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Environmental health aspects of lead

Die gesundheitlichen Aspekte der Umweltverschmutzung durch Blei

Les problèmes sanitaires posés par le plomb présent dans l'environnement

THE CONTENT OF LEAD AND SOME OTHER HEAVY ELEMENTS IN DIFFERENT FISH SPECIES FROM A FJORD IN WESTERN NORWAY

HAVRE G.N., UNDERDAL B. AND CHRISTIANSEN C.

The Veterinary College of Norway
OSLO, NORWAY

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SUMMARY

The investigation deals with uptake and accumulation of heavy elements, especially lead and cadmium, by animals living in a polluted fjord on the western coast of Norway. The source of pollution in this connection is a zinc factory at the inner end of the fjord.

The content of lead, cadmium, zinc and mercury are determined in a number of fish, caught at different localities along the fjord. The zinc content is of interest because it seems to have influence upon the uptake of other heavy elements.

The figures for lead, cadmium and zinc are discussed in correlation to each other, and in correlation to fish species.

The present investigation is not finished at the time of writing this report. During the meeting some more data will be presented, and probably with more comprehensive conclusions.

The investigated area is a fjord, Sörfjorden in Hardanger, on the western coast of Norway. It runs in north-south direction, and is about 40 km long. The fjord is rather narrow, the inner part less than 1 km wide, further out from 2.5 to 3 km, with steep mountain walls on both sides. Several small rivers run into the fjord. Some metallurgical industries are situated at the inner end, and of special interest is a zinc factory at Eitreimsneset (see Fig. 1).

In the inner part of the fjord the animal life is poor, except for eel and salmon migrating to the rivermouths.

The investigation was urgently requested by the Ministry of Agriculture which, together with the Agricultural Research Council of Norway, financed the work. Originally, we were concerned about the content of cadmium and mercury in fish, but, later on, our interest also included lead.

SAMPLING

The material was collected during the fall of 1971, and has been analyzed in 1972. Fish samples were caught on different localities along the fjord, as pointed out on the map (Fig. 1). The fish was kept in frozen condition until analyzed, and was then filleted. The liver was collected from the largest individuals. The whole filleted material from each fish was homogenized with an Ultra Turrax homogenizer, and an adequate sample was drawn for analysis of lead and cadmium.

ANALYSIS

A 20 g sample was wet ashed with sulphuric and nitric acid, neutralized to pH 2.8, and ammoniumpyrrolidinedithiocarbamate

(APDC) added. The APDC-chelates of lead and cadmium were extracted into methylisobutylketone (MIBK) and analyzed on a Perkin-Elmer 303 atomic absorption spectrophotometer.

Standards were prepared as aquous solutions of lead and cadmium chlorides, and extracted as APDC-chelates into MIBK under the same conditions as the samples. These standard curves were compared with standard curves obtained by the method of standard addition, and were found to coincide fairly well. The extraction was controlled by adding radioactive tracers as Cd-109 and Pb-210 to the fish samples.

For a ten times replicated sample the coefficient of variation was 11% for both lead and cadmium.

For the liver samples, the weighings were about 5 g, and the material was treated as the fish samples. In these extracts zinc was determined in addition to lead and cadmium.

The mercury analyses were carried out as activation analyses of small samples of the fish muscles, drawn with an auger.

RESULTS AND DISCUSSION

The analytical results are presented in Table 1. As already mentioned, the investigation was started in order to ascertain whether the fish in Sörfjorden is contaminated by cadmium, due to waste products from the zinc industry. The cadmium content in some of the fish samples certainly is higher than what is found in fish from the open sea, but the figures are not exceptionally high, as compared to previous investigations of fish from other coastal areas of Norway[1]. The lead content, however, was found to be rather high, above 1 p.p.m. in one sample (a haddock), which corresponds to 5 p.p.m. in dry matter. As for cadmium, the content of lead varies from one species to another, but the highest content is found in species living near the bottom, like haddock and flounder. This is not unexpected, as it is known that these species, especially haddock, in fact feed on bottom sediments.

Prior to this investigation Haug[2] analyzed seaweed samples from the same fjord for the elements lead, copper and zinc, but unfortunately not for cadmium. According to his results, there is a rapid drop in the lead content of the seaweed already 5 km from the end of the fjord, while the zinc content remains fairly constant to the mouth of the fjord. A similar, clear picture could, of course, not be expected for fish species, as they are not stationary like the seaweed. However, as will be seen from Table 1, the highest lead content is found in fish samples caught near the end of the fjord, and this seems to be true for flounder and haddock as well as for cod.

It was not expected that the lead content of fish muscles should be so much higher than the cadmium content, in fact about ten times, as seen from Table 1. As cadmium is known to be a zinc antimetabolite[3], the low cadmium content might be due to a high zinc content, and for that reason it was decided to analyse the material also for zinc. (The results will be available at the meeting.) However, zinc was already analyzed in 13 liver samples, and the corresponding results for the content of lead, cadmium and zinc in liver and muscles of these 13 samples are set out in Table 2.

It is seen from Table 2, that while the lead and cadmium content of liver is approximately the same, the lead content of muscles from the same samples is about ten times higher than the cadmium content. The mean ratio Pb liver/Pb muscle is about 6, and the mean ratio Cd liver/Cd muscle is about 42. The two groups of ratios are significantly different by analysis of variance, $P<0.01$. It could be said that the risk of lead contamination of fish muscles is higher than the risk of cadmium contamination when the fish takes up the same amounts of cadmium and lead in the liver.

The lead content of liver and muscles was tested for correlation, but no statistically significant correlation was found. Neither was there a correlation between the cadmium content of liver and muscles.

A highly significant correlation was found between the zinc content and the cadmium content of the liver (Fig. 2), coefficient of correlation 0.84, $P<0.01$. For the correlation between the zinc content and the lead content in liver a coefficient of correlation of 0.30 was found, and for the correlation between the lead content and the cadmium content in liver the coefficient of correlation was 0.45. These two correlations were, however, not statistically significant (Figs. 2 and 3). The figures for the lead content of liver were now divided into two groups, one group of high values, and one group of low values. The corresponding groups of figures for the cadmium content of liver and the zinc content of liver, respectively, were then tested by analysis of variance, and the two cadmium groups as well as the two zinc groups were found to be significantly different.

This indicates that there may be a correlation between the uptake of all the three elements lead, cadmium and zinc, the uptake of zinc and cadmium, however, being most strongly correlated.

It remains to be investigated in which way, if any, the content of zinc in muscles is correlated to the content of cadmium and lead in muscles, and whether this has anything to do with the great difference between the lead and cadmium content of the muscles. This work is in progress.

REFERENCES

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Table 1.

The lead, cadmium and mercury content of fish from Sörfjorden.

Type	Location	No of samples	Hg ppm/ wet weight	Variation	Cd ppm/ wet weight	Variation	Pb ppm/ wet weight	Variation
Cod	Vilurdo	3	0.35	0.18-0.60	0.012	0.010-0.015	0.17	0.17-0.17
"	Kråkevik	1	0.76	-	0.004		0.18	-
"	Bleie	3	0.47	0.39-0.57	0.006	0.004-0.009	0.09	0.06-0.14
"	Lindvik	4	0.61	0.33-1.21	0.007	0.001-018	0.04	0.03-0.05
"	Måge	1	0.69	-	0.001		0.05	
"	Eikhamrane	3	0.62	0.48-0.90	0.030	0.017-0.041	0.20	0.12-0.35
"	Rymbil	1	0.51	-	0.002		0.05	
"	Digranes	2	0.48	0.48-0.49	0.020	0.011-0.028	0.24	0.23-0.27
"	Lindenes	2	0.85	0.69-1.02	0.007	0.002-0.012	0.19	0.13-0.25
"	Byrkjenes	1	0.71	-	0.002		0.06	
Pollack	Bleie	1	0.40	-	0.004		0.07	
"	Måge	1	0.33	-	0.002		0.02	
"	Digranes	2	0.37	0.37-0.38	0.006	0.004-0.008	0.17	
Coalfish	Vilurdo	1	0.06	-	0.001		0.03	
"	Kråkevik	1	0.37	-	0.001		0.06	
"	Eikhamrane	1	0.37	-	0.002		0.05	
Haddock	"	4	0.69	0.60-0.90	0.004	0.003-0.005	0.63	0.22-1.03
"	Apold	1	0.44	-	0.006		0.33	
"	Edna	1	0.53	-	0.014		0.20	
Flounder	Vilurdo	1	1.15	-	0.005		0.19	
"	Måge	1	0.84	-	0.005		0.22	
"	Eikhamrane	1	0.42	-	0.012		0.10	
"	Rymbil	1	0.28	-	0.019		0.47	
"	Digranes	1	0.29	-	0.010		0.19	
"	Apold	1	0.39	-	0.019		0.29	
"	Lindenes	1	1.88	-	0.024		0.68	
"	Byrkjenes	7	0.79	0.23-1.60	0.012	0.005-0.017	0.14	0.02-0.22
Whiting	Edna	2	0.55	-	0.028	0.024-0.032	-	
Herring	"	1	0.54	-	0.016		-	
Ling	Vilurdo	1	0.60	-	0.003		-	
Wrasse	"	1	0.83	-	<0.002		0.05	
Angler	"	1	2.43	-	0.023		-	
Rabbit fish	Kråkevik	2	0.99	-	0.001	0.001-0.001	0.06	0.04-0.09
Lesser Fork-beard	Eikhamrane	1	0.88	-	0.010		0.31	
Lumpsucker	"	1	0.01	-	0.001		0.05	
Shark	"	1	1.90	-	0.003		0.22	

Table 2.

The lead and cadmium content of fish from Sörfjorden with corresponding values for zinc, lead and cadmium in liver.

Type	Location	Cd ppm/ wet weight muscles	Pb ppm/ wet weight muscles	Cd ppm/ wet weight liver	Pb ppm/ wet weight liver	Zn ppm/ wet weight liver
Cod	Vilurdo	0.011	-	0.248	0.166	21.50
"	"	0.015	0.17	0.443	3.282	4.17
"	"	-	-	0.109	0.416	7.13
"	"	0.010	0.17	0.172	0.380	5.42
"	Bleie	0.004	0.06	0.416	0.201	17.35
"	"	0.009	0.08	0.231	0.277	3.51
"	Eikhamrane	-	-	2.225	2.058	70.00
"	"	0.017	0.13	1.021	0.931	30.64
"	Digranes	0.028	0.23	1.299	2.013	21.51
"	"	0.011	0.25	0.330	1.205	19.53
Ling	Vilurdo	0.003	-	0.080	0.184	2.90
Angler	"	0.023	-	2.506	1.112	39.00
Shark	Eikhamrane	0.003	0.22	0.080	0.382	-
Whiting	Edna	0.032	-	0.172	0.697	15.88

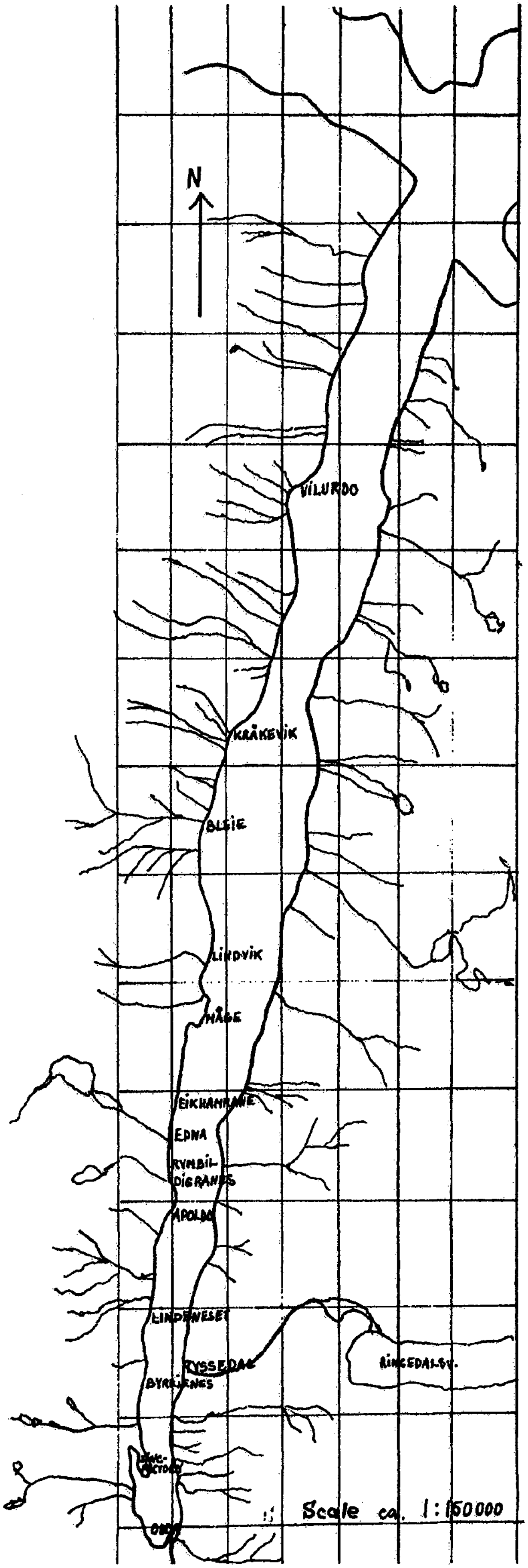
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Fig. 1.

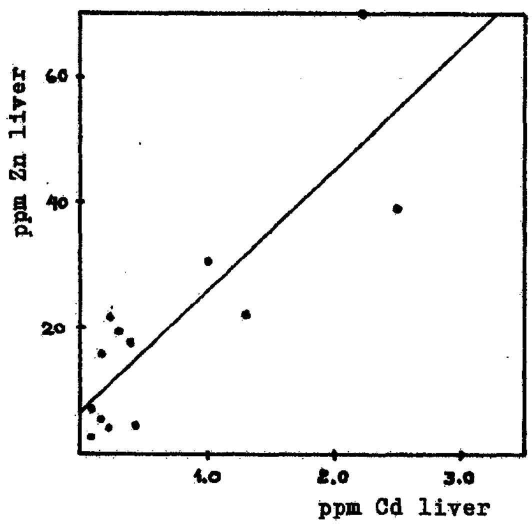

Fig. 2. Correlation Zn liver - Cd liver.

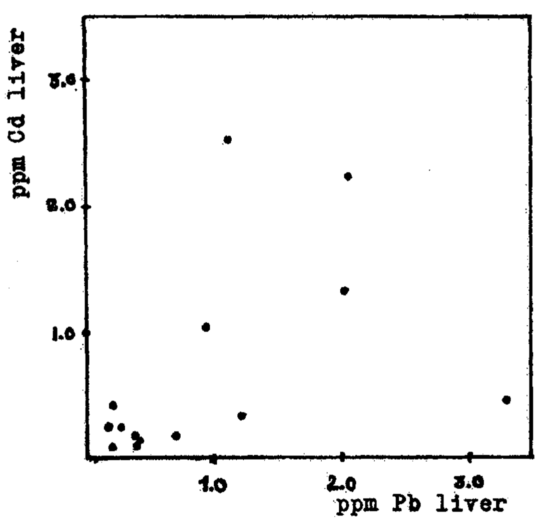

Fig. 3. Correlation Cd liver - Pb liver.

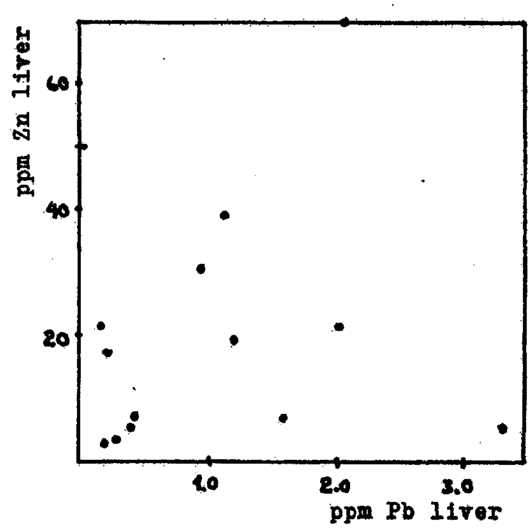

Fig. 4. Correlation Zn liver - Pb liver.