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Effect of asbestos waste products on mussels.
Author: Balsband, Egon

Translator: R. McElroy
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Translated from German by the Ralph McElroy Co., Custom Division, 2102 Rio Grande, Austin, Texas 78705 USA

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THE EFFECT OF ASBESTOS WASTE PRODUCTS ON MUSSELS

The material used for this investigation was made available by the Asbestos Corporation GmbH in Nordenham; it is a secondary rock (fine fraction) of the particle size 0.0-0.5 mm and is to be discharged in the North Sea at the level of the Small Knechtsande and the Eversandloch. The intended discharge area can be seen in Figure 1. Large banks of mussels are located in the vicinity of this area. Since the effect of asbestos waste products on mussels is not known, the tests described below were carried out.

Mussels take up nutrients by filtering water. Studies at the Institute for Marine Research in Bremerhaven have shown that non-nutritive substances which are present in the water do have a great influence on the growth of mussels. This "harmful" effect of the extraneous substances leads to weight losses and, in extreme cases, even to death. In the tests which we conducted, the particular effect on the gastrointestinal tract of mussels by the asbestos fibers contained in the secondary rock was investigated by histological examination. Concentrations were selected which would not exert any substantial influence on the mussels merely as turbidities, because the waste products contain not only suspended particles but also particles which sink immediately (ratio of suspended to sedimentary particles is ca. 48:52).

Conducting the Tests

Into each glass container were placed ten mussels ca. 3 cm long and 3 liters of sea water. Under the bottom of each glass tank was a magnetic agitator so that the suspended matter in each concentration was always in motion and could not settle out. The mussels were on a net above the bottom (mesh width 1 cm). The vessels were always ventilated. The mussels were fed daily with 70 ml of a concentrated algae solution (*Dunaliella* and *Protococcus*), divided into five portions. The water was changed daily.

Tests were conducted with the following concentrations, in which the mussels were left for five days at a time: 100 mg/ltr and 10 mg/ltr. In addition, mussels were also studied which had been kept for seven days in "pure sea water" (North Sea water), under the feeding conditions given above, after a previous stay of five days in each of the above concentrations.

The mussels taken from the test medium were fixed in Bouin's fluid (2-5 days) and then the shells were carefully removed. After being transferred to absolute alcohol (increasing alcohol series), methylbenzoate, benzene, benzene paraffin, and impregnated with paraffin, the mussels were embedded. The well-cooled paraffin blocks were then cut to a thickness of 5-7 µm and the sections were were mounted on slides with albumin glycerin, dried, stained with hemalum (according to Mayer) and eosin, and encased in Caedax.

Experimental Findings

Mussels which were exposed to one of the above concentrations for five days as well as mussels which were kept in "pure sea water" for another seven days after staying in these concentrations showed clearly that asbestos fibers had penetrated into the epithelial tissue of the gastrointestinal tract, by virtue of the sharp-edged structure of the fibers. Figure 2 shows the intestinal contents of a mussel which was exposed to a concentration of 100 mg of asbestos secondary rock per liter for five days. In addition to the high asbestos particle content in the intestinal contents, it is also apparent that ciliated epithelium has been damaged by the asbestos particles, and some particles have penetrated the tissue. Enlargement: 320 times. Figure 3 shows a sharp-edged, weakly stained asbestos particle (size: 6.4 µm × 1.6 µm) which has penetrated the epithelial tissue. (Concentration: 100 mg/ltr asbestos secondary rock for five days, enlargement: 320 times.)

One heavily stained piece of asbestos is seen in Figure 4 to have migrated almost through the intestinal wall. This mussel had been kept for seven days in "pure sea water" after a five-day stay

in the 100 mg/ltr concentration of asbestos. Size of the asbestos particle: 11.6 µm × 4.6 µm; magnification: 320 times. In another mussel which was exposed to the same conditions as those described above for Figure 4, an asbestos particle can be seen to have migrated deep into the tissue of the gastric wall (Figure 5). Size of the asbestos in this case is 6.9 µm × 6.1 µm; magnification: 800 times.

As mentioned at the beginning, the waste product contains not only particles which are suspended in the water, but also particles which sink immediately. As shown by Figure 2, the gastric contents include numerous foreign bodies because of the concentration of 100 mg asbestos per liter. These same experiments were conducted with concentrations which were one-tenth as large in order to be able to determine if the mucous membranes were being damaged merely by the constant filling of the stomach and intestines with these sometimes sharp-edged asbestos particles and by the peristalsis.

Figures 6 and 7 show that asbestos particles have penetrated the gastric mucosa. The size of the particle in Figure 6 is 4.9 µm × 4.6 µm. In Figure 7, the size of the particle is 3.7 µm × 1.8 µm. A regular "halo" has formed around these intruding bodies. Enlargement in both figures is 800 times. Concentration. 10 mg asbestos per liter.

Again with this concentration, asbestos particles could still be detected if the mussels had been kept for an additional seven days in "pure sea water" after a five-day stay in 10 mg asbestos per liter, as shown in Figures 8, 9, and 10. The sharp-edged asbestos particles and needles have penetrated far into the gastric wall (Figure 8). The needle was stained only faintly -- for which reason this photograph was taken again with phase contrast. The needle is 14.5 µm long and 0.6 µm wide. Another piece of asbestos (6.4 µm 3.1 µm) is also visible beside this needle. Enlargement: 800 times. The asbestos particles are clearly visible again in Figures 9 and 10 (from the gastric wall). The asbestos needle in Figure 9 is 10.7 µm long and 0.9 µm wide. Figure 10 is particularly interesting, since it shows a particle of asbestos embedded in a mucous

mass in the tissue. The length of this body is 5.8 µm and the thickness 3.8 µm. Magnification is 800 times in both figures and the phase contrast method is used, as in Figure 8.

Summary

It has been found that the asbestos fibers or sharp-edged asbestos particles contained in the waste material will penetrate into the epithelial tissue of the gastrointestinal tract of mussels. These asbestos intrusions then migrate through the stomach and the intestines, injuring the tissue. These foreign bodies are not eliminated even after the mussels have been left for several days in "pure sea water". To what extent growth is affected by this damage to the gastrointestinal tract, which is to be expected, was not investigated in the laboratory. However, this assumption would follow merely from the fact that unmistakable tissue damage can be detected after such a short exposure to asbestos. The figures shown here represent only a fraction of the asbestos-induced tissue damage which was actually found in the histological preparations. Plans have been made, however, to expose mussels to the asbestos concentrations described above and then place them in the Baltic Sea, where their growth can be observed under natural conditions and compared with non-exposed controls. After these experiments are completed, a report will appear in this publication covering the findings.

This study from the Federal Research Institute for Fishing, Coastal and Inland Fishery, Hamburg, was conducted as part of a research project of the German Research Society.

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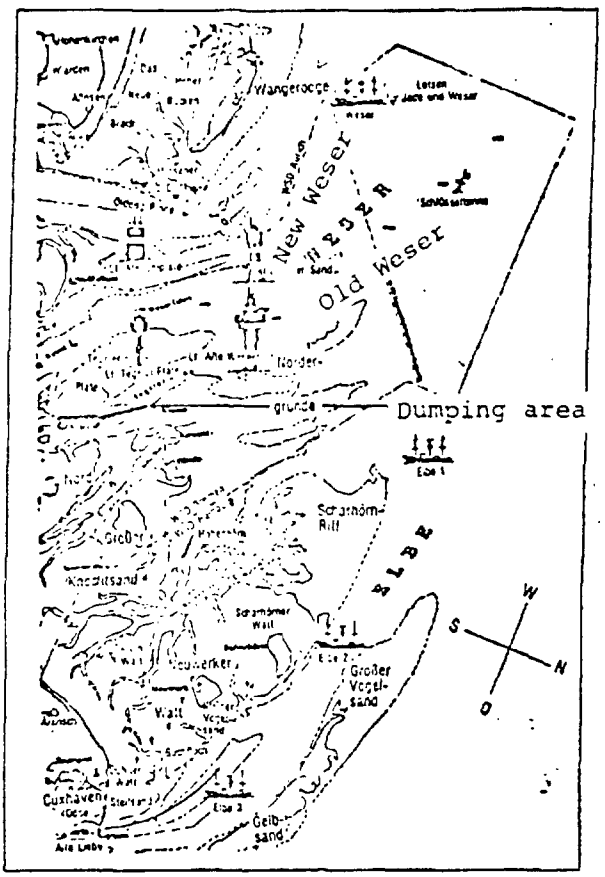


Figure 1. Dumping area for for the accompanying rock.

Figure 2. Intestinal contents of a mussel after 5 days in a concentration of 100 mg/ltr of asbestos accompanying rock.

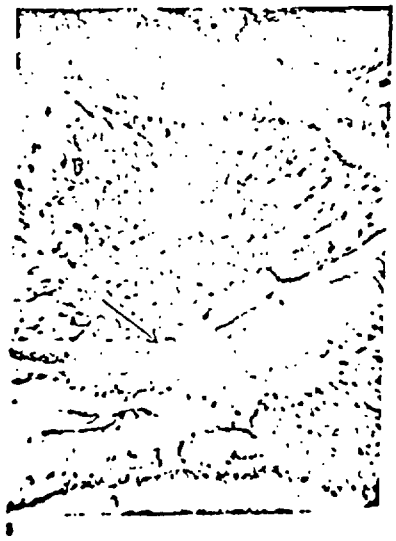


Figure 3. Asbestos particle penetrated into the epithelial tissue (arrow).

Figure 4. Asbestos particle which has almost migrated through the intestinal wall.

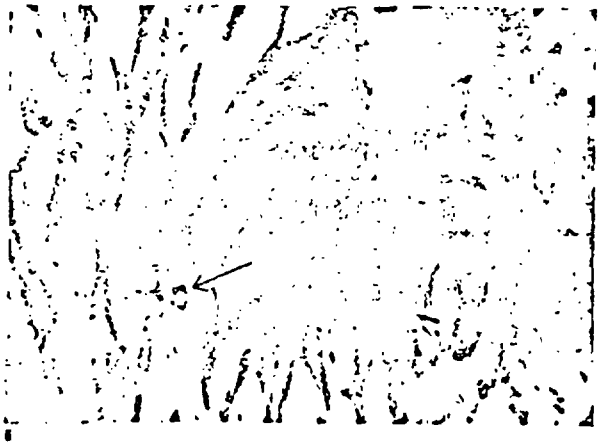
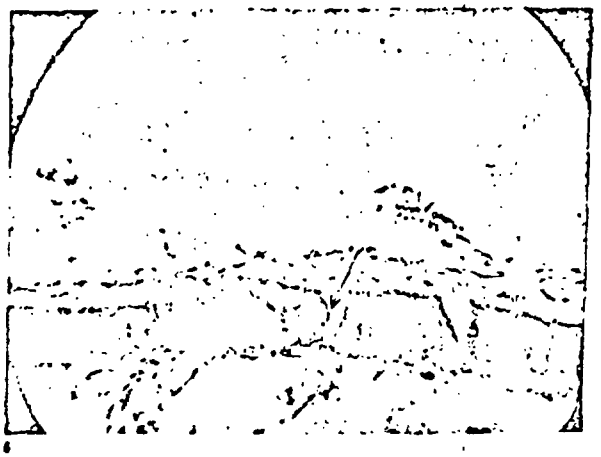


Figure 5. Asbestos particle penetrated far into the tissue of the stomach wall.



Figures 6 and 7. Asbestos particles have penetrated into the mucous membrane of the stomach.

Figure 6

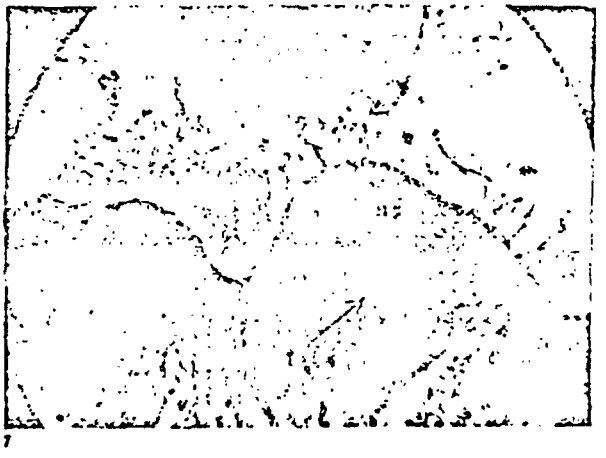


Figure 7

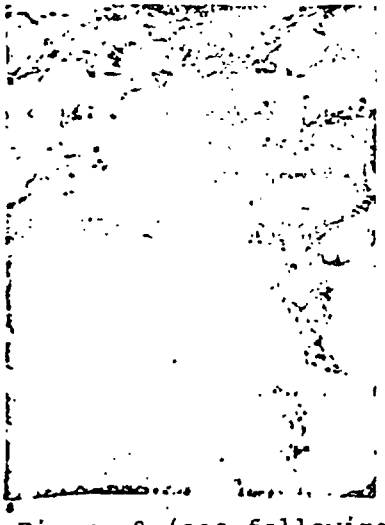


Figure 8 (see following page)

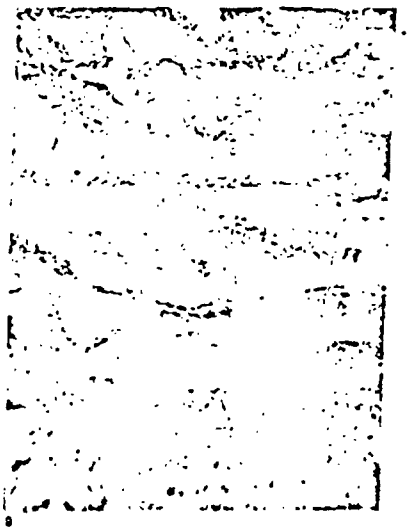


Figure 9

Figures 8, 9, and 10. Asbestos particles can still be detected even after seven days in pure sea water.

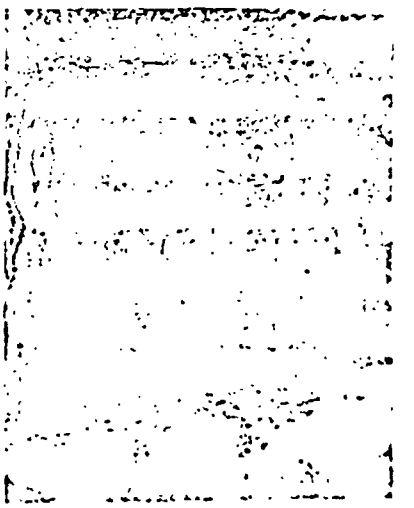


Figure 10.

(Photographs: Federal Research Institute for Fishing, Hamburg)