Composition of fish filleting wastewater

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Abstract

The first step in pollution control is the characterization of the effluent. This work intends to be a contribution to the knowledge of fishery effluents and to give information necessary for wastewater treatment. Analyses for temperature, pH, settleable matter, total residue, grease and oil, phosphate, total Kjeldahl nitrogen, ammonia, nitrate, nitrite, BOD_5 and COD were performed. Data were statistically analysed. It was concluded that the operational policy had a decisive influence on the composition of the wastewater. Moreover, seasonal variation, which could be correlated to raw material seasonal changes, was detected for grease and oil.

Introduction

Fish processing plants, filleting industries in particular, have developed in Argentina during the last years. Wastewater from these plants in close proximity to urban areas, is discharged to the sewer or harbour without treatment. However, federal and state authorities have set up new rules and regulations for the discharge of industrial effluents, with which the industries have to comply. Treatment expenses can be a significant factor in production costs which are likely to increase with the demands for a cleaner environment. Special problems are due to the specific characteristics of fisheries wastewaters such as their high BOD_5 value. The purpose of this work is, therefore, to determine the composition and seasonal variability of liquid effluents from hake filleting plants, as a first step in pollution control.

Materials and Methods

Samples, from the effluent stream prior to passage through the sludge sedimentation tank, were collected in glass or plastic containers and immediately refrigerated.

Data were generated from the analyses of 22 samples from June 1980 to May 1981, so that any seasonal variation could be detected. The temperature was measured by immersion of the bulb of a thermometer into the flowing liquid. The pH was determined with a pH-meter. Non-protein nitrogen was determined following the method of Ironside and Love (1958) by precipitation of proteinaceous material with trichloroacetic acid (15%), separating the supernatant by centrifugation at 3 500 r/min (54 g), and analysing for total nitrogen by Kjeldahl method according to AOAC (1975). Grease was determined by Soxhlet method using diethyl ether as solvent.

The following analyses were performed in accordance with Standard Methods (1975): total residue dried at 103-105°C; settleable matter; nitrogen from ammonia by the phenate method; nitrogen from nitrate by the brucine method; nitrogen from nitrite; dissolved oxygen by the azide modification; phosphate by the vanadomolybdophosphoric acid colorimetric method; biochemical oxygen demand and chemical oxygen demand.

Results

Tables 1 and 2 compare the characteristics of effluents from fish filleting plants as reported in the literature with those determined in this study. Results are expressed as mean values, the numbers in brackets correspond to the maximum and minimum respectively.

Table 3 gives pH, temperature, settleable solids in 10 min, settleable solids in 2 h, non-protein nitrogen and total nitrogen.

The measurement of the chemical oxygen demand (COD) is a short method to assess the pollution potential of municipal and industrial wastewater. However, it depends totally on the chemical oxidation of materials by a powerful oxidizing agent such as potassium dichromate; obviously this method does not involve a biochemical reaction and for practical purposes its results must be correlated with the biochemical oxygen demand (BOD) analysis. The data obtained from eight different samples are shown in Fig. 1. The straight line model can be plotted according to:

$$y = 233 + 0{,}295x$$

where:

$$y = BOD_5 \text{ (mg } O_2/\ell)$$

$$x = COD \text{ (mg } O_2/\ell)$$

with a correlation coefficient r = 0,968.

The mean water supply was 11,3 m^3/t of manually processed fish and 10,4 m^3/t of mechanically processed fish.

Total solids were determined and the results are shown in Table 4. The mean N/P ratio was 5,51.

Discussion

As a result of the seasonal variation in the composition and amount of fish processed, a wide distribution in experimental results was found. Different operating techniques from plant to plant as well as the quality of the water employed (well or tap) may also influence the characteristics of the wastewater. The results are within the range of values reported in the literature. Riddle and Shikaze (1973) found that great fluctuations occur not only when different species of fish are processed in one plant but

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TABLE 1:

SUMMARY OF TOTAL SOLIDS, GREASE AND BOD_5 VALUES FROM FISH FILLETING PLANTS. (RESULTS ARE EXPRESSED AS MEAN VALUES, THE NUMBERS IN BRACKETS CORRESPOND TO THE MAXIMUM AND MINIMUM RESPECTIVELY).

	Total Solids mg/ℓ	Grease mg/ℓ	BOD_5 mg/ℓ
Sørensen			
Herring filleting	1 400	6 000	10 000
Potter			
White fish:			
filleting machine	4 800 (2 800 – 11 300)	–	2 680 (975 – 6 800)
hand filleting	750 (500 – 1 000)	–	280 (110 – 560)
skinning machine	6 200 (1 000 – 11 000)	–	2 300 (250 – 4 900)
drain	900 (400 – 1 100)	–	480 (200 – 750)
Herring:			
filleting machine	3 700 (2 200 – 4 900)	–	2 620 (1 100 – 4 600)
splitting machine	2 200 (1 400 – 2 600)	–	1 400 (1 300 – 1 500)
Tsuchiya	–	–	700 (500 – 1 200)
Herborg			
Herring filleting	5 140	857	3 428
Soderquist			
Bottom fish fillet	–	–	(192 – 1 726)
Ventz	–	–	1 250 (420 – 4 270)
Dazai	(1 556 – 2 446)	(130 – 189)	(1 000 – 1 900)
This study	2 209 (1 290 – 4 300)	40,6 (8,3 – 79,9)	528 (327 – 1 063)

NOTE: Sorensen (1974); Potter *et al.* (1976); Tsuchiya (1971); Herborg (1974); Soderquist *et al.* (1970); Ventz (1970) and Dazai *et al.* (1968).

TABLE 2

SUMMARY OF NO_3^-– N, NH_4^+– N, TOTAL N AND PHOSPHORUS CONTENT IN WASTEWATER FROM PATAGONIAN HAKE *(MERLUCCIUS HUBBSI)* FILLETING PLANTS

	NO_3^-– N mg/ℓ	NH_4^+– N mg/ℓ	Total N mg/ℓ	Total P mg/ℓ
Herborg				
Herring filleting	–	–	485,7	71,4
Ventz	1,15 (0 – 1,97)	70,5 (25,8 – 180)	180 (72 – 523)	98,6 (23,3 – 277)
Dazai	–	–	(70 – 311)	(30 – 60)
This work	10,39 (0,72 – 26,13)	1,159 (0,021 – 2,56)	84,7 (34,4 – 149,2)	13,4 (4,78 – 20,78)

TABLE 3

MEAN VALUE AND RANGE OF pH, TEMPERATURE, SETTLEABLE SOLIDS, NON-PROTEIN NITROGEN AND TOTAL NITROGEN CONTENT IN WASTEWATER FROM PATAGONIAN HAKE *(MERLUCCIUS HUBBSI)* FILLETING PLANTS

pH	Temp °C	Settleable Solids 10 min mℓ/ℓ	Settleable Solids 2 h mℓ/ℓ	Non-protein Nitrogen mg/ℓ	Total Nitrogen mg/ℓ
7,7 (7,0 – 8,3)	13,6 (6 – 18)	3,6 (0,9 – 8,5)	4,7 (1,0 – 10)	32,0 (18,3 – 43,2)	84,7 (34,4 – 149,2)

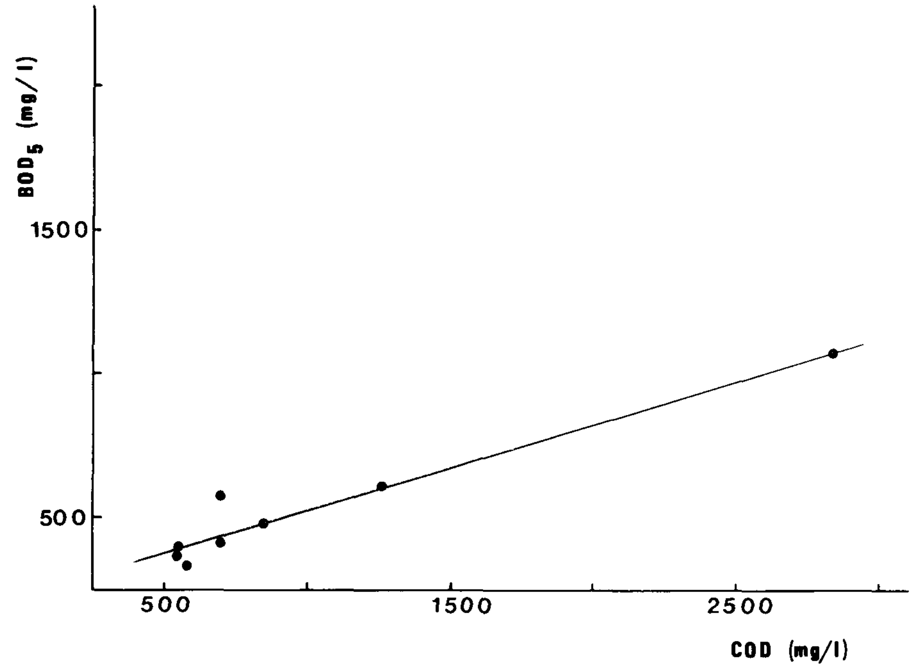

Figure 1
Relationship between BOD_5 and COD for wastewater from Patagonian hake (Merluccius Hubbsi) *filleting plants.*

TABLE 4
TOTAL SOLIDS IN WATER SUPPLY AND WASTEWATER

Sample No	Total solids (mg/ℓ) water supply	waste water	ratio ws:ww
1	0,117	0,150	0,780
2	0,086	0,147	0,585
3	0,110	0,177	0,621
4	0,112	0,186	0,602
			mean ratio 0,65

also when the same species is processed in plants of differing size. No relationship between effluent loading and plant size could be found.

The total solid content is higher than that reported by Potter *et al.* (1976) for manual operation. However, when total solids were measured in wash water it was found that 65% of the solids present in the effluent were already in the water employed. With respect to the grease content it must be taken into account that herring is an oily fish while hake is not; accordingly data obtained from hake processing plants are lower. However, if biological facilities are planned to treat this wastewater, grease should be removed in advance.

With regard to the N:P ratio Metcalf and Eddy (1979) recommended 5:1 while Eckenfelder (1980) chose 4,73:1 for optimum, so the values found in fish filleting wastewater are considered to be appropriate for biological treatment.

The pH of this wastewater is also acceptable for biological treatment.

It can be noticed that 37% of total nitrogen corresponds to non-protein compounds.

Experimental data are statistically defined to provide a basis for the design of the wastewater treatment units (Eckenfelder, Jr; 1980). In Figs. 2 to 17 data are plotted on normal probability paper on which a normal distribution will plot roughly as a straight line.

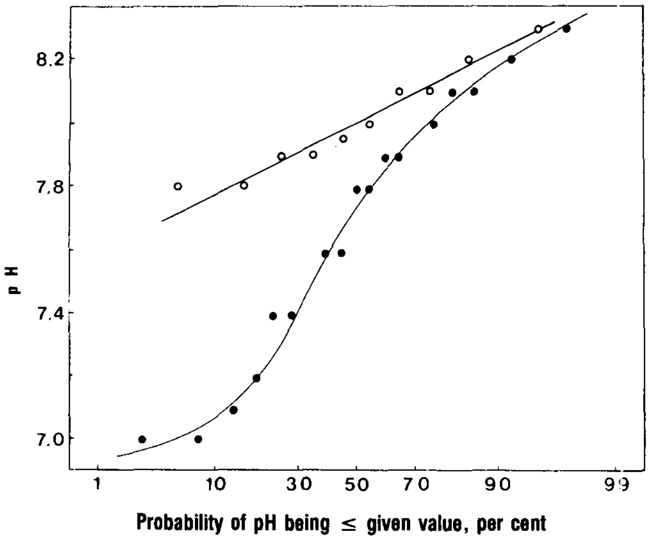

Figure 2
Distribution of wastewater pH values (● data from all the plants, o data from a single plant.)

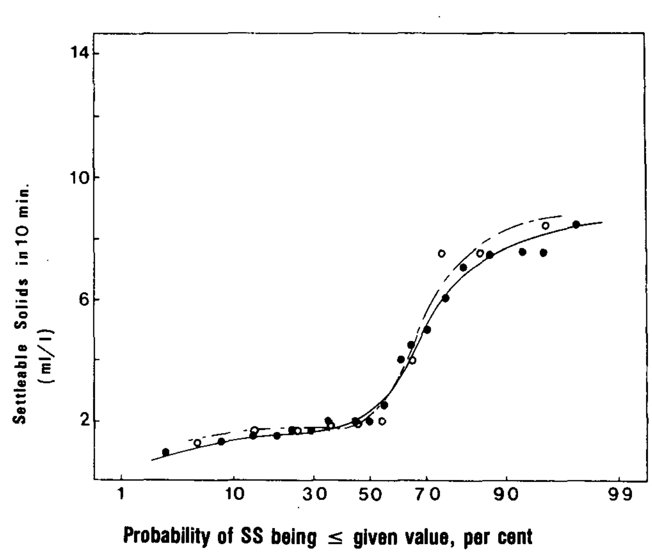

Figure 5
Distribution of settleable solids (in 10 min.) content in wastewater. (● data from all the plants, o data from a single plant.)

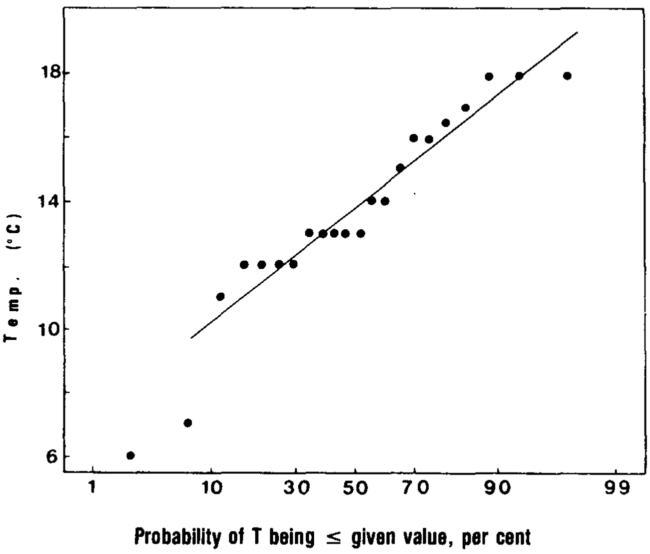

Figure 3
Distribution of wastewater temperature values (● data from all the plants, o data from a single plant)

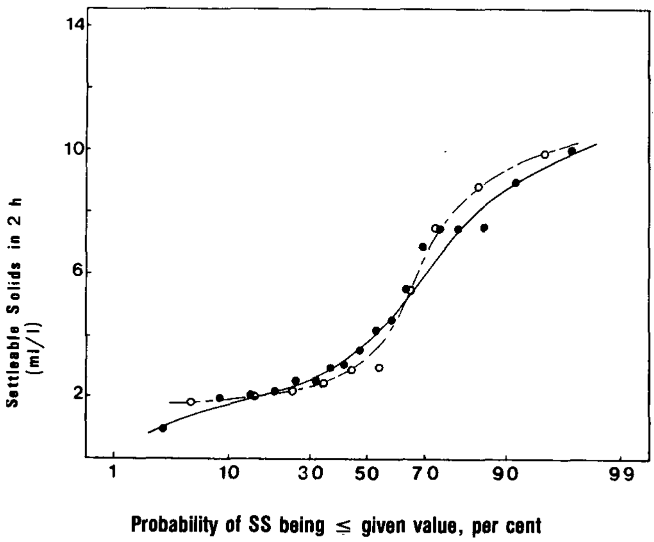

Figure 6
Distribution of settleable solids (in 2 h) content in wastewater (● data from all the plants, o data from a single plant.)

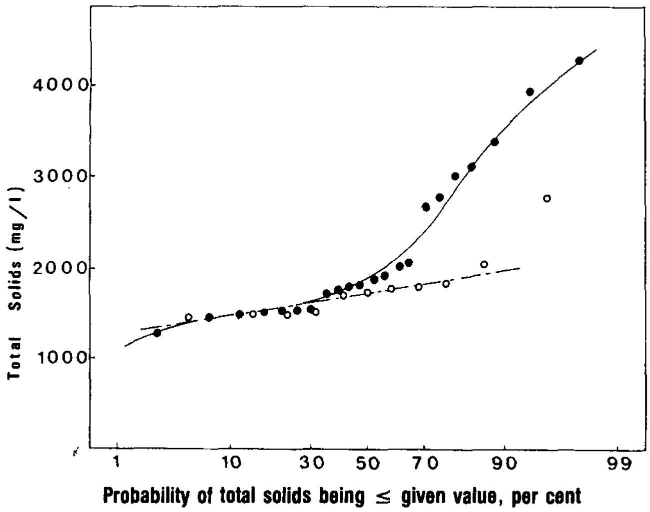

Figure 4
Distribution of total solid content in wastewater (● data from all the plants, o data from a single plant.)

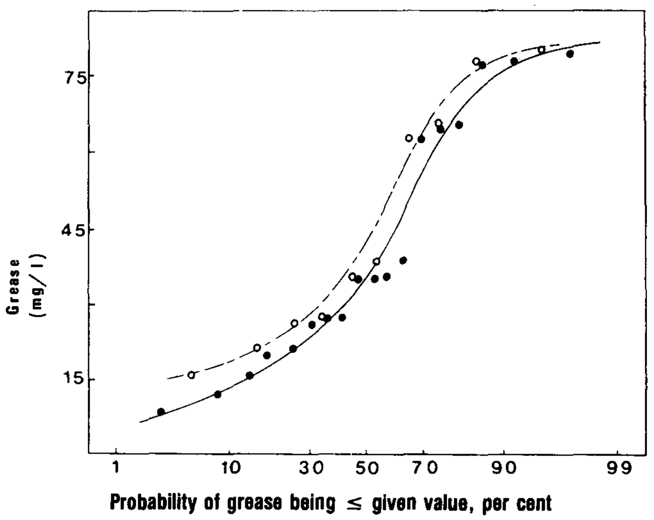

Figure 7
Distribution of grease content in wastewater. (● data from all the plants, o data from a single plant).

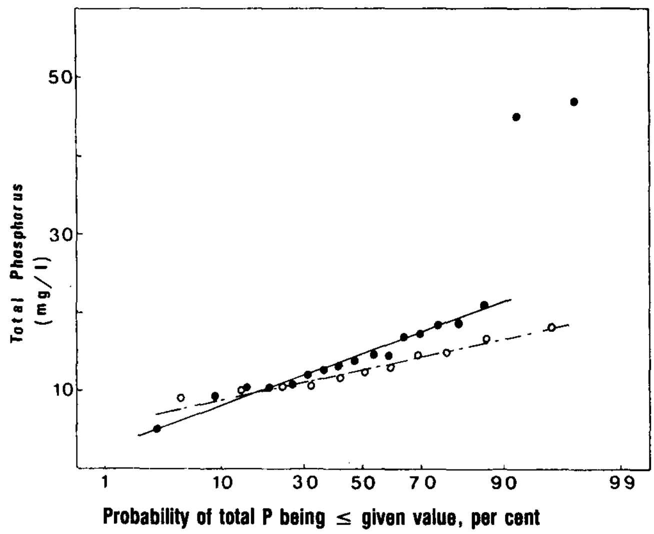

Figure 8
Distribution of total phosphorus content in wastewater. (● data from all the plants, o data from a single plant.)

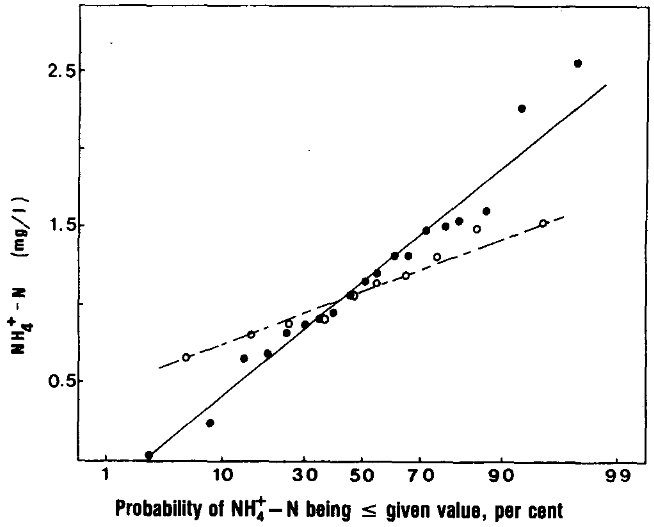

Figure 11
Distribution of NH_4^+ – N content in wastewater. (● data from all the plants, o data from a single plant.)

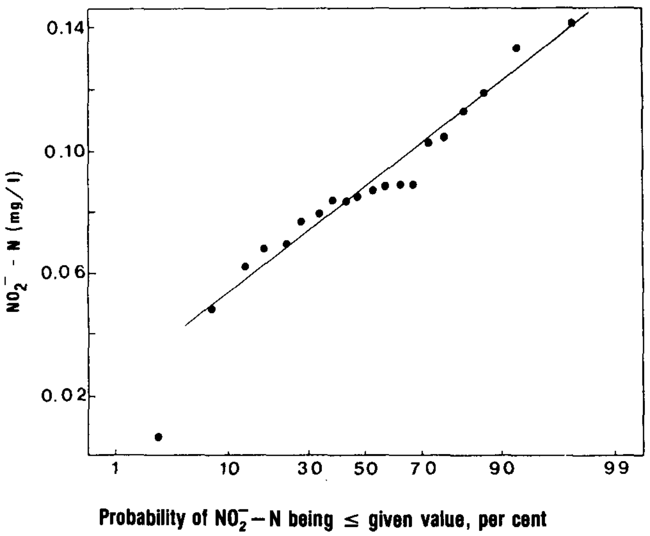

Figure 9
Distribution of NO_2 – N content in wastewater (● data from all the plants, o data from a single plant.)

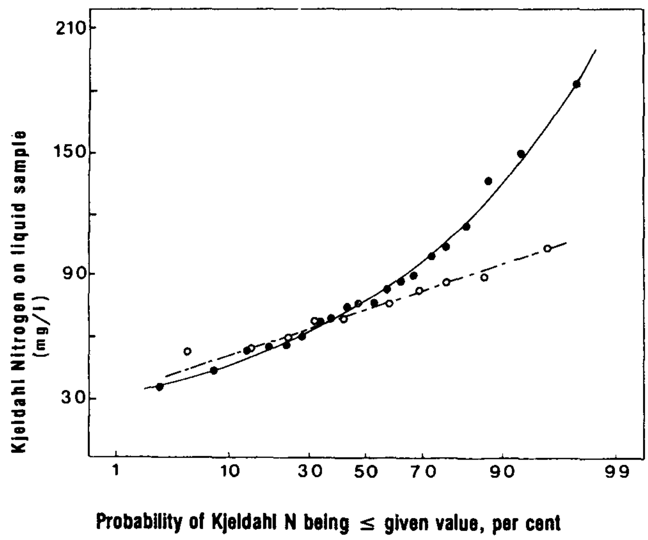

Figure 12
Distribution of Kjeldahl nitrogen (dried base) content in wastewater. (● data from all the plants, o data from a single plant.)

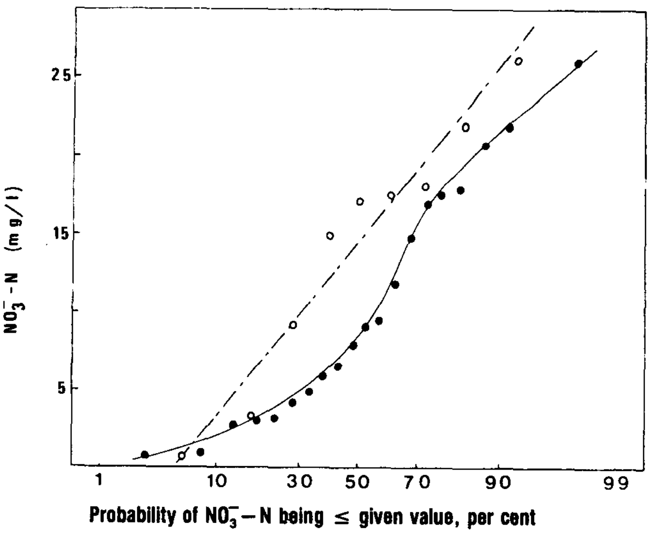

Figure 10
Distribution of NO_3^- – N content in wastewater. (● data from all the plants, o data from a single plant.)

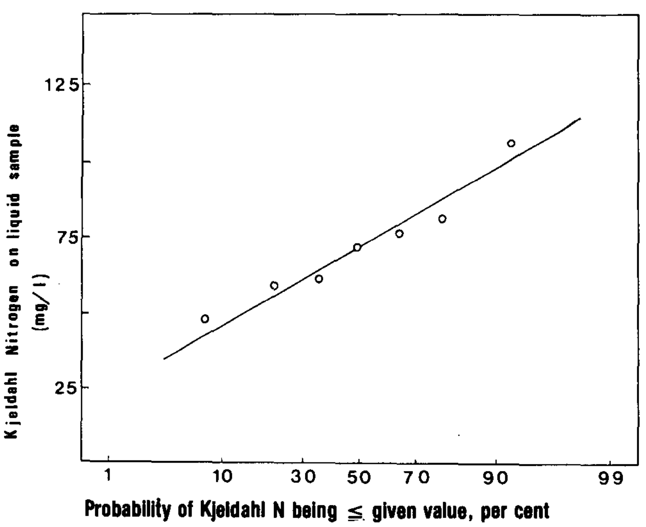

Figure 13
Distribution of Kjeldahl nitrogen (liquid base) content in wastewater. (o data from a single plant).

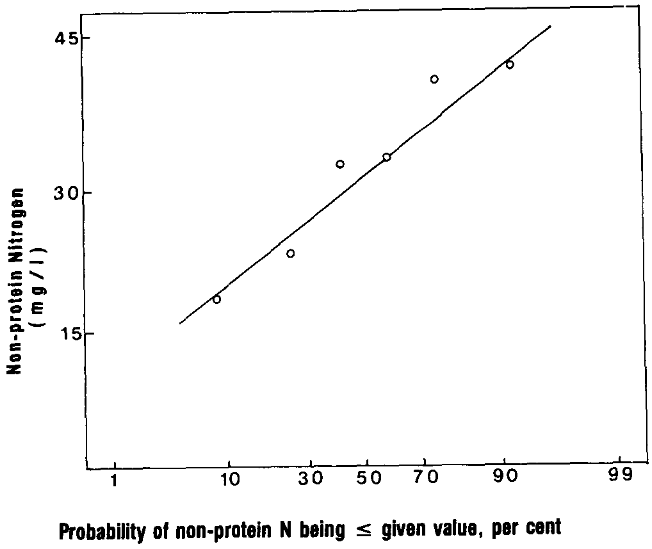

Figure 14
Distribution of non-protein nitrogen in wastewater. (o data from a single plant.)

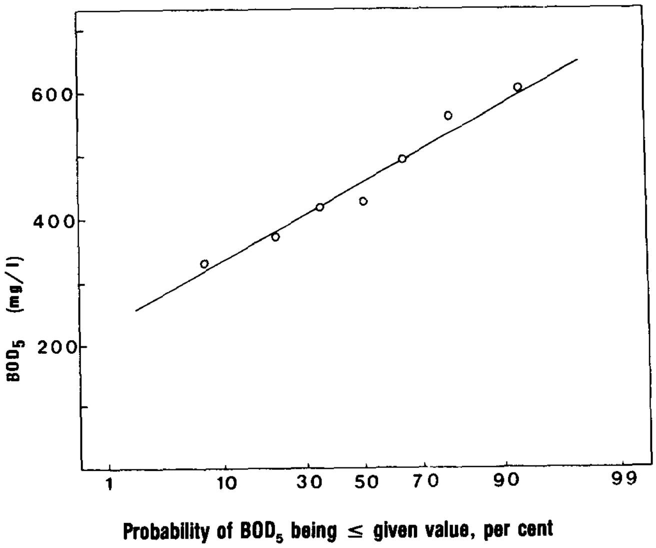

Figure 16
Distribution of BOD_5 values in wastewater. (o data from a single plant.)

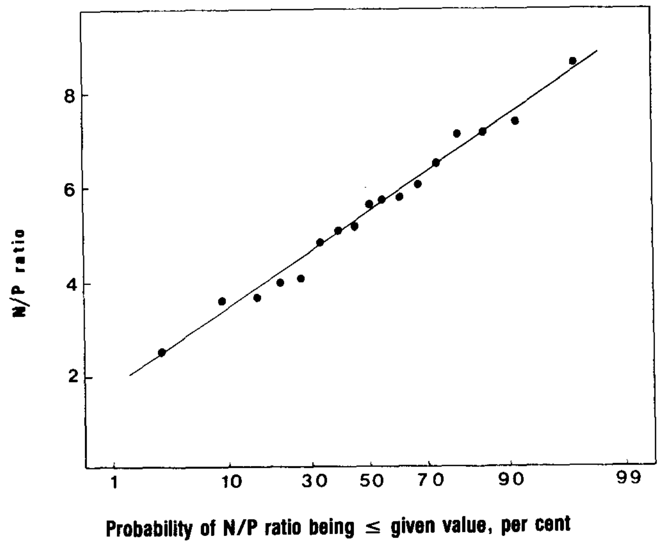

Figure 15
Distribution of N/P ratio in wastewater. (● data from all the plants.)

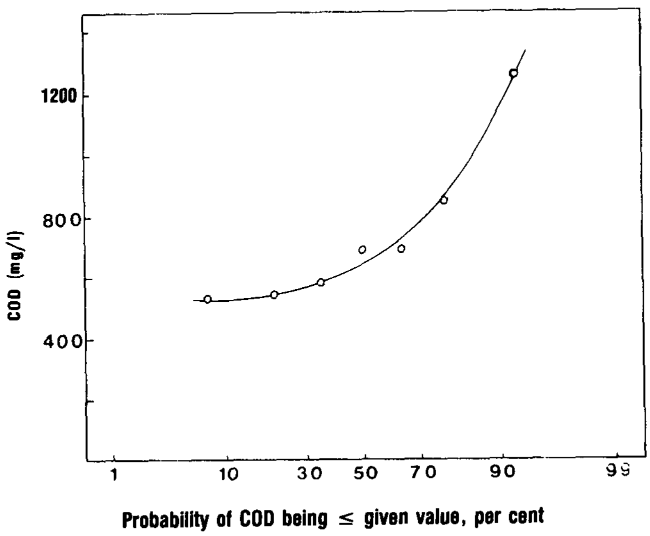

Figure 17
Distribution of COD values in wastewater (o data from a single plant.)

The procedure was as follows:

- Data were arranged in increasing magnitude and numbered from 1 to N.
- The abcissa for the first point is calculated by

$$x_1 = \frac{100}{N} \cdot \frac{1}{2}$$

and the next by

$$x_i = \frac{100}{N} + x_{i-1}$$

These points were then statistically analysed. Table 5 summarizes the average value and the coefficient of variation for all the samples and for samples from a single plant.

The curves of Kjeldahl nitrogen (on liquid sample), non-protein nitrogen, BOD_5 and COD correspond to a single plant.

When a normal distribution for all the samples was not found, single plant samples were plotted and with the exception of settleable solids and grease a straight line fitted the points. This disparity between single plant samples and multiple plant samples indicates a strong influence exerted by the operation routine in each factory on the composition of the effluent and

TABLE 5
SUMMARY OF MEAN VALUES AND COEFFICIENTS OF VARIATION OF DATA REPORTED IN THIS WORK

	Samples from several plants		Samples from a single plant	
	Mean value	Coefficient of Variation ($\sigma_x/\bar{X}$) %	Mean value	Coefficient of Variation ($\sigma_x/\bar{X}$) %
pH	7,68	5,3	8	2,1
Temperature (°C)	13,6	23,38	15,6	13,01
Total solids (mg/ℓ)	2 200	39,27	1 805	21,27
Settleable solids in 10 min (mℓ/ℓ)	3,64	69,49	3,82	75,21
Settleable solids in 2 h (mℓ/ℓ)	4,68	58,76	4,66	66,52
Grease and oil (mg/ℓ)	40,6	59,66	47,64	52,3
Total phosphorus (mg/ℓ)	17,21	68,45	12,7	22,52
NO_2^- – N (mg/ℓ)	0,087	34,48	0,088	29,55
NO_3^- – N (mg/ℓ)	10,39	74,92	14,32	58,45
NH_4^+ – N (mg/ℓ)	1,159	53,06	1,094	26,69
Total nitrogen on dried residue (mg/ℓ)	84,71	44,27	73,34	21,64
Total nitrogen on liquid sample (mg/ℓ)			72,16	26,18
Non protein – N (mg/ℓ)			31,98	30,92
BOD_5 (mg/ℓ)			528	44,72
COD (mg/ℓ)			998,6	27,52
N/P ratio	5,51	29,40	6,04	21,69

points to the need for a specific characterization study as a first step in the design of a wastewater treatment facility.

As it has been already mentioned, data of settleable matter (both in 10 min and in 2 h) do not line up. This is probably due to the variable consistency of fish flesh which depends upon how the fish was handled and upon its biological stage. The wide range and sudden changes in values of settleable solids should be taken into consideration when designing wastewater treatment plants.

The large difference in characteristics between the Patagonian hake *(Merluccius Hubbsi)* caught in winter and those caught in summer had already been pointed out, with regards to their storage life, in a previous paper by Lupín *et al* (1980). They studied seasonal changes by means of organo leptic assessments, total volatile bases (TVB) and pH.

With regard to grease it has been stated that the fat content of specimens caught in different seasons presents variability and it is caused by biological factors such as sex and sexual stage. The curve corresponding to grease in wastewater from one plant matches the curve for fat content in Patagonian hake (Pécora, 1981), both showing seasonal influence (Fig. 18).

These differences found in the raw material could explain the wide range of values obtained for the characteristics of wastewater from fish filleting plants.

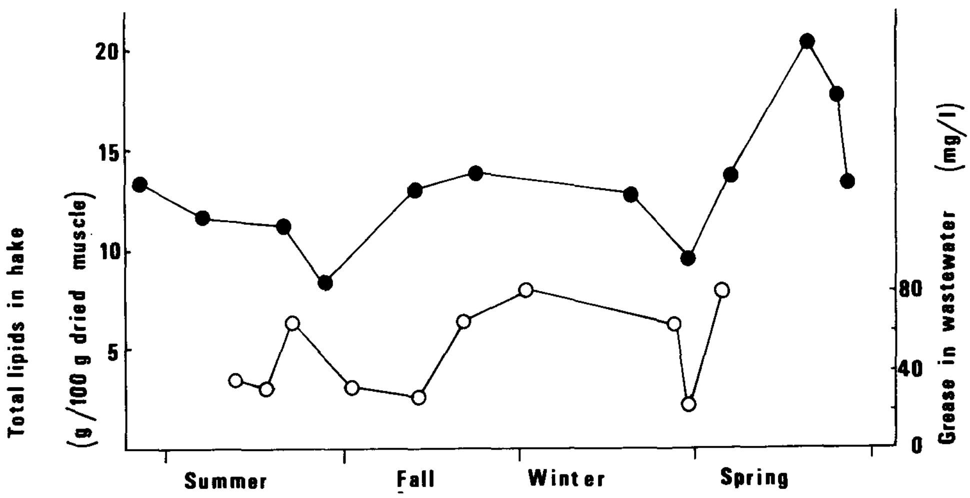

Figure 18
(●) Seasonal variation of fat content in Patagonian hake (Merluccius Hubbsi) *after Pécora (1981); (o) seasonal variation of grease content in wastewater.*

Acknowledgements

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