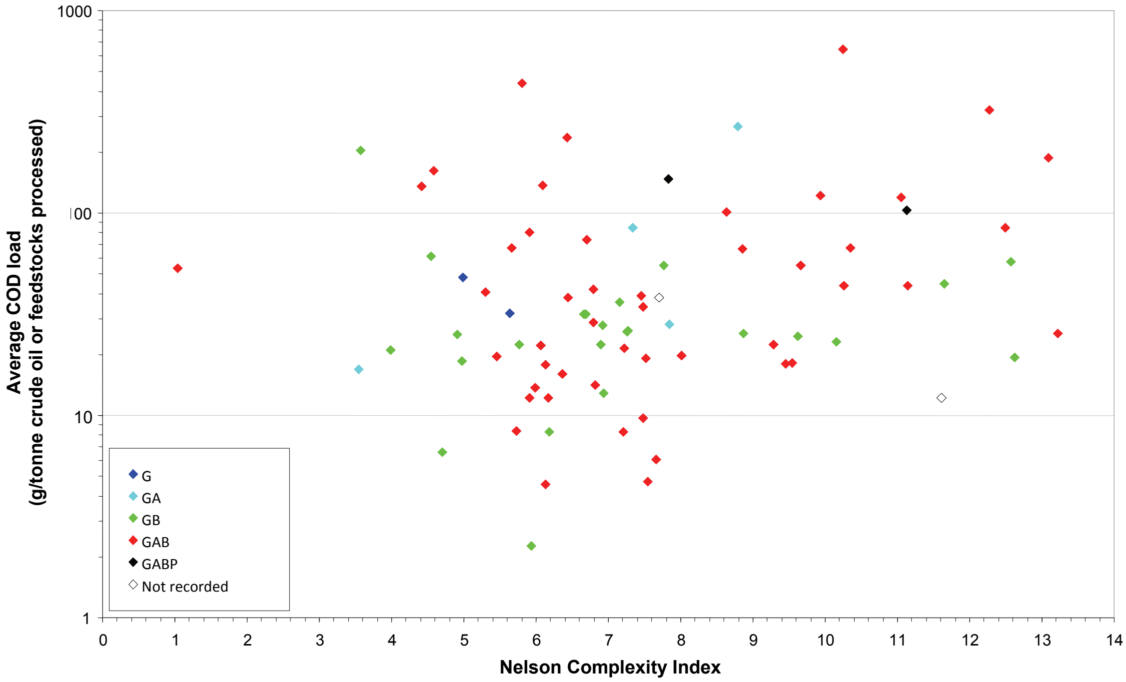


Figure 20 2005 Yearly Average COD loads shown as a function of the NCI



3.4. TOTAL NITROGEN (TN)

The data are presented in **Figures 21** to **26**.

TN is defined as the sum of Kjeldahl (which is organic nitrogen + ammonia), nitrite and nitrate nitrogen however one refinery only reported Kjeldahl Nitrogen.

TN concentrations reported in the survey were determined using the range of methods indicated in **Appendix 4**. The Limit of Detection (LOD) values for the methods were in the range 0.02 to 2.1 mg/l.

Figure 21 shows that 80% of the refineries reported annual average TN concentration between 3 mg/l and35 mg/l. In comparison, the current lower and upper value of the BAT range (not shown in the figures), which are monthly averages and not annual average values, are 1.5 and 25 mg/l.

Figure 22 shows that approximately 85% of the refineries reported annual average TN loads that were lower than 15 g/t crude oil or feedstock processed (upper value of the BAT range) and approximately 99% reported loads that were above 0.5 g/t (lower value of the BAT range).

Figures 23 and **24** show that there were no apparent differences between the type of wastewater treatment applied and the concentration and load of TN.

Figures 25 and **26** show no clustering of data around particular regions of the plots of NCI versus TN concentration or load. The NCI of a refinery does not therefore correlate with the TN content of its wastewater.

The survey did not include sufficient data to evaluate the quantity of TN in the influent water utilised by the refineries to distinguish the net contribution to the total effluent load.

Figure 21 2005 Yearly Average TN concentrations shown as a cumulative frequency plot

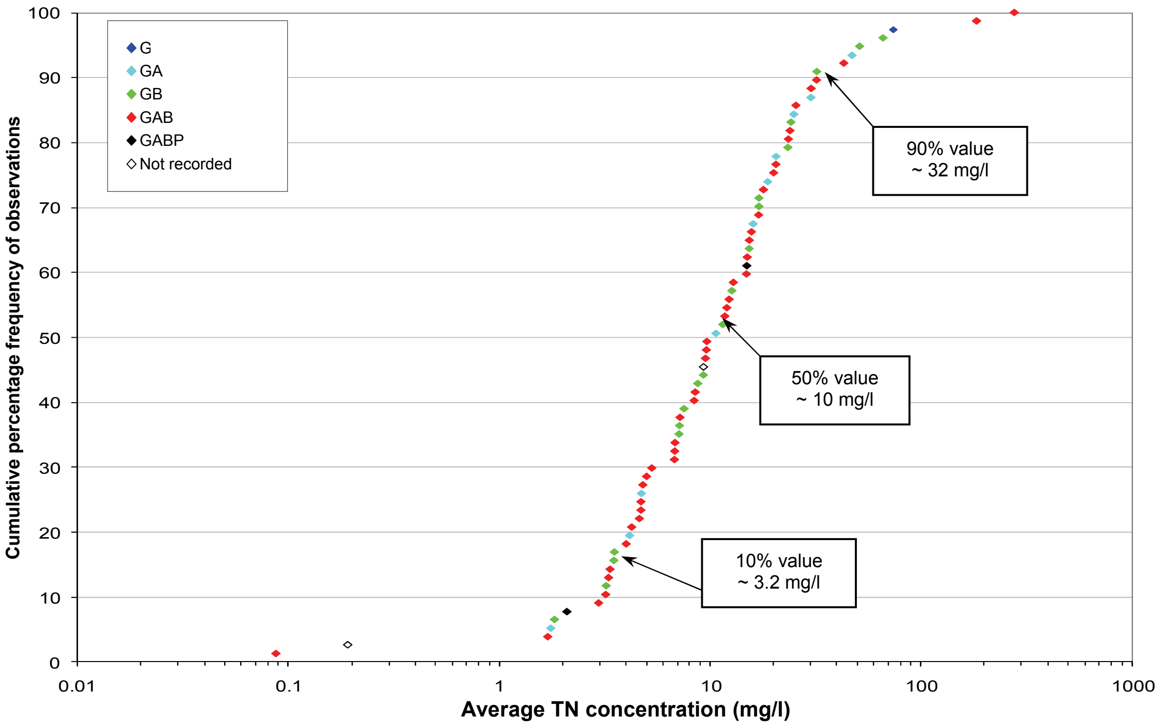


Figure 22 2005 Yearly Average TN loads shown as a cumulative frequency plot

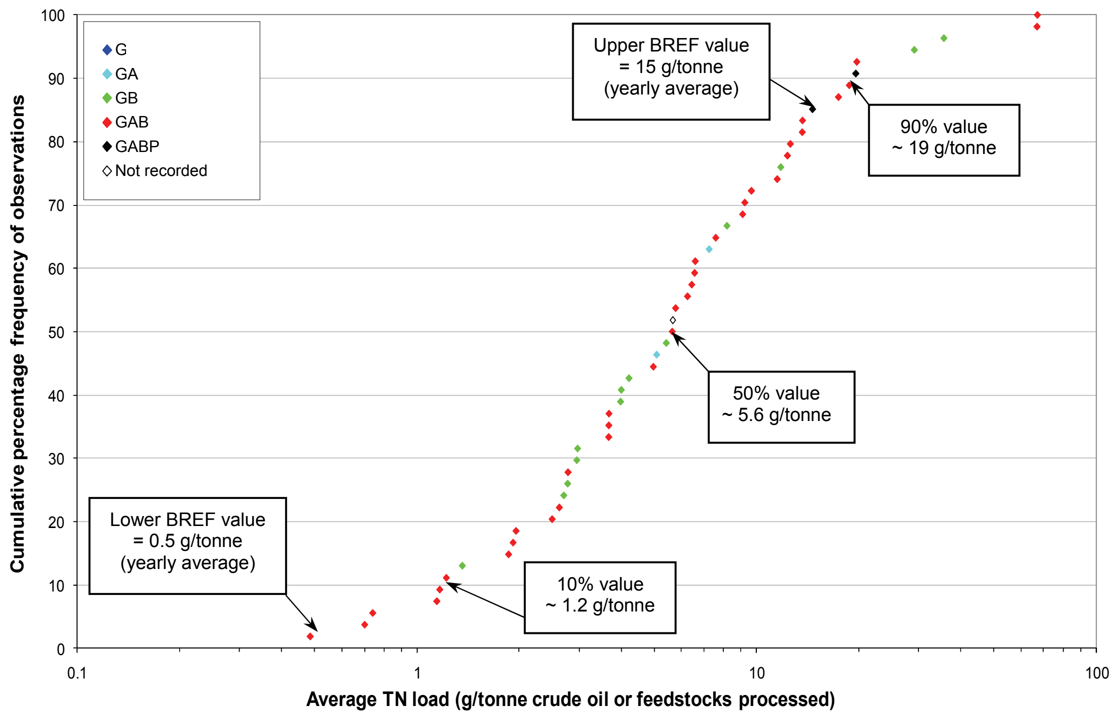


Figure 23 2005 Yearly Average TN concentrations differentiated by type of waste-water treatment process

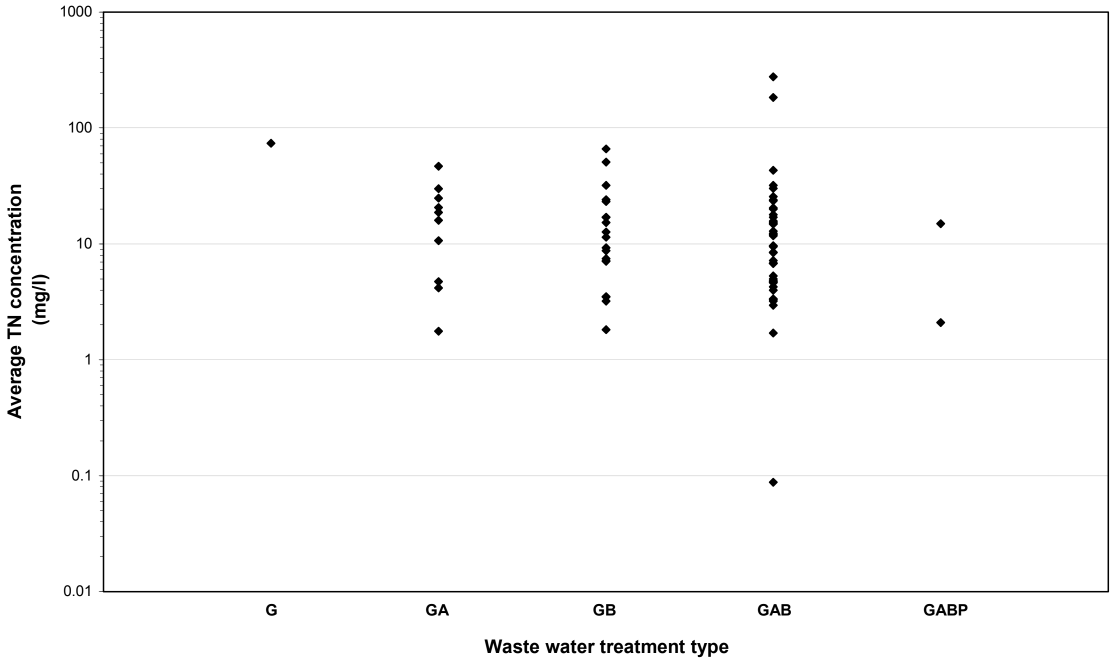


Figure 24 2005 Yearly Average TN loads differentiated by type of waste-water treatment process

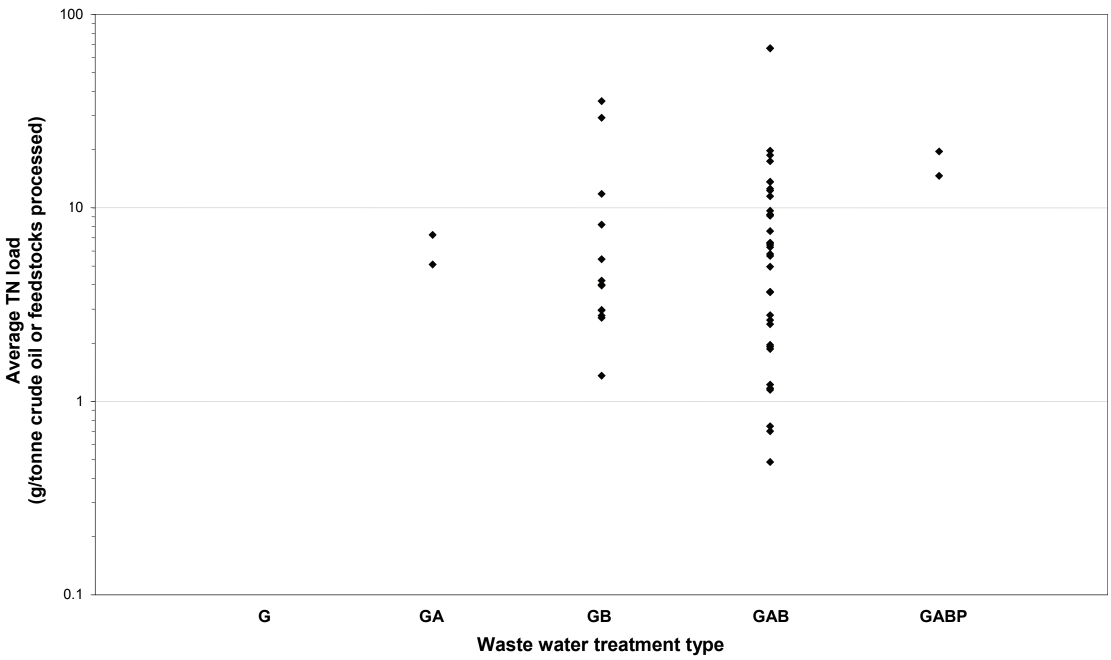


Figure 25 2005 Yearly Average TN concentrations shown as a function of the NCI

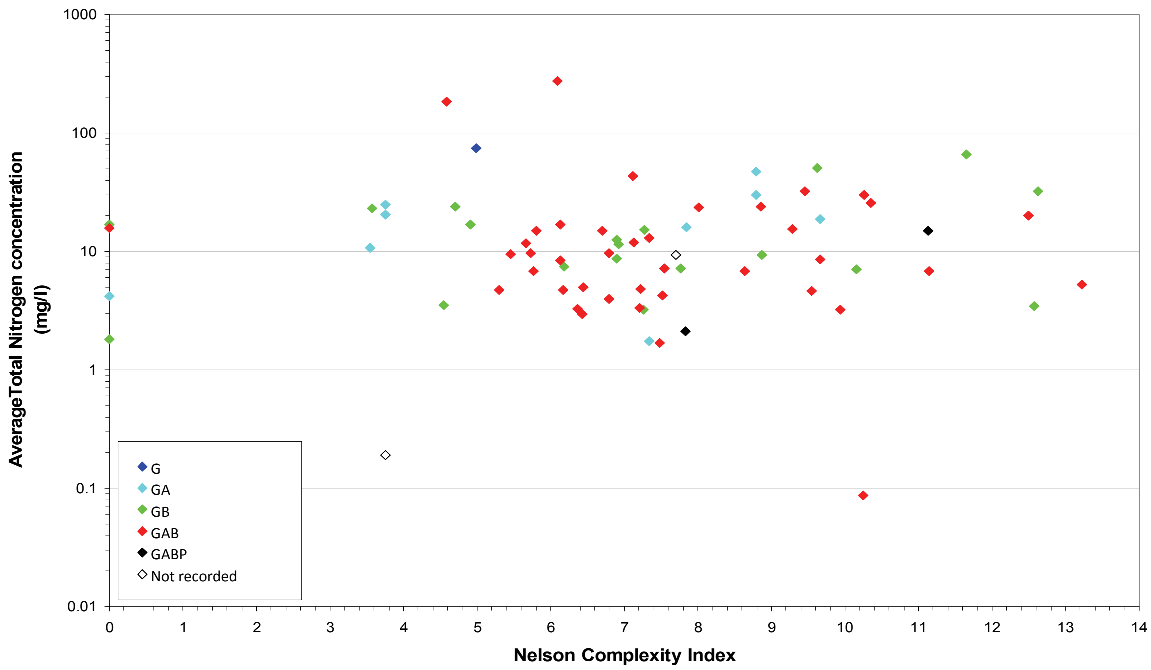
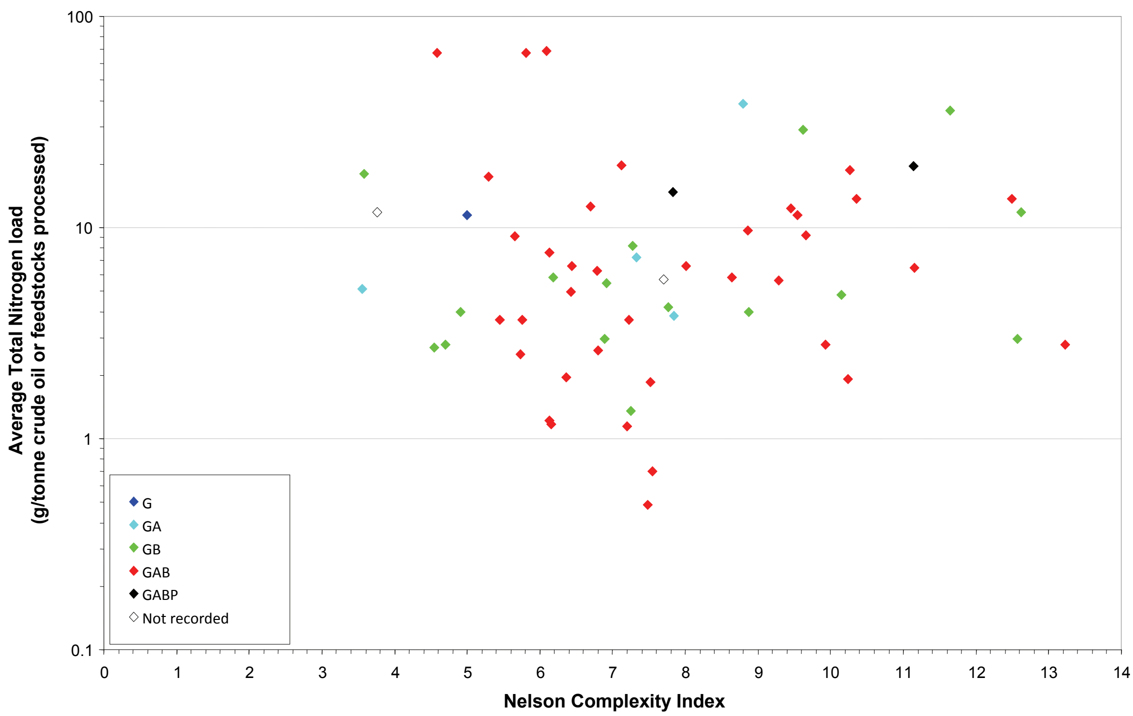


Figure 26 2005 Yearly Average TN loads shown as a function of the NCI



3.5. TOTAL SUSPENDED SOLIDS (TSS)

The data are presented in **Figures 27** to **32**.

TSS concentrations reported in the survey were determined using the range of methods indicated in **Appendix 4**. The Limit of Detection (LOD) values for the methods were in the range 0.1 to 10 mg/l.

Figure 27 shows that 80% of the refineries reported annual average TSS concentrations between 5 mg/l and 35 mg/l. In comparison, the current lower and upper value of the BAT range (not shown in the figures), which are monthly averages and not annual average values, are 2 and 50 mg/l.

Figure 28 shows that approximately 85% of the refineries reported annual average TSS loads that were lower than 25 g/t crude oil or feedstock processed (upper value of the BAT range) and approximately 99% reported loads that were above 1 g/t (lower value of the BAT range).

Figure 29 shows that, the incorporation of a biological treatment stage (classes 3, 4 and 5) does not guarantee lower average TSS concentrations or loads (**Figure 30**) compared with advanced gravity separation or advanced treatment. Because when biological treatment systems are accidentally overloaded (flow rate or COD load) large amounts of suspended solids (biomass) can be measured at the outlet of the biological clarifier.

Figures 31 and **32** show no clustering of data around particular regions of the plots of NCI versus TSS concentration or load. The NCI of a refinery does not therefore correlate with the TSS content of its wastewater.

Figure 27 2005 Yearly Average TSS concentrations shown as a cumulative frequency plot

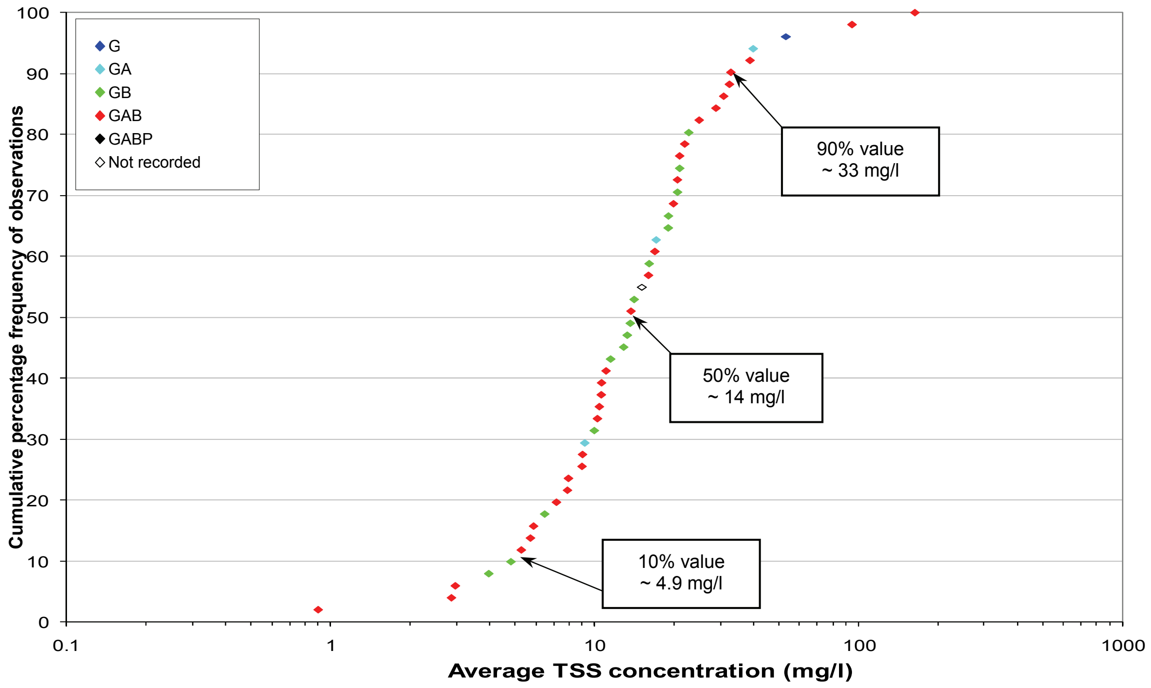


Figure 28 2005 Yearly Average TSS loads shown as a cumulative frequency plot

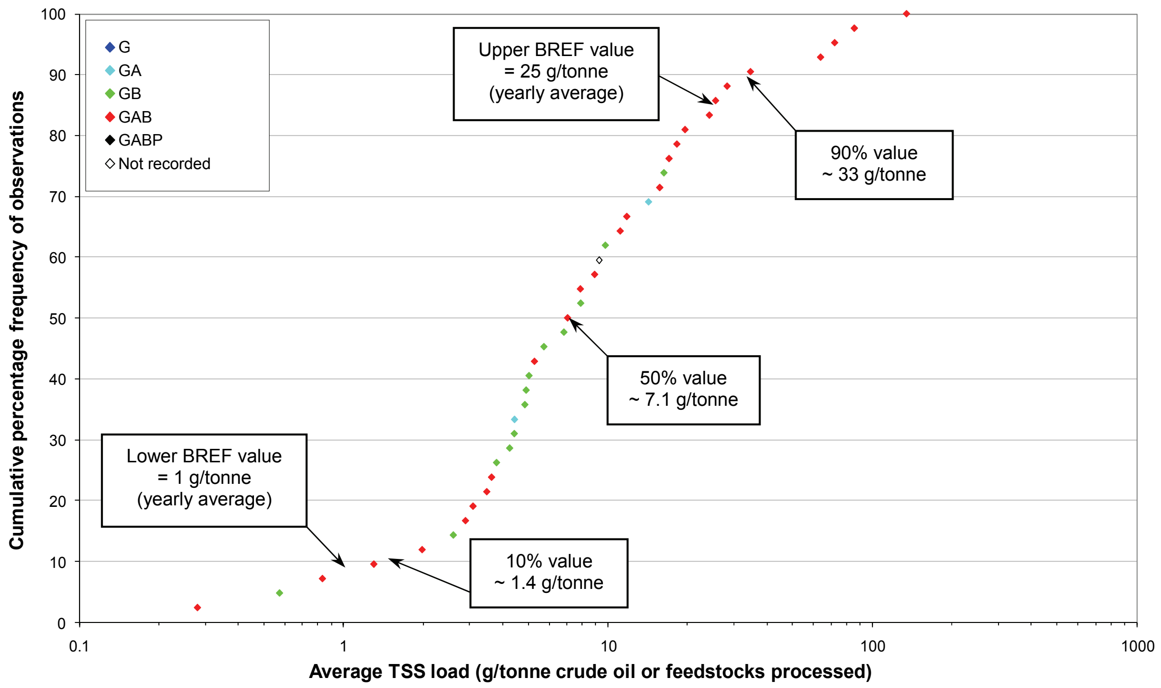


Figure 29 2005 Yearly Average TSS concentrations differentiated by type of waste-water treatment process

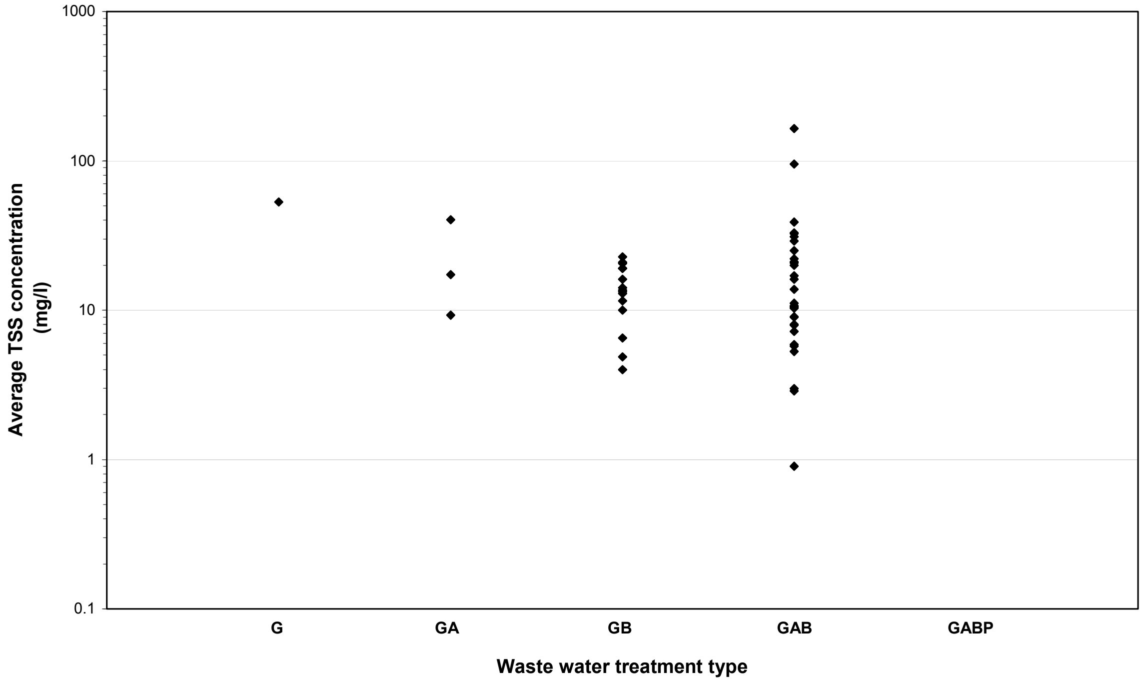


Figure 30 2005 Yearly Average TSS loads differentiated by type of waste-water treatment process

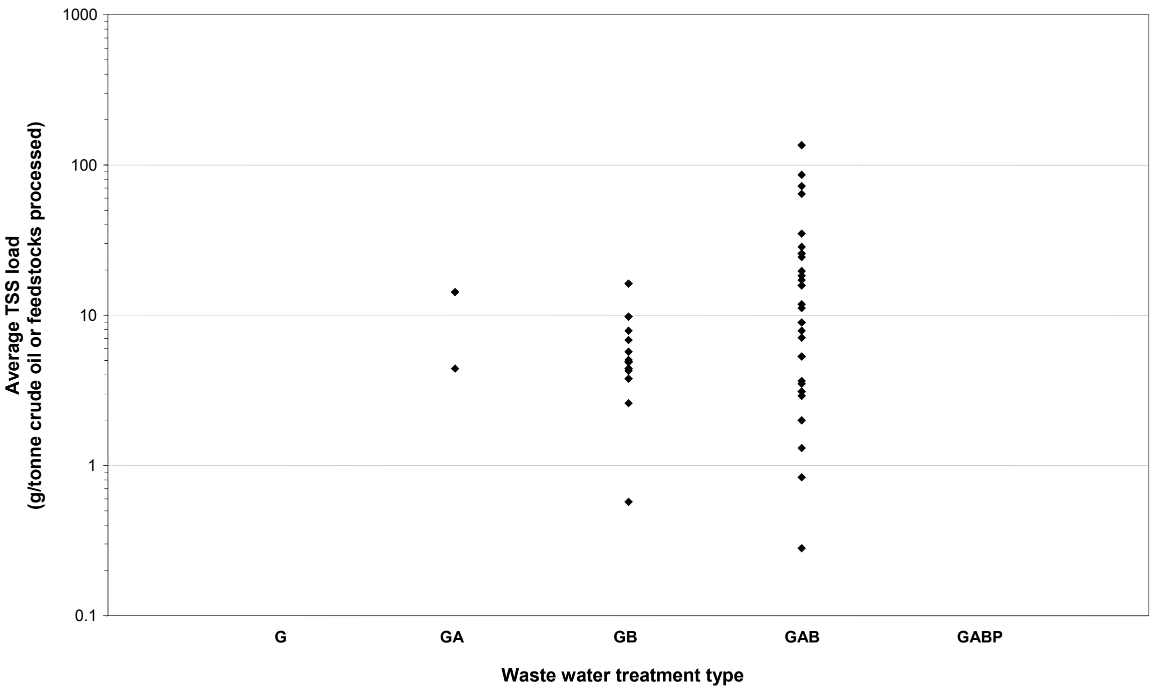


Figure 31 2005 Yearly Average TSS concentrations shown as a function of the NCI

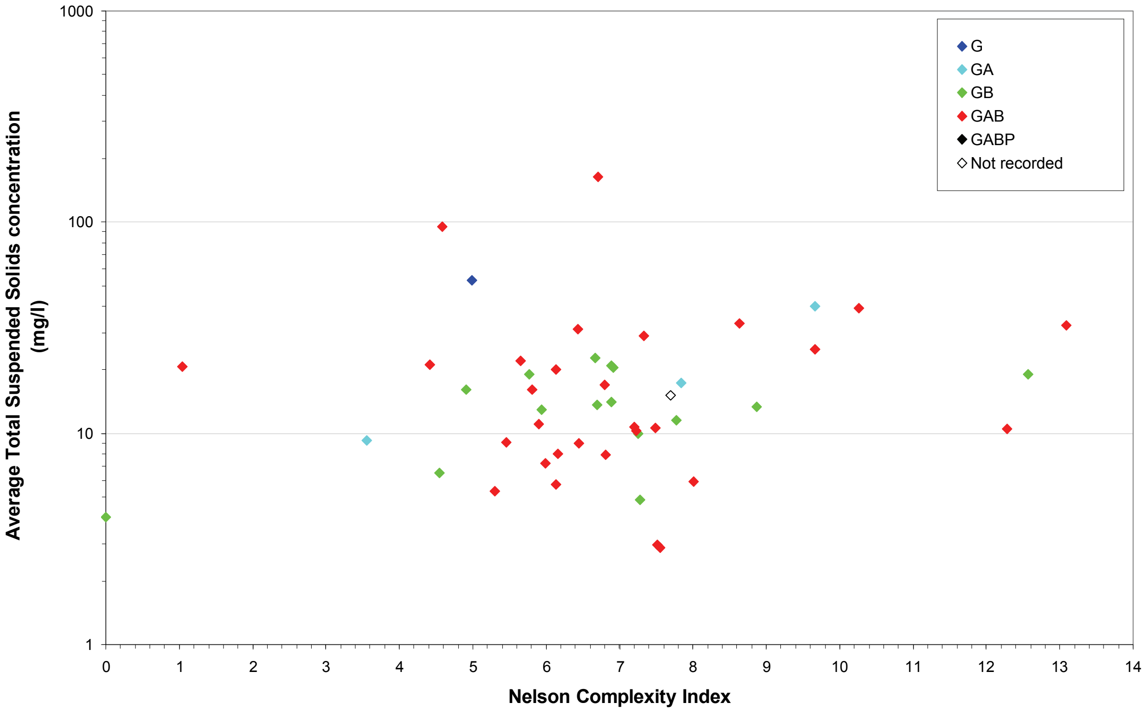
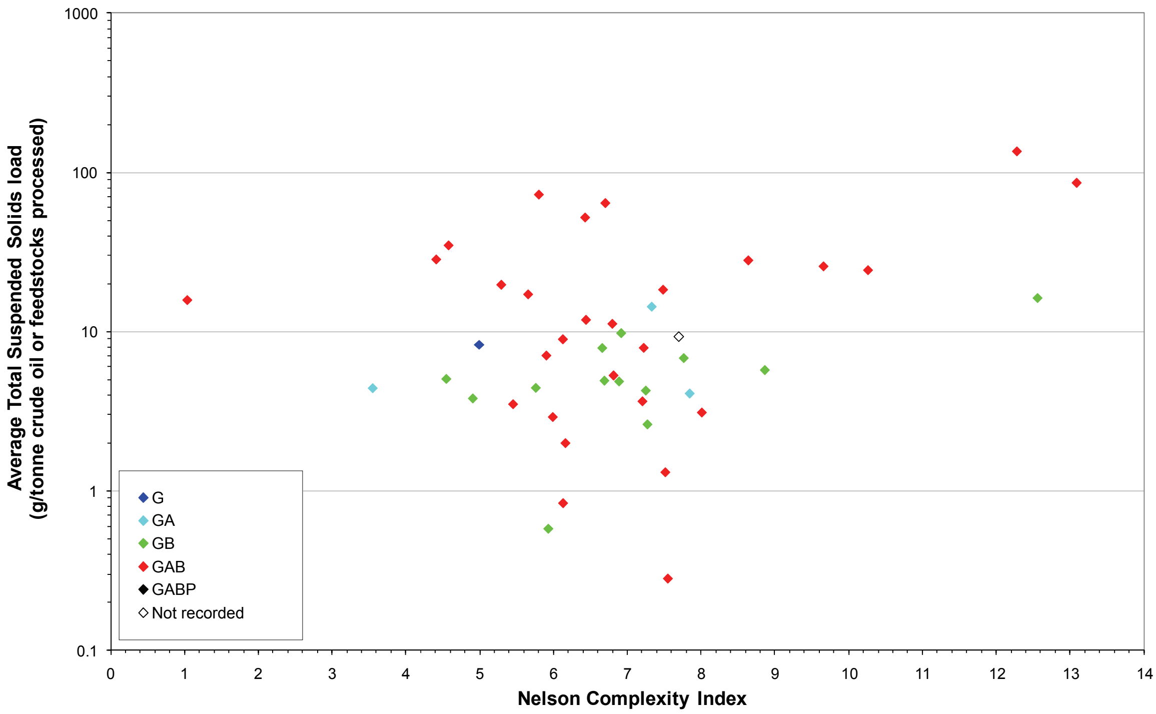


Figure 32 2005 Yearly Average TSS loads shown as a function of the NCI



4. CONCLUSIONS

Comments received from the European IPPC Bureau on the earlier document [1] suggested that a better insight to the survey results would be obtained by re-presenting the data for the parameters in a format that would allow the significance of the type of wastewater treatment technique to be assessed relative to the quality of the final effluent. This has now been completed with the available information summarised and presented in a series of data plots.

The new data plots reveal that:

- There is no direct or simple correlation between concentrations and loads of the five parameters (THC, BOD, COD, TN and TSS) and type of wastewater treatment process.
- The presence of a biological step does seem to be necessary to reach the lower concentrations of COD, BOD, THC.
- The presence of a three-stage treatment process, as described in the refinery BREF, that includes biological treatment, does not guarantee lower discharge concentrations for any of the parameters.
- The level of complexity of a refinery (as characterised by the industry standard Nelson Complexity Index - NCI) has no bearing on the quality of the final effluent.

Based on these findings, it is concluded that it is not currently possible to specify a level of effluent quality that can consistently be achieved by different types of refineries or by refineries operating particular types of wastewater treatment process. Instead it is much more likely that effluent quality is currently determined by a complex combination of operational process and waste-stream management parameters that impact the composition of waste water, hydraulic loading and pollutant mass loading to the waste water treatment system. The scope of the 2006 survey did not include sufficient data or information that could be extracted for this document to evaluate site-specific operational and waste-stream management processes and correlate these to the quality of the final effluent and the type of wastewater treatment technique applied. However, management of these on a site-specific basis is likely to present the most effective way of meeting effluent quality objectives.

The survey has clearly shown that the sampling (location, methods, volumes and frequency) and analysis (pre-treatment, sample preparation, quantification method and limits of detection) protocols that are used to obtain data on effluent quality are not standardised across European refineries. This certainly contributes to the wide variation in the reported datasets. In order to establish a consistent approach and minimise this source of variation it is therefore recommended that a BREF effluent quality standard should be related to specific sampling and analytical protocols and the results presented in relation to consistent averaging periods (i.e. monthly or yearly). This will lead to sufficiently robust, reliable and consistent data sets.

5. REFERENCES

1. CONCAWE (2009) Some related environmental parameters for aqueous discharges from refineries in Europe. Document No. 09/01. Brussels: CONCAWE

2. EIPPCB (2003) Integrated Pollution Prevention and Control (IPPC) – reference document on best available techniques for mineral oil and gas refineries. Seville: European IPPC Bureau

3. CONCAWE (1999) Best available techniques to reduce emissions from refineries. Document No. 99/01. Brussels: CONCAWE

4. Nelson, W.L. (1960) How to describe refining complexity. *Oil & Gas J, March 14, 1960*

5. Nelson, W.L. (1960) How complexity of a refinery affects costs of construction. *Oil & Gas J, Sept. 26, 1960*

6. Nelson, W.L. (1961) How to compute refinery complexity. *Oil & Gas J, June 19, 1961*

7. Nelson, W.L. (1976) The concept of refinery complexity. *Oil & Gas J, Sept. 13, 1976*

8. Nelson, W.L. (1976) The concept of refinery complexity. *Oil & Gas J, Sept. 20, 1976*

9. Nelson, W.L. (1976) The concept of refinery complexity. *Oil & Gas J, Sept. 27, 1976*

10. CONCAWE (2003) The IPPC directive, refinery BREF, and European refineries – a guidance manual. Report No. 4/03. Brussels: CONCAWE

11. CONCAWE (2004) Trends in oil discharged with aqueous effluents from oil refineries in Europe - 2000 survey. Report No. 4/04. Brussels: CONCAWE

12. Oil & Gas Journal (2004) Worldwide refining survey 2004. *Oil & Gas J 102, 47, 1-39*

6. LIST OF ABBREVIATIONS

BAT	Best Available Technique
BOD	Biochemical Oxygen Demand
BREF	BAT Reference document
IPPC	Integrated Pollution Prevention and Control
COD	Chemical Oxygen Demand
GC	Gas Chromatography
IR	Infra Red
LoD	Limit of Detection
LoQ	Limit of Quantitation
NCI	Nelson Complexity Index
THC	Total Hydrocarbon Content
TN	Total Nitrogen
TPH	Total Petroleum Hydrocarbon
TSS	Total Suspended Solids

APPENDIX 1 DATA RECEIVED FROM CONCAWE MEMBERSHIP REFINERIES ON THE REPORTED PARAMETERS

Company code	1.00	2.00	2.01	2.03	2.04	3.00	3.01	4.00	4.01	5.00	5.02
Waste water sent to offsite Waste Water Treatment Plant	Yes					Yes					
2004 crude oil or feedstock throughput used to calculate Load (ktonne/annum)	9387	13860	4905.585	4050	12375	3150	4788	9000	2331	5355	9587.565
Effluent flow rate used to calculate Mass emission (tonne/annum)	7242000	11616342	20071669	418934	1800000	490000	1299000	7629000	1531000	7037200	3326093
Average concentration (mg/l)											
Total N	7.49	15.00			8.40	74.00		6.82	4.00	5.00	
Oil	0.40	0.98			0.27	3.60		1.18	0.20	4.80	2.70
COD	10.74	87.88			31.40	310.00		119.67	64.00	29.00	90.80
BOD5	1.09	19.80			2.10	255.00			9.60		14.00
Total Suspended Solids					5.74	53.00		33.00	17.00	9.00	22.70
Calculated Mass emission (tonne/annum)											
Total N	54.24	174.25			15.12	36.26		52.00	6.12	35.19	
Oil	2.90	11.38			0.49	1.76		9.00	0.31	33.78	8.98
COD	77.78	1020.84			56.52	151.90		913.00	97.98	204.08	302.01
BOD5	7.89	230.00			3.78	124.95			14.70		46.57
Total Suspended Solids					10.33	25.97		251.76	26.03	63.33	75.50
Load (g/tonne crude oil or feedstock processed)											
Total N	5.78	12.57			1.22	11.51		5.78	2.63	6.57	
Oil	0.31	0.82			0.04	0.56		1.00	0.13	6.31	0.94
COD	8.29	73.65			4.57	48.22		101.44	42.04	38.11	31.50
BOD5	0.84	16.59			0.31	39.67			6.31		4.86
Total Suspended Solids					0.83	8.24		#	11.17	11.83	7.88

#Calculated load could not be verified

Company code	5.03	5.04	5.04	5.05	5.06	5.07	5.08	5.10	5.11	5.12	5.14
Waste water sent to offsite Waste Water Treatment Plant											
2004 crude oil or feedstock throughput used to calculate Load (ktonne/annum)	5279.085	4366.665		10485	3591	3690	6345	7147.035	15431.13	7213.68	9319.5
Effluent flow rate used to calculate Mass emission (tonne/annum)	4091559	834382	446433	13766042	13306559	2710610	44276000	3070380	9114884	2585571	2167260
Average concentration (mg/l)											
Total N	11.74	8.71	12.63	14.90	4.70		2.10	9.26	7.13		
Oil	1.55	0.67	0.29	2.70	0.14	0.70	0.40	2.12	0.99	1.72	2.00
COD	86.34	73.80	81.58	79.00	11.00	49.30	21.00	59.32	93.36	88.27	96.00
BOD5	19.97	7.58	15.53	15.00	4.00	14.80	3.00	8.96	10.67	24.07	17.00
Total Suspended Solids	22.06	14.13	20.98		5.30			13.31	11.52	13.67	19.00
Calculated Mass emission (tonne/annum)											
Total N	48.03	7.27	5.64	205.11	62.54		92.98	28.43	65.00		
Oil	6.34	0.56	0.13	37.17	1.86	1.90	17.71	6.52	9.02	4.44	4.33
COD	353.27	61.58	36.42	1087.52	146.37	133.63	929.80	182.14	851.00	228.24	208.06
BOD5	81.71	6.33	6.94	206.49	53.23	40.12	132.83	27.51	97.26	62.23	36.84
Total Suspended Solids	90.26	11.79	9.37		70.52			40.88	105.00	35.34	41.18
Load (g/tonne crude oil or feedstock processed)											
Total N	9.10	2.96		19.56	17.42		14.65	3.98	4.21		
Oil	1.20	0.16		3.54	0.52	0.51	2.79	0.91	0.58	0.61	#
COD	66.92	22.44		103.72	40.76	36.21	146.54	25.48	55.15	31.64	22.32
BOD5	15.48	3.04		19.69	14.82	10.87	20.93	3.85	6.30	8.63	3.95
Total Suspended Solids	17.10	4.85			19.64			5.72	6.80	4.90	4.42

#Calculated load could not be verified

Company code	5.15	6.01	6.04	6.05	6.08	6.08	6.08c	6.10	6.11	6.14	6.15
Waste water sent to offsite Waste Water Treatment Plant											
2004 crude oil or feedstock throughput used to calculate Load (ktonne/annum)		13590	4770		11803.5			9900	4365		3915
Effluent flow rate used to calculate Mass emission (tonne/annum)	1370697	5000000	465357	420000	1219000	2065000	1001000	1140000	2500000	570000	2063036
Average concentration (mg/l)											
Total N	4.73	15.35	7.20	15.70	23.50	17.90	12.30	24.12	51.00	17.00	5.29
Oil	3.30	<0.1	0.28	1.00					0.20	0.70	0.20
COD	46.10	61.00	48.26	63.00	63.00	55.00	42.00	57.10	43.00	44.00	48.00
BOD5		11.00		3.90	10.00	8.00	6.00		3.60	11.00	2.80
Total Suspended Solids			2.88		5.90	13.80	0.90				
Calculated Mass emission (tonne/annum)											
Total N	6.48	76.75	3.35	6.59	28.65	36.96	12.31	27.50	127.50	9.69	10.91
Oil	4.52		0.13	0.42					0.50	0.40	0.41
COD	63.19	305.00	22.46	26.46	76.80	113.58	42.04	65.09	107.50	25.08	99.03
BOD5		55.00		1.64	12.19	16.52	6.01		9.00	6.27	5.78
Total Suspended Solids			1.34		7.19	28.50	0.90				
Load (g/tonne crude oil or feedstock processed)											
Total N		5.65	0.70		6.60			2.78	29.21		2.79
Oil			0.03						0.11		0.11
COD		22.44	4.71		19.69			6.58	24.63		25.29
BOD5		4.05			2.94				2.06		1.48
Total Suspended Solids			0.28		3.10						

#Calculated load could not be verified

Company code	6.16	6.17	6.17	6.18	6.22	6.23	6.24	6.24	6.26	6.27	7.00
Waste water sent to offsite Waste Water Treatment Plant							Yes	Yes			
2004 crude oil or feedstock throughput used to calculate Load (ktonne/annum)	3240	6300	7290	9900	3600	3510	12235.5			10125	6070.5
Effluent flow rate used to calculate Mass emission (tonne/annum)	1736686	3740520	18142000	6733000	1578310	1568000	7907616	3290932	2430167	366580	2452000
Average concentration (mg/l)											
Total N	15.28	3.30	4.62	7.10	4.25	16.98	47.00	30.00	12.00	20.50	23.90
Oil	0.03	0.26	0.08	0.12	0.25	1.10	3.90	40.00	0.12	0.12	6.15
COD	49.12	26.94	7.33	34.00	43.55	40.00	238.00	420.00	31.00	67.80	165.00
BOD5	1.57			3.00	2.23	5.00			3.00	16.00	74.00
Total Suspended Solids	4.85				2.98	20.00					
Calculated Mass emission (tonne/annum)											
Total N	26.54	12.34	83.82	47.80	6.71	26.62	371.66	98.73	29.16	7.51	58.60
Oil	0.05	0.97	1.45	0.81	0.39	1.72	30.84	131.64	0.29	0.04	15.08
COD	85.31	100.77	132.98	228.92	68.74	62.72	1882.01	1382.19	75.34	24.85	404.58
BOD5	2.73			20.20	3.52	7.84			7.29	5.87	181.45
Total Suspended Solids	8.42			0.00	4.70	31.36					
Load (g/tonne crude oil or feedstock processed)											
Total N	8.19	1.96	11.50	#	1.86	7.59	38.44			0.74	9.65
Oil	0.02	0.15	0.20	#	0.11	0.49	13.28			0.0043	2.48
COD	26.33	16.00	18.24	23.12	19.09	17.87	266.78			2.45	66.65
BOD5	0.84			#	0.98	2.23				0.58	29.89
Total Suspended Solids	2.60				1.31	8.93					

#Calculated load could not be verified

Company code	7.01	7.02	7.03	8.00	8.00	8.01	8.02	8.03	8.04	8.04	8.04
Waste water sent to offsite Waste Water Treatment Plant				Yes	Yes				Yes	Yes	Yes
2004 crude oil or feedstock throughput used to calculate Load (ktonne/annum)	2992.5	4500	4500	8910		7830	4032.675	4725	10125		
Effluent flow rate used to calculate Mass emission (tonne/annum)	1903000	3423000	3066000	1750000	4297000	3156000	1712530	12439200	4818000		
Average concentration (mg/l)											
Total N			20.00				3.20				
Oil	3.30	3.24	8.00	0.15	0.15	1.00	3.43	0.08	<0.0005	<0.0005	<0.0005
COD	126.50	70.48	124.00	18.00	18.00	34.00	60.80	71.50	<2.5	<2.5	<2.5
BOD5	15.40	15.58	35.00	2.00	2.00	10.10	20.10	22.75	<0.5	<0.5	<0.5
Total Suspended Solids	11.10	20.71				7.20	10.00	32.59			
Calculated Mass emission (tonne/annum)											
Total N			61.32				5.48				
Oil	6.28	11.09	24.53	0.26	0.64	3.16	5.87	0.99			
COD	240.73	241.25	380.18	31.50	77.35	107.30	104.12	889.40			
BOD5	29.31	53.33	107.31	3.50	8.59	31.88	34.42	282.99			
Total Suspended Solids	21.12	70.89				22.72	17.13	405.39			
Load (g/tonne crude oil or feedstock processed)											
Total N			13.63				1.36		11.82		
Oil	2.10	2.46	5.45	0.10		0.40	1.46	0.21			
COD	80.44	53.61	84.49	12.22		13.70	25.82	188.23			
BOD5	9.79	11.85	23.85	1.36		4.07	8.54	59.89			
Total Suspended Solids	7.06	15.75				2.90	4.25	85.80			

#Calculated load could not be verified

Company code	8.04	8.04	8.04	8.04	8.07	8.07	8.09	8.11	8.12	8.13	8.14
Waste water sent to offsite Waste Water Treatment Plant	Yes	Yes	Yes								
2004 crude oil or feedstock throughput used to calculate Load (ktonne/annum)				10710	3730.5		3780	10858.5	3780	9000	3600
Effluent flow rate used to calculate Mass emission (tonne/annum)	87600	4743081	74508	18400000	3200000	386000	82974720	3483824	3227000	6896900	2404800
Average concentration (mg/l)											
Total N	0.19	24.90	20.53		8.50	18.75	0.09		3.48	4.80	
Oil	<0.0005	<0.0005	<0.0005	0.62	1.75	0.41	0.07		2.60	0.47	0.19
COD	<2.5	<2.5	<2.5	19.93	51.25	109.18	29.43	38.20	67.00	28.00	21.19
BOD5	<0.5	<0.5	<0.5	6.39	25.76	33.84	2.37		15.40	13.00	4.22
Total Suspended Solids				10.65	25.03	40.20			19.03	10.30	7.93
Calculated Mass emission (tonne/annum)											
Total N	0.02	118.10	1.53		27.20	7.24	7.26	0.00	11.23	33.10	
Oil				11.41	5.60	0.16	5.76	0.00	8.39	3.24	0.45
COD				366.71	164.00	42.14	2441.56	133.08	216.20	193.11	50.95
BOD5				117.58	82.42	13.06	196.40	0.00	49.69	89.66	10.14
Total Suspended Solids				195.96	80.10	15.52	0.00	0.00	61.41	71.04	19.06
Load (g/tonne crude oil or feedstock processed)											
Total N					9.23		1.92		2.97	3.68	
Oil				1.07	1.54		1.52		2.22	0.36	0.13
COD				34.24	55.26		645.92	12.26	57.20	21.46	14.15
BOD5				10.98	25.59		51.96		13.15	9.96	2.82
Total Suspended Solids				18.30	25.63				16.25	7.89	5.29

#Calculated load could not be verified

Company code	8.16	8.18	8.20	8.21	9.00	9.01	9.02	9.03	9.04	9.04	9.11
Waste water sent to offsite Waste Water Treatment Plant							Yes				Yes
2004 crude oil or feedstock throughput used to calculate Load (ktonne/annum)	2547	1777.5	13500	4050	3397.5	8460	7110	17100	18720		
Effluent flow rate used to calculate Mass emission (tonne/annum)	1652696	850000	4750500	1382687	1839600	5267980	1688487	4022423	9746376	9214189	38807
Average concentration (mg/l)											
Total N	9.65	10.65		3.36	65.90	30.10	16.00	17.00	1.76	12.89	1.82
Oil	1.24	0.50		0.94	1.30	0.50	4.60	0.50	1.00		1.00
COD	44.30	35.25		24.14	82.30	70.00	119.00	107.00	38.92	130.18	68.20
BOD5		11.25		8.49	10.40	3.00	18.00	17.00		16.67	4.90
Total Suspended Solids		9.25		10.67		39.00	17.25	16.10		28.97	4.00
Calculated Mass emission (tonne/annum)											
Total N	15.95	9.05		4.64	121.23	158.57	27.02	68.38	17.17	118.75	0.07
Oil	2.05	0.43		1.30	2.39	2.63	7.77	2.01	9.79		0.04
COD	73.21	29.96		33.38	151.40	368.76	200.93	430.40	379.34	1199.50	2.65
BOD5		9.56		11.74	19.13	15.80	30.39	68.38		153.57	0.19
Total Suspended Solids		7.86		14.76		205.45	29.13	64.76		266.91	0.16
Load (g/tonne crude oil or feedstock processed)											
Total N	6.26	5.09		1.15	35.68	18.74	3.80	4.00	7.26		
Oil	0.80	0.24		0.32	0.70	0.31	#	0.12	0.52		
COD	28.75	16.86		8.24	44.56	43.59	28.26	25.17	84.34		
BOD5		5.38		2.90	5.63	1.87	4.27	4.00	8.20		
Total Suspended Solids		4.42		3.64		24.29	4.10	3.79	14.26		

#Calculated load could not be verified

Company code	10.00	10.02	11.00	11.01	11.02	11.03	11.04	11.05	11.06	11.07	11.08
Waste water sent to offsite Waste Water Treatment Plant											
2004 crude oil or feedstock throughput used to calculate Load (ktonne/annum)	4950	9000	10800	3915	9900	4702.5	4500	5400	4500	7200	
Effluent flow rate used to calculate Mass emission (tonne/annum)	1000000	4883600	4201100	1432000	4692300	1813000	2408000	3300000	200000	3301062	341640
Average concentration (mg/l)											
Total N		6.77		183.16	11.45	31.96	25.50	9.27		43.00	
Oil	0.98	1.07	12.10	23.00	3.56	3.27	<2	2.25			3.30
COD	104.00			443.00	58.58	46.70	126.00	62.44	51.00		46.50
BOD5	19.30			211.00		33.00		20.00	6.00		<5
Total Suspended Solids			164.50	95.00	20.59			15.18	12.90		
Calculated Mass emission (tonne/annum)											
Total N		33.06	0.00	262.29	53.73	57.94	61.40	30.59		141.95	
Oil	0.98	5.23	50.83	32.94	16.70	5.93		7.43			1.13
COD	104.00			634.38	274.87	84.67	303.41	206.05	10.20		15.89
BOD5	19.30			302.15		59.83		66.00	1.20		
Total Suspended Solids			691.08	136.04	96.61			50.09	2.58		
Load (g/tonne crude oil or feedstock processed)											
Total N		3.67		66.99	5.43	12.32	13.65	5.67		19.71	
Oil	0.20	0.58	4.71	8.41	1.69	1.26		1.38			
COD	#			162.04	27.77	18.00	#	38.16	2.27		
BOD5	3.90			77.18		12.72		12.22	0.27		
Total Suspended Solids			63.99	34.75	9.76			9.28	0.57		

#Calculated load could not be verified

Company code	11.09	12.00	12.01	12.02	12.03	12.04	13.00	13.01	13.02	13.04	13.05
Waste water sent to offsite Waste Water Treatment Plant										Yes	
2004 crude oil or feedstock throughput used to calculate Load (ktonne/annum)	6300	3465	9450	4770	585	1260	14445	10149.53	11025	4500	9945
Effluent flow rate used to calculate Mass emission (tonne/annum)	5500000	5810000	2700000	1186000	112000	1100000	1.55E+08	2497776	27600000		3666894
Average concentration (mg/l)											
Total N	3.20	2.96	1.70	4.70							32.00
Oil	4.60	0.71	0.60	2.20				1.30	0.67		0.08
COD	140.00	141.14	34.00	49.00				90.00			52.19
BOD5	49.00	3.83	4.00	8.00					11.88		7.00
Total Suspended Solids		31.00		8.00							
Calculated Mass emission (tonne/annum)											
Total N	17.60	17.21	4.59	5.57							117.34
Oil	25.30	4.13	1.62	2.61				3.25	18.50		0.29
COD	770.00	820.01	91.80	58.11				224.80			191.36
BOD5	269.50	22.28	10.80	9.49					328.00		25.67
Total Suspended Solids	0.00	180.11	0.00	9.49							
Load (g/tonne crude oil or feedstock processed)											
Total N	#	4.97	0.49	1.17							11.80
Oil	4.02	1.19	0.17	0.55				0.32	1.68		0.03
COD	122.22	236.66	9.71	12.18				22.15			19.24
BOD5	42.78	#	1.14	#					29.75		2.58
Total Suspended Solids	0.00	#	0.00	1.99							

#Calculated load could not be verified

Company code	13.07	13.10	13.11	13.12	13.13	13.14	14.00	14.01	15.01	15.02	16.00
Waste water sent to offsite Waste Water Treatment Plant				Yes						Yes	
2004 crude oil or feedstock throughput used to calculate Load (ktonne/annum)	4713.525	7353	8806.5	9450	1215	540	2700	3240	4107.463	9580.275	3195
Effluent flow rate used to calculate Mass emission (tonne/annum)	3066000	1600	5128000	4975680	10500	91270	390185	2776200	1587476	2380972	606000
Average concentration (mg/l)											
Total N									9.50	276.40	
Oil	2.80		0.41	6.00	1.08	0.50	1.37	2.66	4.09	62.30	17.07
COD			32.00	199.34			42.00	15.00	50.73	550.90	168.00
BOD5			3.72		16.50			13.00	9.08	202.50	81.50
Total Suspended Solids									9.04		
Calculated Mass emission (tonne/annum)											
Total N									15.08	658.10	
Oil	8.58		2.08	29.85	0.011	0.046	0.53	7.38	6.48	148.33	10.34
COD			164.10	991.85			16.39	41.64	80.53	1311.68	101.81
BOD5			19.08		0.17			36.09	14.42	482.15	49.39
Total Suspended Solids									14.35	0.00	0.00
Load (g/tonne crude oil or feedstock processed)											
Total N									3.67	68.69	
Oil	1.82		0.24	3.16	#	0.085	#	2.28	1.58	15.48	3.24
COD			18.63	104.96			#	12.85	19.61	136.91	31.86
BOD5			2.17		#			11.14	3.51	50.33	15.46
Total Suspended Solids									3.49		

#Calculated load could not be verified

Company code	17.00	21.00	21.01	21.02	21.03	23.00	24.00	24.01	24.02	24.03	24.04
Waste water sent to offsite Waste Water Treatment Plant		Yes	Yes	Yes							
2004 crude oil or feedstock throughput used to calculate Load (ktonne/annum)	7245	3060	4950	900		11853.9	4050	11700			
Effluent flow rate used to calculate Mass emission (tonne/annum)	10297000	1803978	2143000	694958	704594	3090090	3837000	9043000	741957.3	709000	989000
Average concentration (mg/l)											
Total N				23.30		9.60	6.80	3.50			4.16
Oil	4.20			11.90	0.31	0.06		1.10	8.10	1.60	3.62
COD	84.00	65.96		263.20	86.50	32.00	46.30	78.80	961.80	86.50	61.60
BOD5	29.00	10.08		103.30	9.48	4.52	11.60		186.67	14.10	12.10
Total Suspended Solids								6.50			
Calculated Mass emission (tonne/annum)											
Total N				16.19	0.00	29.66	26.09	31.65			4.11
Oil	43.25			8.27	0.22	0.19	0.00	9.95	6.01	1.13	3.58
COD	864.95	118.99		182.91	60.95	98.88	177.65	712.59	713.61	61.33	60.92
BOD5	298.61	18.18		71.79	6.68	13.97	44.51	0.00	138.50	10.00	11.97
Total Suspended Solids	0.00	0.00		0.00	0.00			58.78			
Load (g/tonne crude oil or feedstock processed)											
Total N				17.99		2.50	6.44	2.71			
Oil	5.97			9.19		#	0.00	0.85			
COD	119.39	38.88		203.24		8.34	43.86	60.90			
BOD5	41.22	5.94		79.77		1.18	10.99	0.00			
Total Suspended Solids								5.02			

#Calculated load could not be verified

Company code	25.00	27.03	27.05	28.01
Waste water sent to offsite Waste Water Treatment Plant				
2004 crude oil or feedstock throughput used to calculate Load (ktonne/annum)	5175	4680	3150	5185.8
Effluent flow rate used to calculate Mass emission (tonne/annum)	66820548		4234000	23328816
Average concentration (mg/l)				
Total N				14.86
Oil	0.44		1.33	3.59
COD	24.99		100.46	96.74
BOD5	4.45		13.23	10.32
Total Suspended Solids	10.47		21.10	16.08
Calculated Mass emission (tonne/annum)				
Total N				346.67
Oil	29.07		5.63	83.75
COD	1669.71		425.35	2256.83
BOD5	297.42		56.02	240.75
Total Suspended Solids	699.81		89.33	375.13
Load (g/tonne crude oil or feedstock processed)				
Total N				66.85
Oil	#		1.79	16.15
COD	#		135.03	435.19
BOD5	#		17.78	46.43
Total Suspended Solids	135.23		28.36	72.34

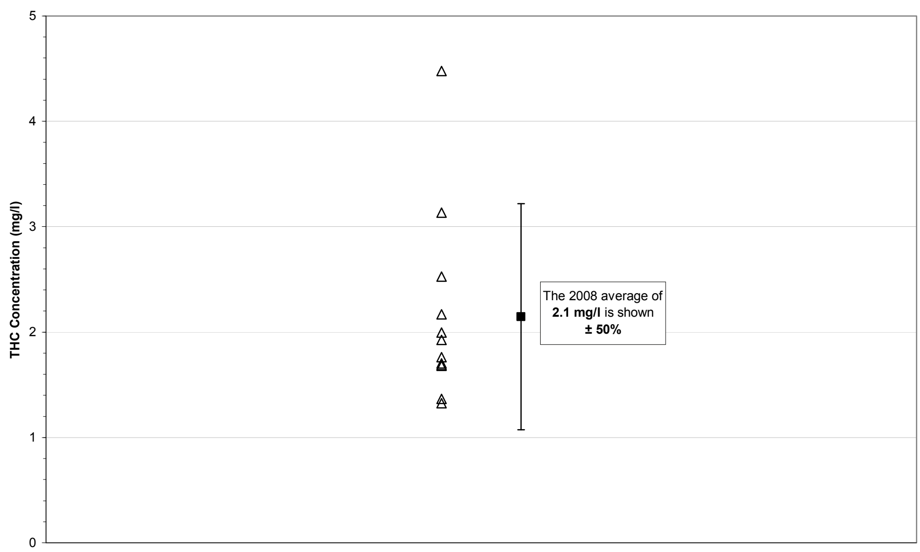
#Calculated load could not be verified

APPENDIX 2 DATA RECEIVED FROM THE CONCAWE MEMBERSHIP SHOWING VARIABILITY IN MEASURED PARAMETERS RELATIVE TO THE 2008 ANNUAL AVERAGE FOR 12 SITES

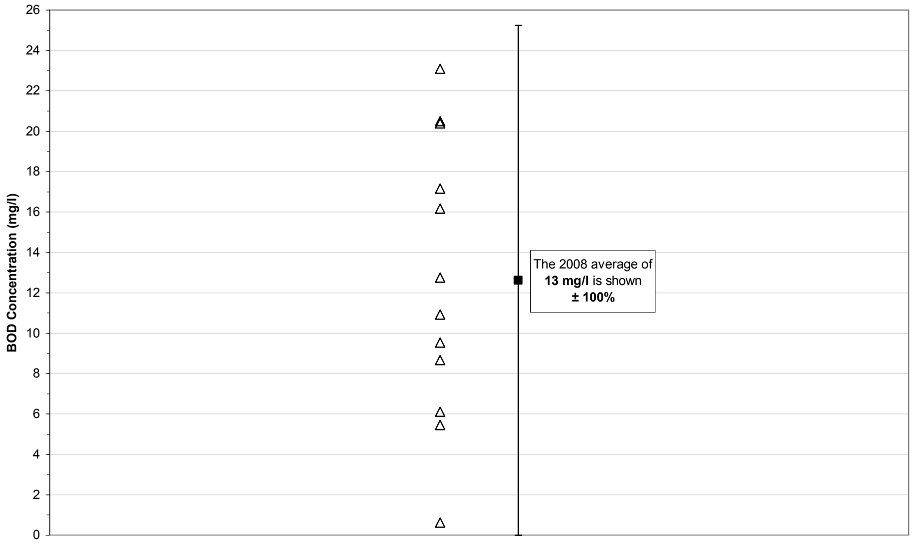
Site	COD Annual Average (mg/l)	Variation (%)	THC Annual Average (mg/l)	Variation (%)	TSS Annual Average (mg/l)	Variation (%)	BOD Annual Average (mg/l)	Variation (%)	TN Annual Average (mg/l)	Variation (%)
1	76	±24	2,1	±41	16	±26	13	±72	23	±35
2	54	±28	1,1	±13	7	±43	14	±76	22	±30
3a	88	±30	0,9	±120	23	±36	12	±79	17	±69
3b	80	±86	1,4	±58	18	±62	8	±62	17	±67
4	44	±45	1,2	±75	8	32	4,8	±38	-	-
5	95	±14	1,9	±51	11	±44	14	±97	8	±100
6	73	±15	4,4	±58	12	±37	7,7	±48	11,3	±70
7	97	±27	1,3	±38	13	±30	-	-	-	-
8	150	±4	3,6	±12	-	-	-	-	-	-
9	85	±20	2,2	±29	3,8	±46	3	±36	-	-
10	92	±23	3,6	±65	25	±24	28	±46	14	±18
11	128	±44	3,7	±33	-	-	-	-	20	±39
12	119	±130	1,1	±86	30,5	±54	25	±62	32	±39
Average	91	±38	2	±52	15	±39	13	±62	18	±52

Figures showing monthly- (open symbols) and annual-average (filled symbol) concentrations (mg/l) for the five parameters reported for Site 1

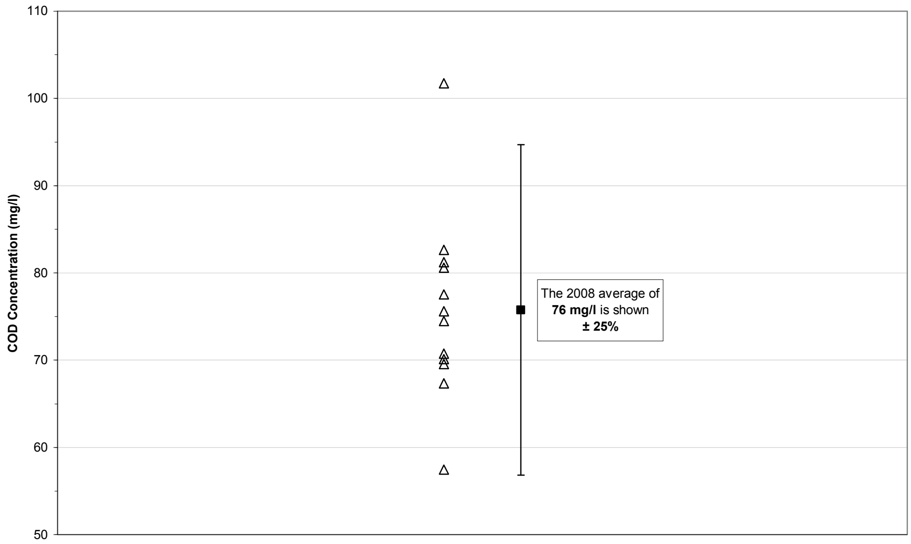
TOTAL HYDROCARBON CONTENT (THC)



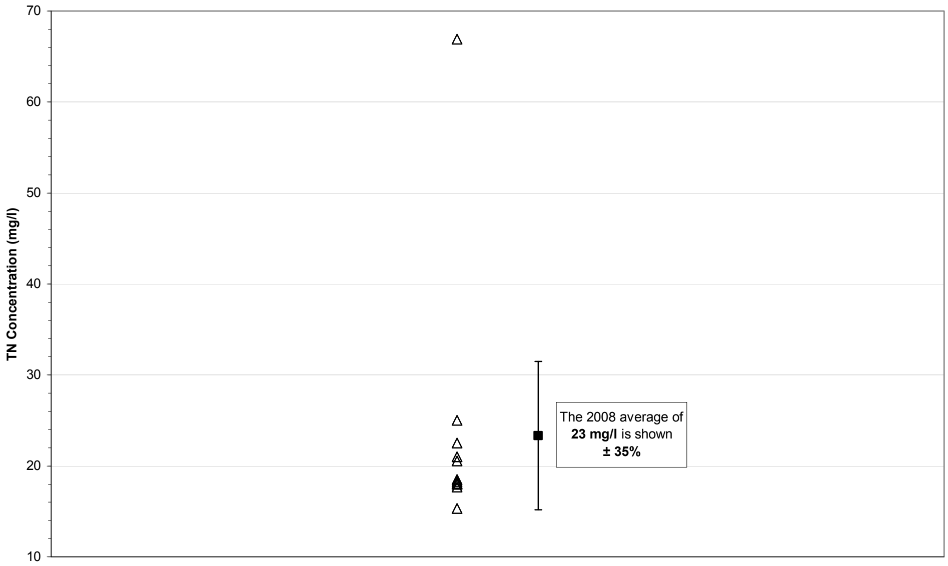
BIOCHEMICAL OXYGEN DEMAND (BOD)



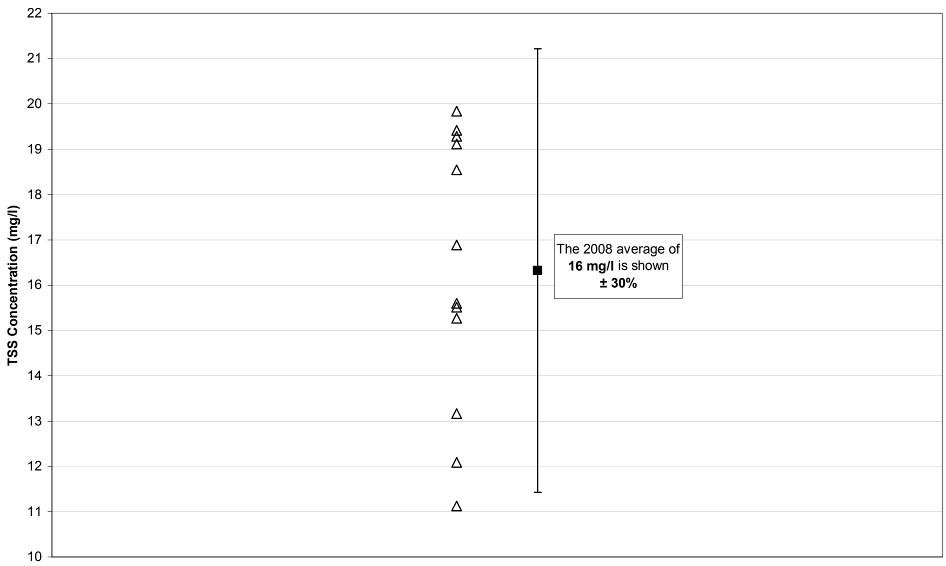
CHEMICAL OXYGEN DEMAND (COD)



TOTAL NITROGEN (TN)



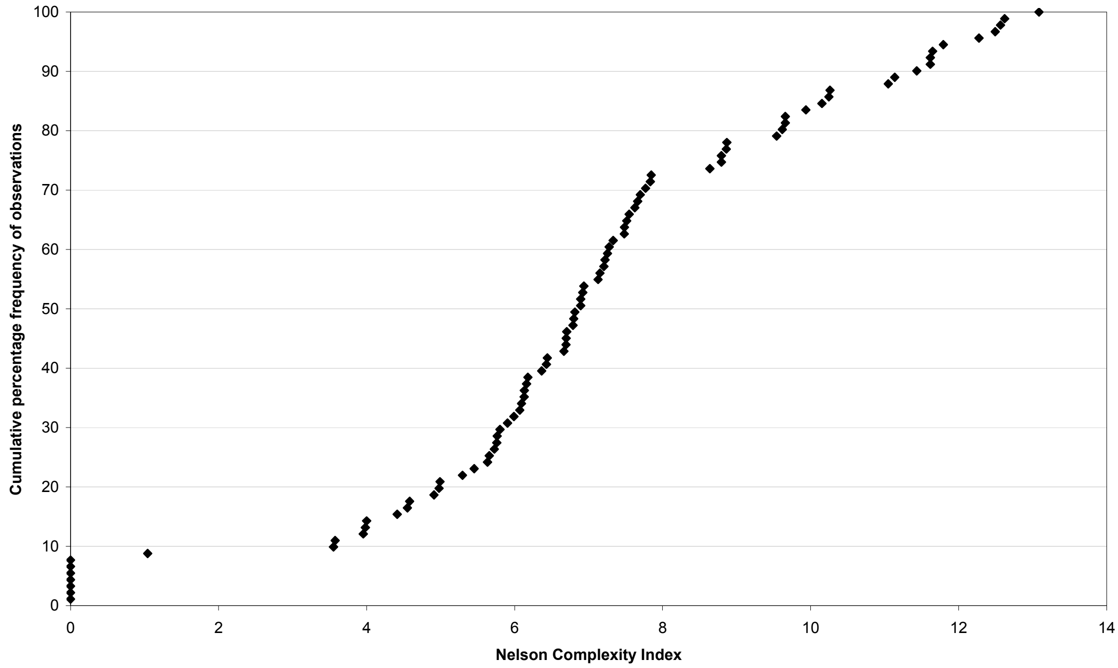
TOTAL SUSPENDED SOLIDS (TSS)



APPENDIX 3 NELSON COMPLEXITY INDEX: CALCULATED VALUES AND CUMULATIVE FREQUENCY DISTRIBUTION FOR REFINERIES REPORTING IN THE 2006 SURVEY

Refinery reference code	Calculated NCI[1]	Refinery reference code	Calculated NCI[1]	Refinery reference code	Calculated NCI[1]	Refinery reference code	Calculated NCI[1]
1.00	6.2	6.17	6.4	8.16	6.8	13.05	12.6
2.00	6.7	6.17	9.5	8.18	3.6	13.07	11.8
2.01	5.2	6.18	10.2	8.20	7.7	13.10	14.8
2.03	2.0	6.22	7.5	8.21	7.2	13.11	5.0
2.04	6.1	6.23	6.1	9.00	11.6	13.12	11.4
3.00	5.0	6.24	8.8	9.01	10.3	13.13	4.0
3.01	3.1	6.24	8.8	9.02	7.8	13.14	4.0
4.00	8.6	6.26	7.1	9.03	4.9	14.00	7.7
4.01	6.8	6.27	ND[2]	9.04	7.3	14.01	6.9
5.00	6.4	7.00	11.6	9.04	7.3	15.01	5.5
5.02	6.7	7.00	11.6	9.11	0.0	15.02	6.1
5.03	5.7	7.00	8.9	10.00	4.0	16.00	5.6
5.04	6.9	7.01	5.9	10.02	5.8	17.00	11.0
5.04	6.9	7.02	1.0	11.00	6.7	21.00	7.5
5.05	11.1	7.03	12.5	11.01	4.6	21.01	8.4
5.06	5.3	8.01	6.0	11.02	6.9	21.02	3.6
5.07	7.2	8.02	7.3	11.03	9.5	21.03	0.0
5.08	7.8	8.03	13.1	11.04	10.4	23.00	5.7
5.10	8.9	8.04	3.8	11.05	7.7	24.00	11.1
5.11	7.8	8.04	3.8	11.06	5.9	24.01	4.6
5.12	6.7	8.04	3.8	11.07	7.1	24.02	0.0
5.14	5.8	8.04	3.8	11.08	ND[2]	24.03	0.0
5.15	ND[2]	8.04	3.8	11.09	9.9	24.04	0.0
6.01	9.3	8.04	3.8	12.00	6.4	25.00	12.3
6.04	7.5	8.04	7.5	12.01	7.5	27.03	7.6
6.05	0.0	8.07	9.7	12.02	6.2	27.05	4.4
6.08	8.0	8.07	9.7	12.03	4.0	28.01	5.8
6.10	4.7	8.09	10.2	12.04	5.1	28.01	5.8
6.11	9.6	8.11	5.9	13.00	9.9		
6.14	0.0	8.12	12.6	13.01	6.1		
6.15	13.2	8.13	7.2	13.02	7.6		
6.16	7.3	8.14	6.8	13.04	1.6		

[1]A zero (0) value signifies……
[2]ND signifies value not determined.



Cumulative Frequency Plot of Nelson Complexity Index (NCI) for Refineries reporting in the 2006 Survey

APPENDIX 4 METHODS USED TO MEASURE EACH PARAMETER BY THE REFINERIES REPORTING IN THE SURVEY

TOTAL HYDROCARBON CONTENT

Methods described in National or International Standards	Number of Refineries	Countries where used	LOD (mg/l)
ISO 9377	10	F, D, NL, N, Hun	0.1 - 1
NF T 90-203	8	F	0.1 - 0.5
APHA 5520	6	GR, ES, P	0.1 - 0.2
IP 426	3	UK	0.5 - 1
IRSA 5140	2	It	0.0005
IRSA 5160	2	It	0.01 - 0.05
DEV H18	2	D	0.05 - 0.5
BBMS 036	1	F	Not reported
NFT 90-114	1	F	0.1
EA Blue Book 117517283A	1	UK	0.2
HMSO 1983	1	UK	0.1
UK 1412	1	UK	0.1
SCA 1983	1	UK	Not reported
ROG-2110	1	D	0.5
Waste water regulation	1	D	Not reported
SCR 1102	1	S	Not reported
SPI - SCR	1	S	0.2
SS 02 81 45-4	1	S	0.4
DS/R 209 modified	1	DK	0.1
PN-C-04565-01:1982	1	Pol	0.1
EPA METHOD 418 .1	1	GR	Not reported
Li National method	1	Lit	0.05
Other method descriptions			
IR	4	F, ES, CH	0.1
FT-ir spectroscopy	1	UK	Not reported
GC	1	N	0.1
Optical absorbance (3.4-3.5nm)	1	GR	Not reported
KW Index (HC Index)	1	D	Not reported
Total hydrocarbon analysis	1	CH	0.02
Methods not described	3	SU, NL, ES, D, It	0.0005 - 2
LOD Overall range (if known)			0.0005 - 2

TOTAL NITROGEN

Methods described in National or International Standards	Number of Refineries	Countries where used	LOD (mg/l)
EN ISO 7890 (EN 25663/EN 26777/UNE 77028)	6	D, F, ES, Lit	0.057 - 1
EN 12260	2	F, N	1 - 2
SS EN ISO 13395	2	S	0.1
NF M07-058	1	F	1
T 90-060	1	F	0.5
IRSA CNR 5030	1	It	Not reported
APAT CNR IRSA 4030 A2 Man 29 2003 - 4050 - 4020	1	It	2.1
NEN6481	1	NL	Not reported
NL National method	1	NL	Not reported
ROG-2030 / DIN 38409 H27	1	D	1
Waste water regulation	1	D	Not reported
ASTM D5176	1	B	Not reported
DS 221	1	DK	0.03
NIQ 144/ ISSO 10048	1	P	Not reported
SM 418E-DEVARDAS Alloy reduction / SM 4500 Norganic	1	GR	Not reported
Test Merck'a nr 1.14537 M043 PB-1:2003 [A]	1	Pol	0.5
Other method descriptions			
Kjeldhal	1	ES	Not reported
SUM (NTK + NO2 + NO3)	1	F	Not reported
Method proposed by Jean Rodier in L'analyse de l'eau	1	P	Not reported
Test Hach Lange	1	Pol	0.5
Dr Lange, LCK 138	1	S	Not reported
Methods not described	4	A, SU, NL	0.1 - 2
LOD Overall range (if known)			0.02 - 2.1

BIOCHEMICAL OXYGEN DEMAND

Methods described in National or International Standards	Number of Refineries	Countries where used	LOD (mg/l)
EN 1899	9	DK, F, D, NL, S, Hun	0.5 - 5
EN 1889-1	4	F, D, NL	0.5 - 3
APHA 5210	6	GR, ES, P	1 - 2
ISO 5815	4	It, UK, Lit	0.5 - 5
T 90-103	3	F	2 - 5
UK 1320	1	UK	3
NEN 6634	2	B, NL	Not reported
IRSA 5100	2	It	0.5
IRSA 5120	1	It	5
IRSA 5130	1	It	10
Waste water regulation	1	D	Not reported
DIN 38409-H51	1	D	Not reported
BBMS 046	1	F	Not reported
NL National method	1	NL	Not reported
NP 4329 (1996) (modified)	1	P	Not reported
Other method descriptions			
Hach method and instrument "Bodtrak".	1	UK	Not reported
Dilution, sowing and Winkler	1	ES	Not reported
OXITOP	4	F, Pol	0.5 - 15
OXYDIRECT SYSTEM	1	GR	Not reported
Sappromat	1	D	1
Methods not described	4	A, NL, It, ES	0.5 - 5
LOD Overall range (if known)			0.5 - 15

CHEMICAL OXYGEN DEMAND

Methods described in National or International Standards	Number of Refineries	Countries where used	LOD (mg/l)
T 90-101	10	F	10 - 30
APHA 5220	7	GR, It, ES, P	1 - 10
ISO 15705	5	D, NL, UK, Hun, Pol	1 - 10
DIN 38409-H41	5	D	10 - 15
IRSA CNR 5110	3	It	2.5 - 50
IRSA 2003 Met.5130	1	It	Not reported
IRSA 5130	1	It	5
NEN 6633	2	NL	Not reported
ASTM 1252	2	F, UK	10
DS 217	2	DK	0.01-100
DEV H41 (analog) Küvettentest Merck	1	D	50
Waste water regulation	1	D	Not reported
ISO	1	Lit	3.3
ISO 6060:2006	1	Pol	10
NBN-T91-201	1	B	Not reported
NL National method	1	NL	Not reported
NP 4329 (1996) (modified)	1	P	Not reported
UNE 77-004-89	1	ES	Not reported
Other method descriptions			
HACH Spectrophotometer	1	UK	10
HACH 8000 (titrometric)	1	GR	Not reported
Spectrophotometer UV	1	CH	2
Digestion with dichromate	1	ES	Not reported
Dr Lange, LCK 114	2	S	20
Merck Nova 60	1	S	30
Methods not described	4	A, SU, NL, It	0.1 - 20
LOD Overall range (if known)			0.01 - 100

TOTAL SUSPENDED SOLIDS

Methods described in National or International Standards	Number of Refineries	Countries where used	LOD (mg/l)
EN 872	9	F, S	1 - 2
APHA 2540	5	GR, B, ES, P	1
NEN 6621	4	NL	1
IRSA 2090	3	It	0.1 - 10
T 90-105	3	F	2
DIN 38409 Part 2	1	D	1
DS 207	1	DK	3
NL National method	1	NL	Not reported
Other method descriptions			
By filtration	1	GR	Not reported
LOD Overall range (if known)			0.1-10

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