MAN-MADE MINERAL FIBRE SURVEY AT ELKEM-ROCKWOOL A/S, MOSS

BY

GRETE EDHOLM, BJØRN GYLSETH
AND DAVID G. NICHOLSON

HD 780/78

INSTITUTE OF OCCUPATIONAL HEALTH, BOX 8149, DEP, OSLO I

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I INTRODUCTION

The question as to whether occupational exposure to Man-made-mineral-fibres (MMMF) is harmful is of current interest; especially as these materials are being increasingly used as substitutes for asbestos. The Joint-European Medical Research Board(JEMBR) has initiated an ambitious programme with the view to establishing the consequences of such exposures. An integral part of this programme consists of working out a strategy, and analytical methods, for recording present total dust/fibre concentrations in the working atmospheres in a number of European MMMF producing plants. The organisation responsible for this aspect of the study is the Institute of Occupational Medicine (IOM), Edinburgh.

One of the countries actively participating in this programme is Norway, where there are six MMMF plants. Four of these were considered suitable subjects for the programme because they keep detailed medical records of workers.

Due to slightly differing methods of sampling and analysis it was considered of interest to compare the procedures used by the two institutes. Such a comparison was carried out during the IOM investigations at Elkem-Rockwool A/S at Moss and Larvik. The results from the YHI-survey at Moss are presented in this report.

II METHODS

The dust samples were collected on 37 mmø, 0,8 µm Millipore membrane filters using Casella personal air samplers with an adjusted flow of 2 l/min. The flow was checked with a calibrated external flowmeter before and after sampling. Before sampling the upper part of the filter monitor was removed, thus leaving the whole filter area exposed to air. Then the monitors were mounted in the workers breathing zones. The workers carried the air samplers for 6 - 8 hours of the shift, including the lunch period.

A new filter was used every day. Before and after use the filters were desiccated for 24 hours in a desiccator and weighed with an accuracy of $\pm$ 0,1 mg.

After the total dust determinations a segment from each filter was cut and placed dust-side up onto a clean standard microscope slide. The slide was exposed to acetone vapour in order to render the filter transparent, a few drops of triacetine added and a cover glass placed over the specimen. Fibre concentrations were recorded in a Zeiss binocular microscope with positive phase-contrast optics at 500x magnification. This microscope was equipped with a Ph 2 40/0,75 objective with green filter and Kohler illumination. The specimens were surveyed by scanning intermittently across the filter. Some of the samples were counted by two persons using graticule A. All samples were also counted twice by one person using different graticules. Graticule A is a 200 µm x 200 µm grid divided into 10 µm squares.

Graticule B. Circular graticule, 100 µmø, recommended by IOM (1). In this way one could establish potential personal as well as instrumental differences. The counting proceedures described as below.

Graticule A. All fibres completely within the field were counted. Two adjacent field sides were defined as "counting sides" and all fibres crossing these sides were included. No other fibres were considered.

Graticule B. As specified by IOM (1).

For each sample 40 fields or 100 fibres were counted.

Random samples from each working place were chosen for fibre size evaluations and fibre concentration determination in the scanning electron microscope.

The fibre size evaluations were performed by mounting a piece of the membrane filter on a standard scanning electron micriscope (SEM) brass stub. The filter piece was fastened to the stub with carbon cement or silver paint and thereafter covered with a thin layer of carbon or gold by evaporating to make them conductive.

The fibre concentrations were recorded in the SEM at 1500x magnification. Hundred fields were surveyed (0,108 mm^2). Fibre size evaluations were made at 1500x (length) and 15000x (diameter) magnification respectively. At least 50 fibres in each sample were evaluated.

(1) W. H. Walton and S.T. Beckett.
Ann. Occup. Hyg. 20 (1977) 19 - 23.

III RESULTS

Table 1 - 5 contains filter numbers, working places (in English/Norwegian), total dust concentrations (mg/m^3), fibre concentrations as determined by optical microscopy (fibres < 3µm and > 3µm in diameter) and finally, the total fibre concentration determined by SEM at 1500x magnification.

No statistically significant difference ($p < 0,05$) between the mean values for the two series (A and B) was observed for the two different graticules, neither for fibres < 3µm in diameter nor for the total fibre concentration.

A statistically significant difference between the two counters were observed both for fibres thinner than 3 µm and for the total fibre concentrations using graticule A. These results are shown in Table 6 and 7.

In table 8 and 9 the fibre diameter and length from the SEM size evaluation are given. Table 10 contains mean distribution, standard deviation and range respectively. These results are further illustrated in Figures 1 and 2. The relation between fibre concentration per unit area and magnification is demonstrated in Figure 3. Finally the correlation between the SEM and the OM is given in Figure 4.

ELKEM-ROCKWOOL A/S, MOSS

Table I

Filter No.	Working place/Prøvested	Total dust conc./ totalstøv mg/m^3	Optical microscopy (fibres/ml) Optiske mikroskop: Fibre conc. /fiber konsentrasjon Ø>3µm	Optical microscopy (fibres/ml) Optiske mikroskop: Fibre conc. /fiber konsentrasjon Ø<3µm	SEM: Total fibre conc./total fiber konsentrasjon (fibres /ml)
	PRE-PRODUCTION/FØR PRODUKSJON				
26	Spinnerman/Ovnsrep. - N. Gustavsen	2,8	0,05	0,02	0,89
21		6,7	0,07	0,04	
44	Binderman/Blandingsmiddel- G. Kristoffersen	1,4	0,02	-	
		1,0	0,02	0,01	0,56
	PRODUCTION/PRODUKSJON				
39	Packing man/Operatør ved	1,3	-	-	
49	sager på enden av linjen -	3,1	0,04	0,01	
24	J. Wetten	2,1	0,03	0,01	0,55
2	Foreman/Formann	3,4	0,06	0,02	0,39
12	S. Kristoffersen		0,06	0,04	
6	Gen. foreman/Formann	1,0	0,03	0,02	
28	Operator cavity wool/	2,9	0,07	0,02	0,55
5	Stationary pump/Stasjonær	1,9	0,05	0,01	
76		2,2	0,08	0,02	

Table 2

Filter No.	Working place/Prøvested	Total dust conc./ totalstøv mg/m³	Optical microscopy (fibres/ml) Optiske mikroskop: Fibre conc. /fiber konsentrasjon Ø>3µm	Optical microscopy (fibres/ml) Optiske mikroskop: Fibre conc. /fiber konsentrasjon Ø<3µm	SEM: Total fibre conc./total fiber konsentrasjon (fibres /ml)
	PRODUCTION/PRODUKSJON				
27	Line end man/Operatør ved sager på enden av linjen - S. Jøraholmen	2,1	0,08	0,04	0,88
16		2,2	0,12	0,02	
	SECONDARY PROCESS/ETTER-BEHANDLING				
33	Sewing machine, thermal isulation/symaskin, tekn. matter - T. Askerød	0,8	0,11	0,05	0,99
13		2,8	0,14	0,06	
38	Packing man/Operatør på pakkemaskin - R. Halonen	5,8	-	-	
1		6,5	0,14	0,04	
20		1,9	0,08	0,04	1,13
43	Pipe cutting/Kutting skåler- O. Fredriksen	4,6	0,08	0,04	
47		1,2	0,13	0,05	0,43

Table 3			Optical microscopy (fibres/ml) Optiske mikroskop		SEM
Filter No.	Working place/Prøvested	Total dust conc./ totalstøv mg/m^3	Fibre conc. /fiber konsen-trasjon Ø>3µm	Fibre conc. /fiber konsen-trasjon Ø<3µm	Total fibre conc./total fiber konsen-trasjon (fibres /ml)
	SECONDARY PROCESS/ ETTERBEHANDLING				
31	Sewing machine, thermal insulation/Symaskin, tekn.	1,9	0,12	0,06	0,88
22	matter- A. Bakke	1,2	0,07	0,06	
29	Sewing machine, thermal	1,2	0,08	0,04	
3	insulation/Symaskin, tekn.	1,7	0,06	0,03	1,54
25	matter - J. V. Johansen	0,8	0,07	0,02	
37	Pipe lagging m/c man, lining/Skåler, rulling	5,0	-	-	
77	- A. Grønvold	1,2	0,09	0,06	0,96
40	Pipepack/Pakking, skåler	0,8	0,07	0,03	
48	- G. Frantzen	0,9	0,09	0,02	
19		0,9	0,06	0,03	0,87

ELKEM-ROCKWOOL A/S, MOSS

Table 4			Optical microscopy (fibres/ml) Optiske mikroskop		SEM
Filter No.	Working place/prøvested	Total dust conc./ totalstøv mg/m^3	Fibre conc. /fiber konsentrasjon Ø>3µm	Fibre conc. /fiber konsentrasjon Ø<3µm	Total fibre conc./total fiber konsentrasjon (fibres /ml)
	MAINTENANCE/VEDLIKEHOLD				
46	Electrician/Elektriker	1,5	0,06	0,04	0,85
14	J. H. Olsen	1,4	0,04	0,02	
34	Maintenance/Vedlikehold	1,4	0,06	0,03	1,00
9	T. Johansen	2,6	-	-	
41	Maintenance/Vedlikehold	2,0	0,04	0,02	
7	T. Pedersen	1,9	0,09	0,06	1,35
	QUALITY CONTROL/ KVALITETSKONTROLL				
8	Quality control/ Kvalitets-kontroll - R. Ahlsen	0,8	0,04	0,02	

Table 5

Filter No.	Working place/Prøvested	Total dust conc./ totalstøv mg/m^3	Optical microscopy (fibres/ml) Optiske mikroskop: Fibre conc. /fiber konsentrasjon Ø>3µm	Optical microscopy (fibres/ml) Optiske mikroskop: Fibre conc. /fiber konsentrasjon Ø<3µm	SEM: Total fibre conc./total fiber konsentrasjon (fibres /ml)
	DISTRIBUTION/LAGER				
42	Distribution/Lager	0,9	0,04	0,03	
50	- P. Lauritzen	1,4	0,06	0,01	
11		1,5	0,07	0,02	0,89
30	Distribution/Lager	2,7	0,06	0,04	
4	- V. Larsen	1,0	0,07	0,02	0,62
17		1,6	0,07	0,03	
	POLYSTYRENE PLANT/ POLYSTYREN AVD.				
35	Isopore, polystyrene	4,0	0,03	0,02	
45	- R. Vinberg	0,8	0,01	0,01	0,18

Table 6	Mean A{□}	95% conf. limits	Mean B (o)	95% conf. limits	t-value at n = degrees of freedom
Fibres <3µmØ	0,074	0,062-0,088	0,071	0,060-0,084	t = -0,3166 n = 84
Total fibre concentration	0,105	0,089-0,126	0,105	0,088-0,124	t = -0,0752 n = 84

Table 7	COUNTER 1		COUNTER 2		t-value at n = degrees of freedom
	Mean	95% conf. limits	Mean	95% conf. limits	
Fibres <3µmØ	0,081	0,060-0,100	0,044	0,035-0,052	t = 4,1075 n = 56
Total fibre concentration	0,113	0,092-0,140	0,079	0,064-0,097	t = 2,4382 n = 56

TABLE 8

Filter No.	Work place	% WITH DIAMETER (µm) WITHIN EACH GROUP					
		≤ 0,1	0,1-0,5	0,5-1	1 - 3	3 - 5	7 - 5
2	FORMAN	-	4	8	70	14	4
3	THERMAL INSULATION/LINE LOADMAN	-	18	24	36	16	6
4	DISTRIBUTION	-	10	28	50	10	-
7	MAINTENANCE (PEDERSEN)	-	18	34	38	8	2
11	DISTRIBUTION (LAUTITZEN)	-	4	18	58	18	2
19	PIPEPACKING	-	24	20	48	8	-
20	PACKING MAN (HALONEN)	-	16	12	48	20	2
23	BINDERMAN	-	16	20	48	6	-
24	PRODUCTION/PACKING MAN(SAWS)	-	48	28	22	2	-
26	SPINNERMAN	-	28	18	44	6	4
27	PRODUCTION/LINE-END/SAWS	-	18	24	48	8	2
28	CAVITY WOOL/STATIONARY PUMP	-	14	22	48	16	-
31	SEWING MACHINE/THERMAL INSUL.	-	10	18	54	14	4
33	" " " "	-	22	16	46	14	2
34	MAINTENANCE	-	8	14	64	14	-
45	POLYSTYRENE	-	28	20	44	8	-
46	ELECTRICIAN	-	12	14	60	14	-
47	PIPE CUTTING	-	26	46	24	4	-
77	PIPE LAGGING	-	12	24	58	6	-

TABLE 9

Filter No.	Work place	% WITH LENGTH (µm) WITHIN EACH GROUP					
		≤ 5	5 - 10	10 - 20	20 - 50	50 - 100	> 100
2	FOREMAN	-	6	22	26	22	24
3	THERMAL INSULATION/LINE LOADMAN	-	20	42	24	10	4
4	DISTRIBUTION	-	16	34	28	14	6
7	MAINTENANCE (PEDERSEN)	-	18	34	38	8	2
11	DISTRIBUTION (LAURITZEN)	-	22	20	26	28	4
19	PIPEPACKING	-	14	18	56	6	6
20	PACKING MAN (HALONEN)	-	14	14	42	16	14
23	BINDERMAN	2	38	28	32	6	2
24	PRODUCTION/PACKING MAN (SAWS)	2	26	56	10	4	2
26	SPINNERMAN	-	10	14	38	22	16
27	PRODUCTION/LINE END/SAWS	4	10	16	44	22	4
28	CAVITY WOOL/STATIONARY PUMP	-	12	30	30	16	12
31	SEWING MACHINE/THERMAL INSUL.	-	6	14	38	30	12
33	" " " "	-	4	20	48	22	6
34	MAINTENANCE	2	6	20	30	30	12
45	POLYSTYRENE	-	20	40	12	12	16
46	ELECTRICIAN	2	2	20	30	30	16
47	PIPE CUTTING	2	12	30	44	10	2
77	PIPE LAGGING	4	16	20	40	4	16

TABLE 10

DIAMETER (µm)	≤ 1	0,1 - 0,5	0,5 - 1	1 - 3	3 - 5	> 5
MEAN (%)	-	17,7	21,5	47,8	10,8	1,5
STANDARD DEVIATION ±(SD) (%)	-	10,3	8,6	12,2	5,1	1,9
RANGE (%)	-	4 - 48	8 - 46	22 - 70	2 - 20	0 - 6
LENGTH (µm)	≤ 5	5 - 10	10 - 20	20 - 50	50 - 100	> 100
MEAN (%)	1,0	14,3	25,9	33,5	16,4	9,3
STANDARD DEVIATION ±(SD) (%)	1,4	8,7	11,3	11,5	9,2	6,5
RANGE (%)	0 - 4	2 - 38	14 - 56	10 - 48	4 - 30	2 - 24

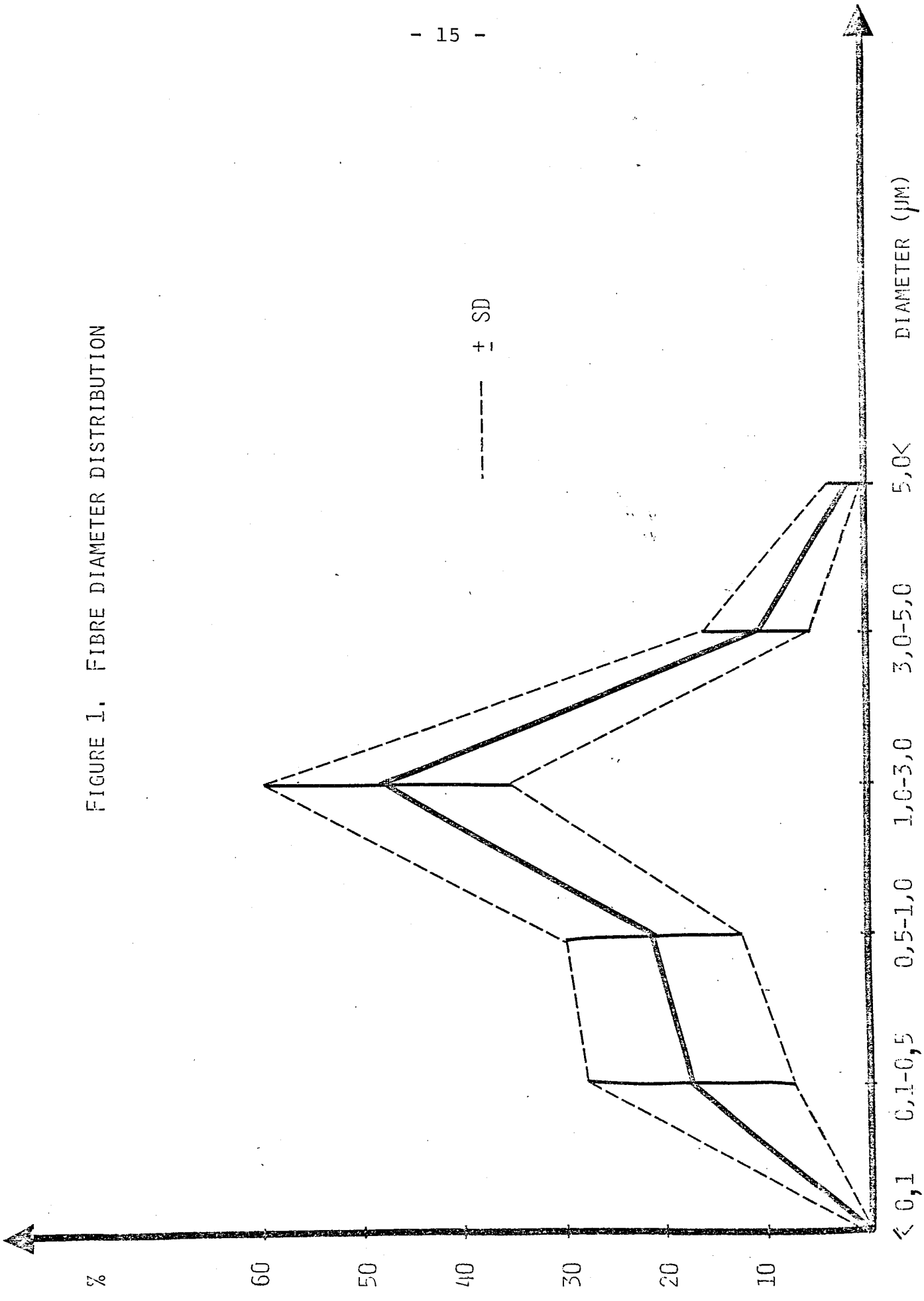


FIGURE 1. FIBRE DIAMETER DISTRIBUTION

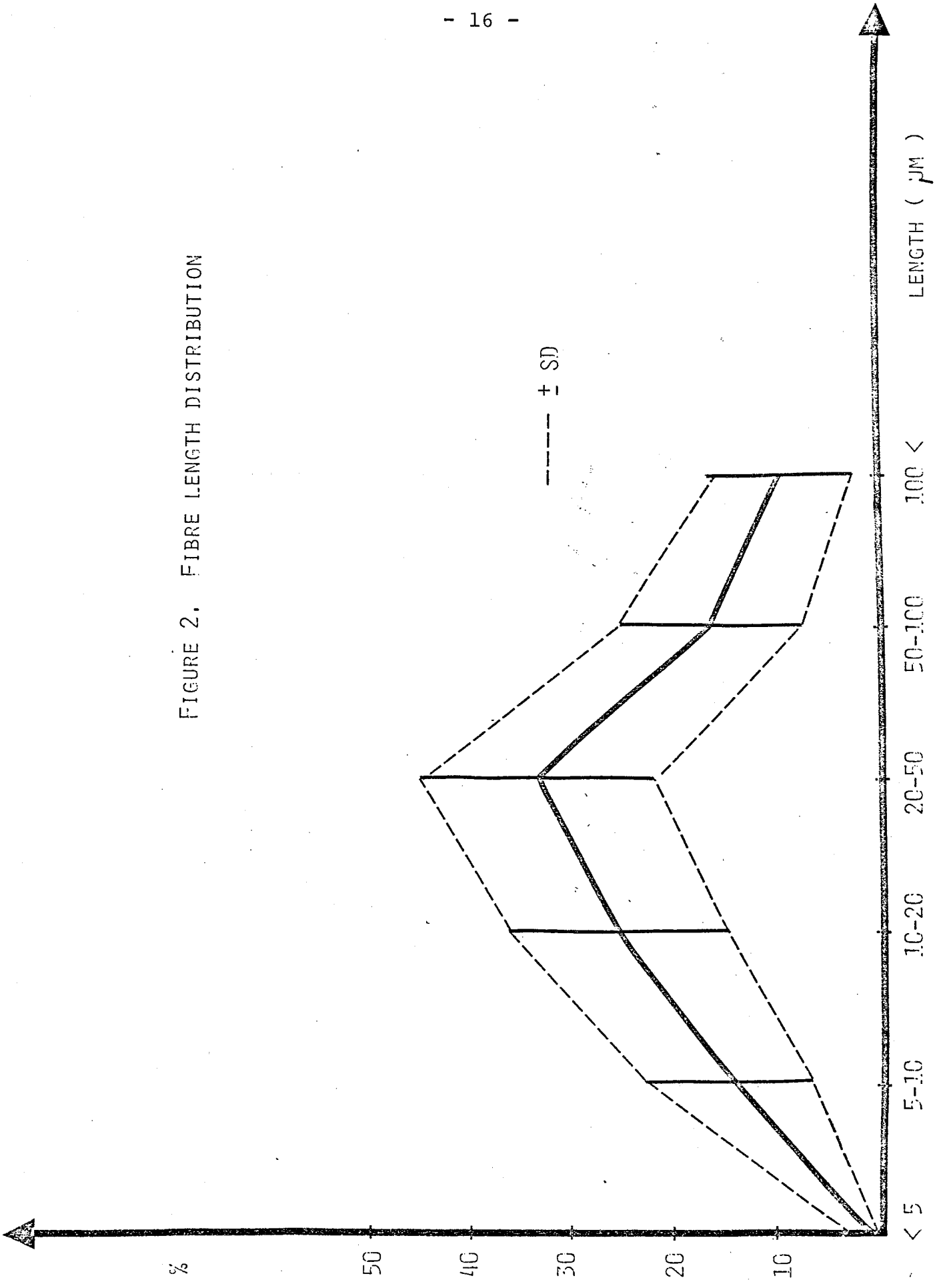
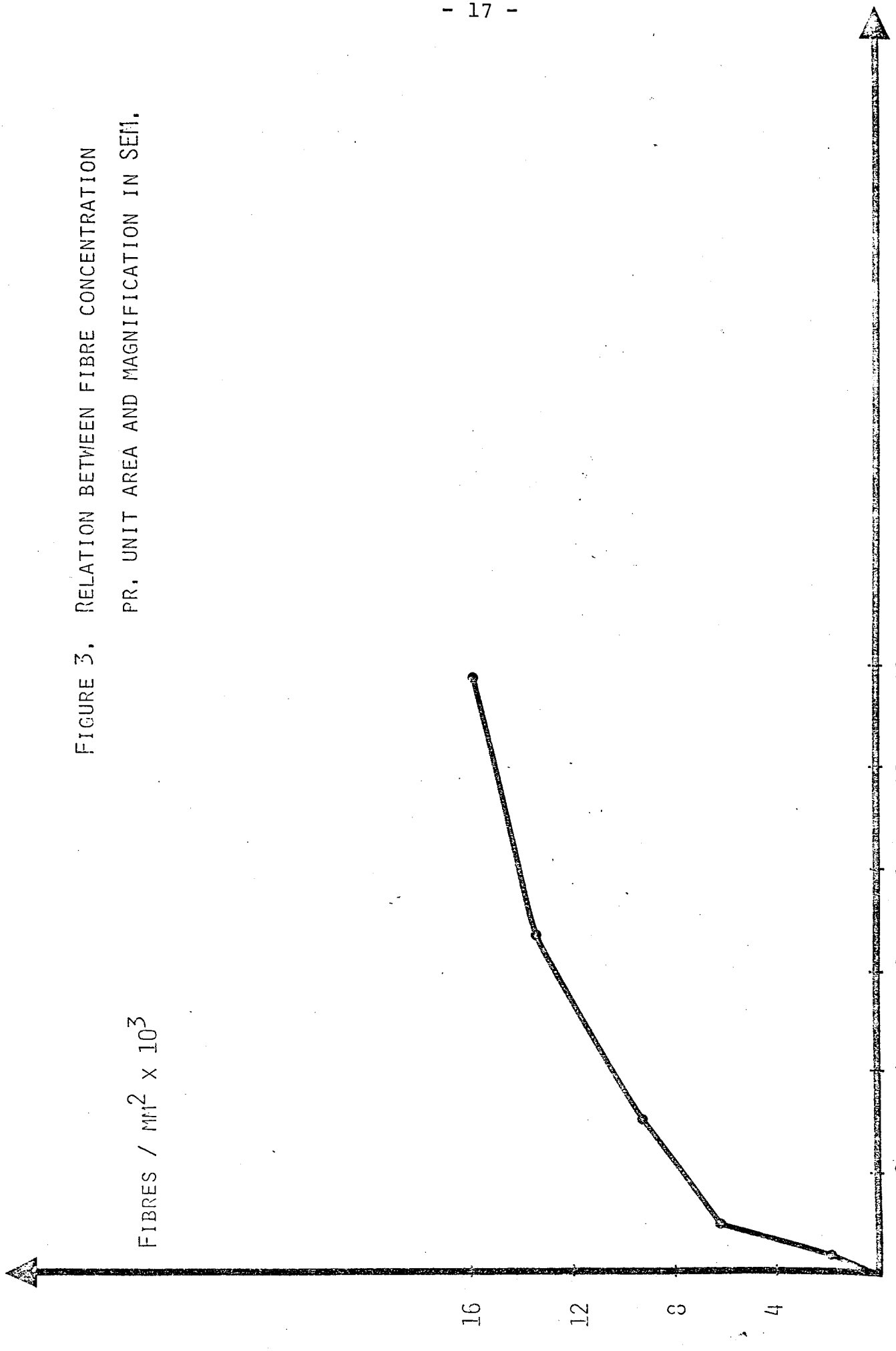


FIGURE 2. FIBRE LENGTH DISTRIBUTION

FIGURE 3. RELATION BETWEEN FIBRE CONCENTRATION PR. UNIT AREA AND MAGNIFICATION IN SEM.



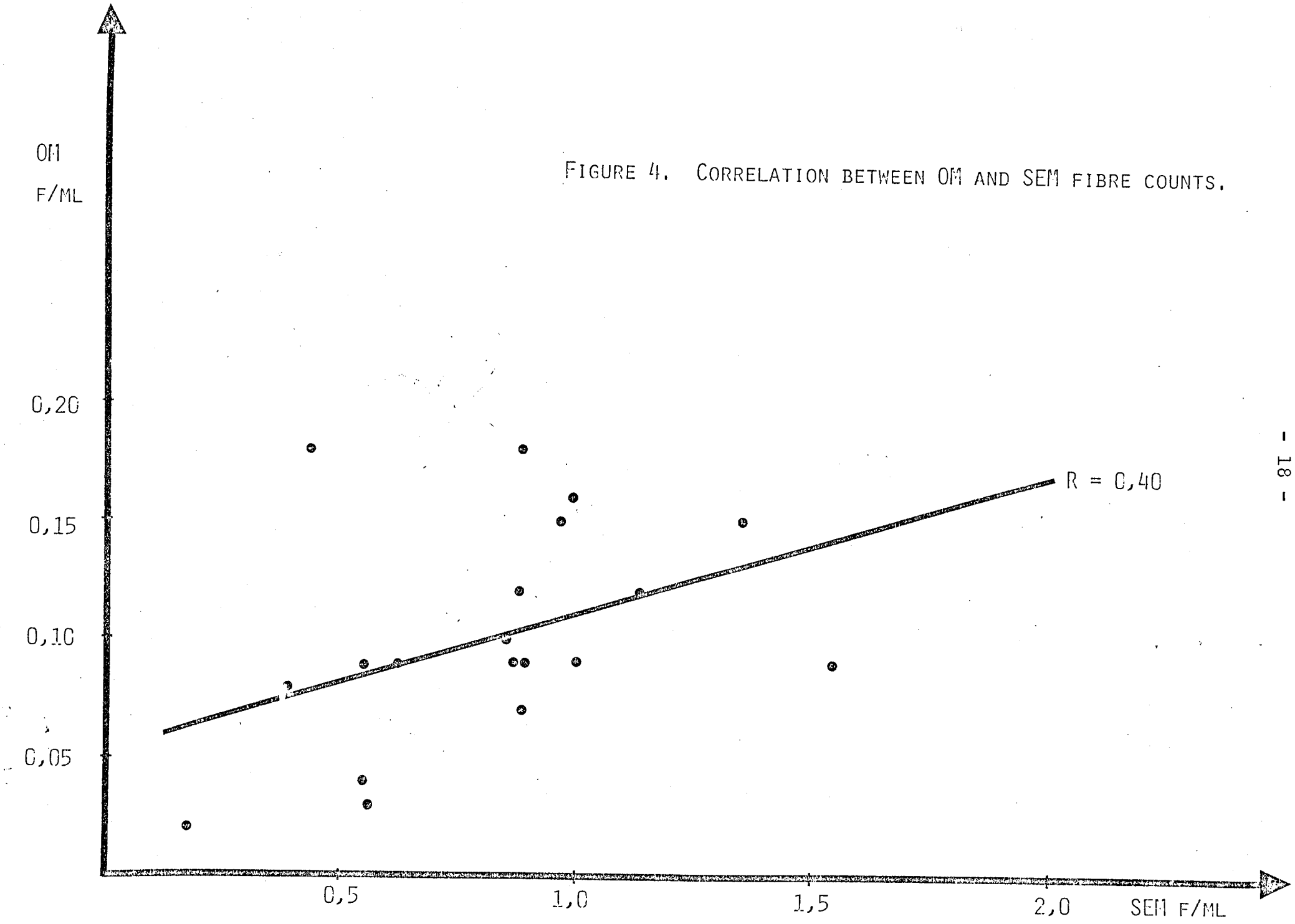


FIGURE 4. CORRELATION BETWEEN OM AND SEM FIBRE COUNTS.