Ocean incineration in a nutshell

Incineration of chemical wastes at sea started in 1969. Since then, the technique has been developed into a highly sophisticated, efficient and safe method for the destruction of liquid wastes, under full control by the authorities and with a capacity which is sufficiently high to meet the needs of a modern industrial society.

It must be stressed that incineration at sea does not cause any harm to the marine environment and is relatively cheap.

In 1985 we issued a rather detailed review of the method in our booklet "15 years of waste incineration at sea". However, for those people who want to make themselves acquainted with the main facts without the need to read 30 pages of text, we made this brochure which in essence exists of copies of the six posters we use at scientific meetings and exhibitions.

We believe that they speak for themselves.

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Waste incineration at sea

Beginning and present scope

THE VINYL CHLORIDE MONOMER PRODUCTION IN WESTERN EUROPE*

Production up to 1970	16 — 20. 10^6 tons
Waste ('EDC tar')	0.7 — 1. 10^6 tons
Production 1971 – 1985	ca. 65. 10^6 tons
Waste ('EDC tar')	1.5 — 2. 10^6 tons

The total production of other organochlorine products and the resultant waste are probably the same order of magnitude again.

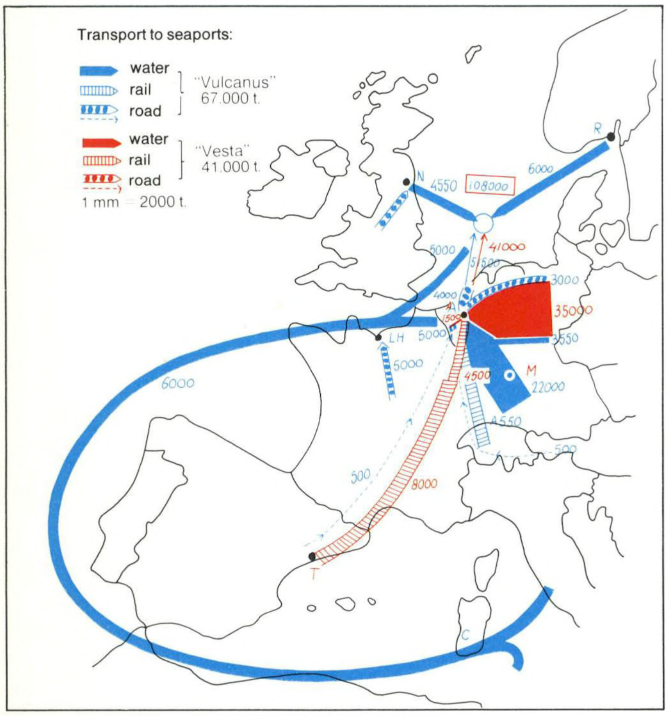
Up into the Seventies an unknown amount of EDC tar was dumped in the North Sea.

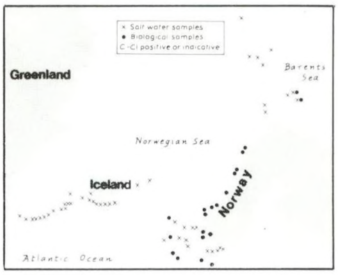
Incineration on the North Sea has only been:

1969-1970: ca.	10,000	tons EDC tar
1971-1985:	600,000-800,000	" " "
1969-1985:	500,000-700,000	" other organochlorine waste

Per annum: a total of some 100.000 tons

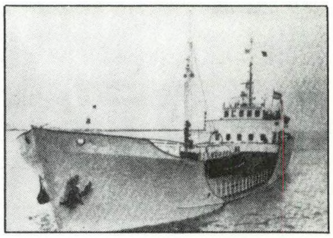
* Estimations based on various sources.





Places where EDC tar residue has been found in biological and salt water samples, which were taken between 18.6.1970 and 28.9.1970 by the Norwegian research vessel "Johan Hjort".

STELLA MARIS WEER TERUG*



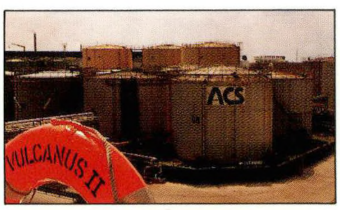
In the summer of 1971 an international conflict arose over the planned dumping of 500 tons EDC tar in the North Sea. The "Stella Maris" was compelled to sail back to Rotterdam without carrying out her mission.

The "Stella Maris" conflict hastened the materialization of the "Oslo Convention" and the "London Dumping Convention", which since 1981 have laid down the guidelines for the combustion of chemical waste at sea.

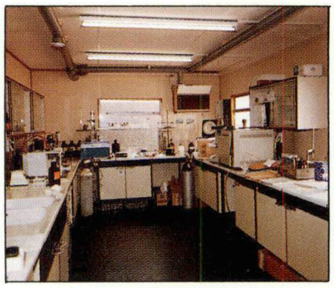
Organochlorine waste transport to the incineration area in the North Sea 1986

Total amount	108,000 t.
via Antwerp	92,500 t.
of which:	
by river	54,500 t.
by rail	15,500 t.
by road	22,500 t.
by sea	6,000 t.

From	
FRG	63,000 t. (58%)
France	5,000 t. (4.5%)
U.K.	4,500 t. (4%)



Waste tanks in Antwerp



The laboratory in Antwerp.

In the OCS laboratory in Antwerp routine analyses of waste are carried out. More difficult analyses, as for example the determination of dioxin, are for the time being passed on to a specialized institute.

* Stella Maris back again

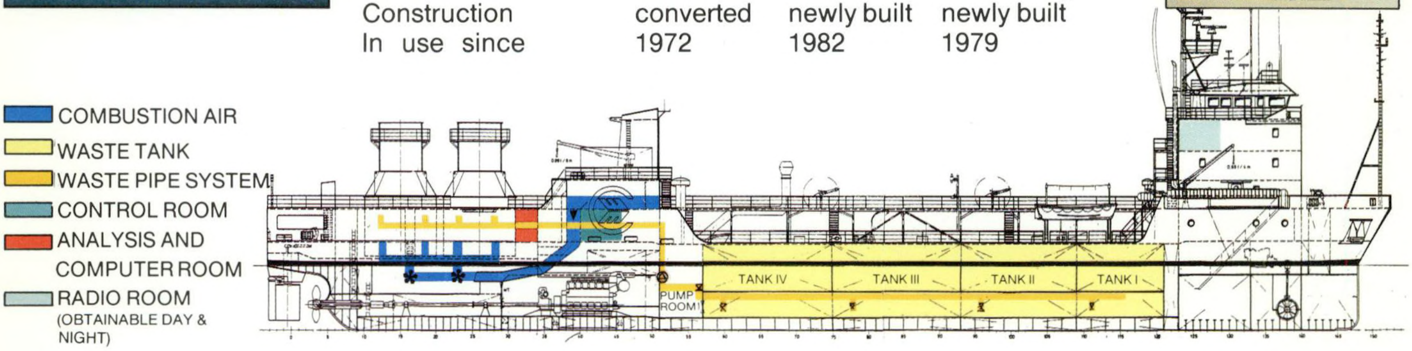
Waste incineration at sea

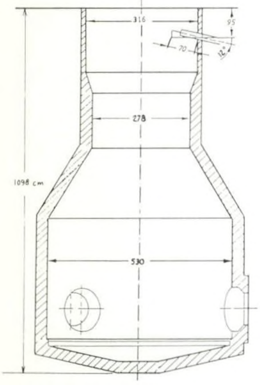
The ships

At the present time there are three ships, which are certified and operational. The "Vesta" and the "Vulcanus II" work on the North Sea. At the moment the "Vulcanus I" is not in use. Only liquid waste can be burnt on the ships. The chlorine content must not exceed some 70 weight%.

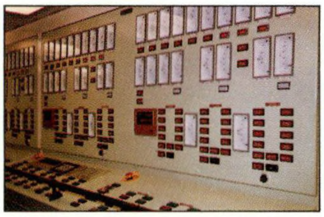
	Vulcanus I	Vulcanus II	Vesta
Length	97 m	93.5 m	72 m
Width	16 m	16.0 m	11 m
Draught (max.)	6.06 m	6.12 m	4.3 m
Unladen capacity (t)	3990	4430	999
Tank capacity (m^3)	3200	3200	1300
Incinerators	2	3	1
Burners	3 for each incinerator (rotating cups; Saacke KG)		
Air flow rate	90.000 m^3/hour for each incinerator		
Capacity (max.)	25 t/h	35 t/h	12.5 t/h
Owners	WMI/OCS	WMI/OCS	Lehnkering
Construction	converted	newly built	newly built
In use since	1972	1982	1979

Bridge





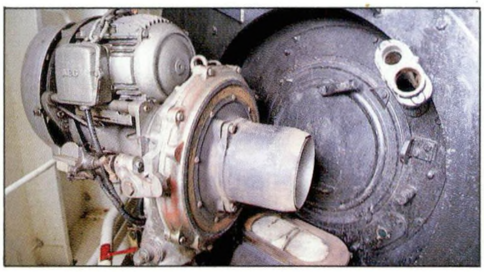
Inside and outside configuration of one of the three identical incinerators & position of the waste gas sampling probe and burner on the "VULCANUS II".



Control panel for incinerator system

Pump room. There are no loading & unloading pumps on board!

The tunnel for the waste pipes from the tanks to the incinerators



Burners in open position

Mess

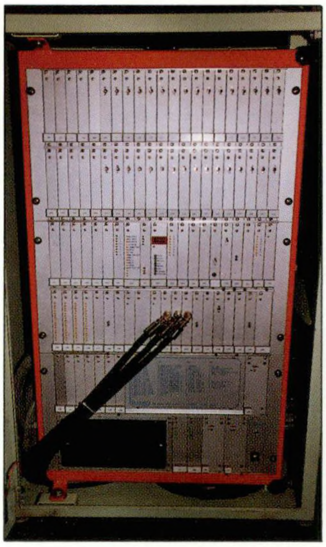
Waste incineration at sea

Monitoring and measurement of the combustion efficiency (CE)

It has been laid down internationally, that during the incineration process there should be continuous measurement of the CO, CO_2 and O_2 in the waste gases.
The combustion efficiency is defined as follows:

$$CE = \frac{[CO_2] - [CO]}{[CO_2]} \times 100\%,$$

and shall not be lower than 99.9%. During the measurement on board the CE is continuously calculated and registered in the data acquisition system.
The following data amongst others are automatically monitored, registered and recorded during an incineration voyage by the data logger, which has been sealed by the authorities:
date; time; CO, CO_2, O_2 CE and four temperatures for each incinerator; functioning of the burner pumps, the status "oil" or "waste"; the position of the ship.

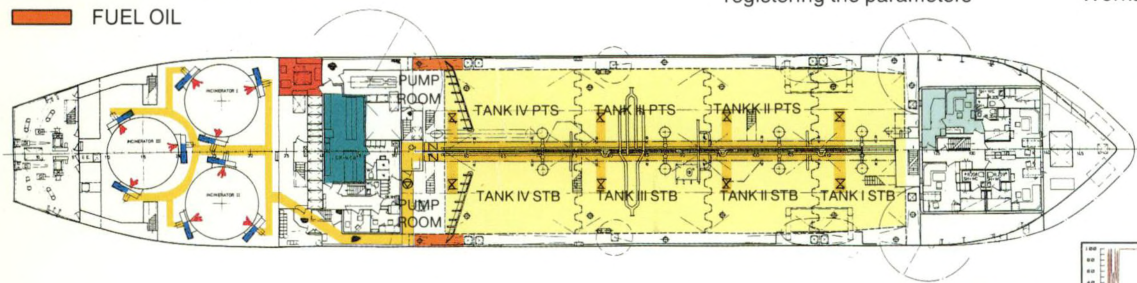


Central computer for monitoring the incinerator system and registering the parameters

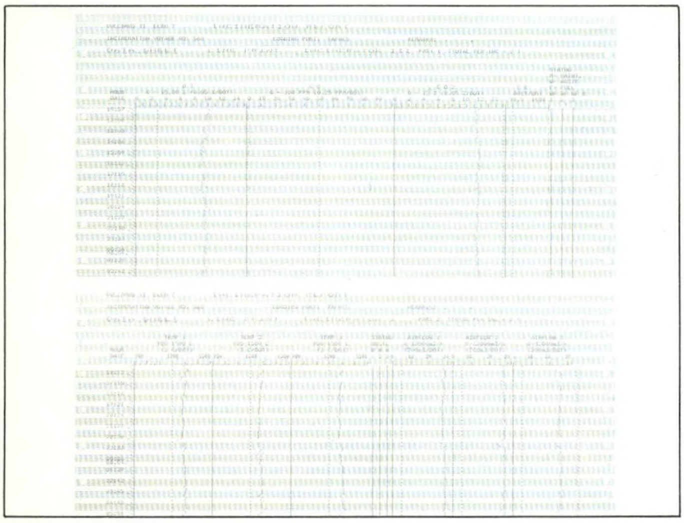
Satellite navigator

The sealed data logger of "Rijkswaterstaat" (Ministry of Public Works), The Netherlands

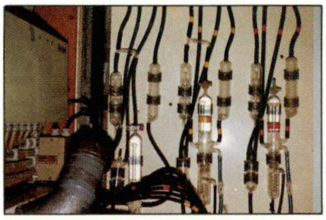
INCINERATOR AIR
WASTE TANK
WASTE PIPE SYSTEM
FUEL OIL



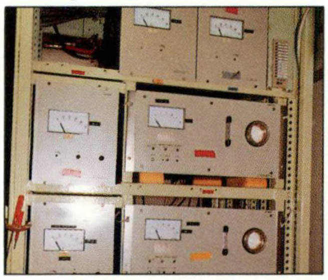
CONTROL ROOM
ANALYSIS AND COMPUTER ROOM
RADIO ROOM
(DAY & NIGHT OBTAINABLE)



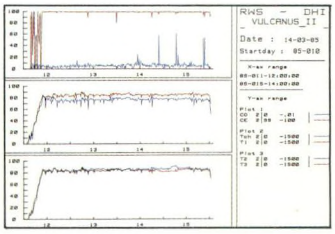
Extract from an on board incineration report



Waste gas washers



Waste gas analysis instruments (CO: 0-100 ppm; CO_2 und O_2. 0-15%)



Control print-out from the monitoring authority (Rijkswaterstaat, The Netherlands)

The incineration is automatically stopped if the wall temperature drops under 1180°. When the CE drops below 99.9%, an alarm goes off. Alarm is also sounded if a small amount of waste should flow onto the floor of the pump room, and if the waste tanks are 85% resp. 98% filled.

Waste incineration at sea

Determination of the destruction efficiency (DE)

dr. J. W. J. Gielen and H. Compaan
MT - TNO, Delft, The Netherlands

No clear connection exists between incineration and destruction. Up to the present there is no instrument for the continuous measurement of DE during the incineration of organochlorine waste. The DE is therefore determined for each type of waste during special test incineration voyages.
(up to now a DE of at least 99.9% has been laid down)

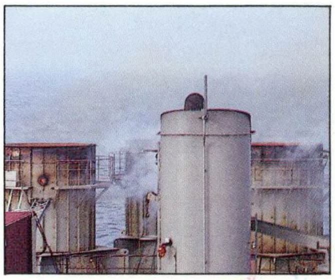
For the determination of DE it is necessary to have:

- an exact GC-MS waste analysis
- the measurement of the waste flow rate
- the measurement of the incineration air flow rate
- the measurement of the incineration temperature
- an exact GC-MS determination of organochlorine traces in a series of waste gas samples

In January 1983 during a normal waste incineration a comparison was made between a USEPA and a TNO sampling instrument. The measured destruction efficiencies were almost identical.

	USEPA	TNO
1,1,2-trichlorethane	>99,9995%	>99,9996%
tetrachlorethylene	>99,9934%	>99,9999%
1,1,1,2-tetrachlorethane	>99,9990%	>99,9998%
1,1,2,2-tetrachlorethane	>99,9983%	>99,9982%

Measured DE of four EDC tar components; January 1983



The incinerator with sampling hole in the starboard incinerator and sampling rail from the red container (Vulcanus II)

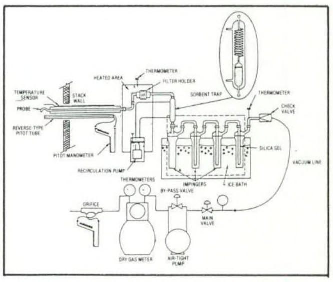
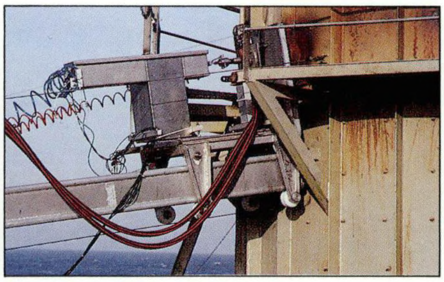
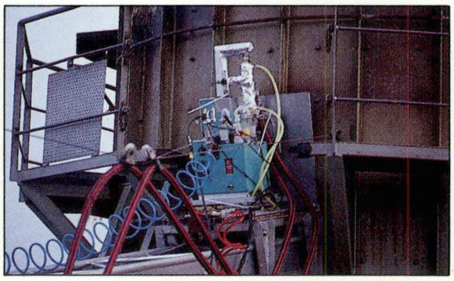


Diagram of the USEPA "Modified Method 5" sampling instrument.

The TNO sampling instrument on the way to the incinerator



The TNO sampling instrument in position.



The USEPA sampling instrument in position.

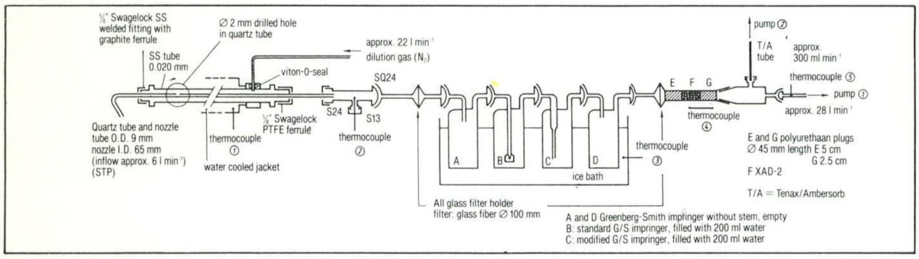
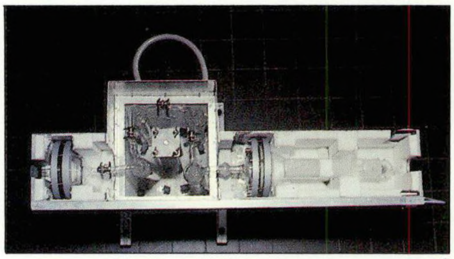


Diagram of the TNO waste gas sampling instrument.



The TNO sampling instrument in open position.

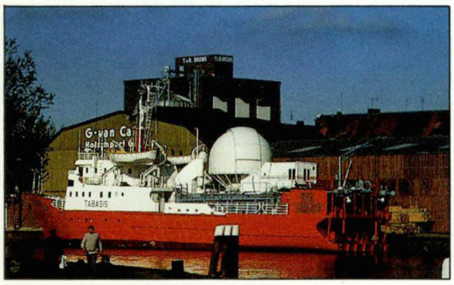
Note: Test incinerations took place in 1971, 1974 (6x), 1975, 1976, 1977 (4x), 1978 (2x), 1979 (2x), 1981, 1981/82, 1982, 1983 and two more are planned.

Waste incineration at sea

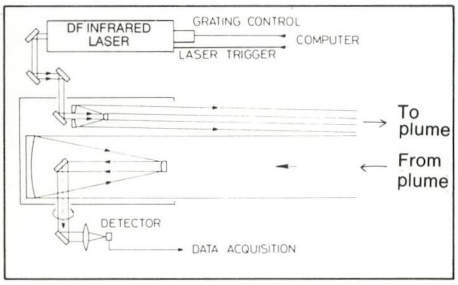
Lidar measurements of the waste gas plume

Research under the direction of Dr. C. Weitkamp, GKSS, Geesthacht, FRG

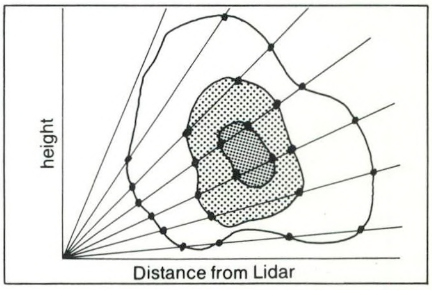
The waste gas plume can take very different forms



The research ship "Tabasis" with the LIDAR dome.



The operating principle of the Differential. Absorption & Scattering LIDAR (DAS LIDAR)

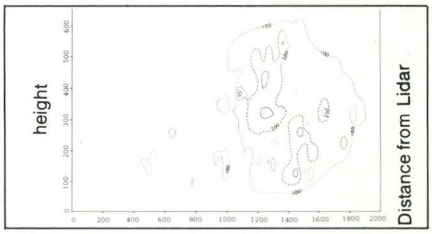


The construction of the cross-section of a plume

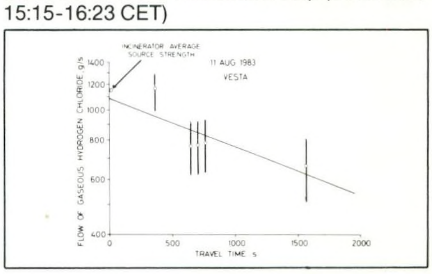
The only quantitatively important and not entirely harmless substance in the waste gas plume is hydrochloric acid. The dilution and breakdown of the hydrochloric acid in the plume has been examined over a number of years by means of DAS infrared LIDAR.

SOME CONCLUSIONS:

1. 97.7% of the hydrochloric acid in the plume is gasiform HCl.
2. The maximum HCl concentrations are 0.5-5 ppm at distances of 1-10 km, with incineration of 10 tons per hour of waste with 40% chlorine.
3. Dilution and breakdown of the hydrochloric acid can be measured separately.
4. The life time (1/e) of the hydrochloric acid in the plume is:
   39 minutes, calculated from LIDAR measurements;
   31 minutes, calculated from in situ measurements.
5. Of the hydrochloric acid which crosses the West European North Sea coast only about 1 thousand millionth part comes from incineration at sea.
6. **Harmful effects of hydrochloric acid from the incineration at sea on life in and on the sea, on the beaches or on land can be ruled out.**



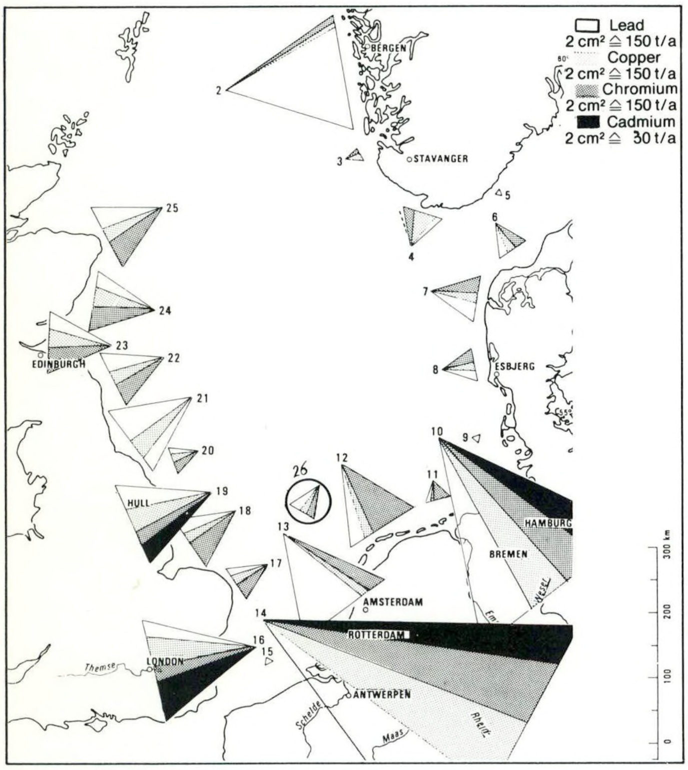
Isometric representation of the hydrochloric acid concentration in a cross-section of a plume (parts per thousand million) at 5700 m. distance from the incinerator ship (24.6.1982; 15:15-16:23 CET)



The breakdown of the hydrochloric acid in the waste gas plume

Waste incineration at sea

Pollutants and influence on the North Sea ecosystem

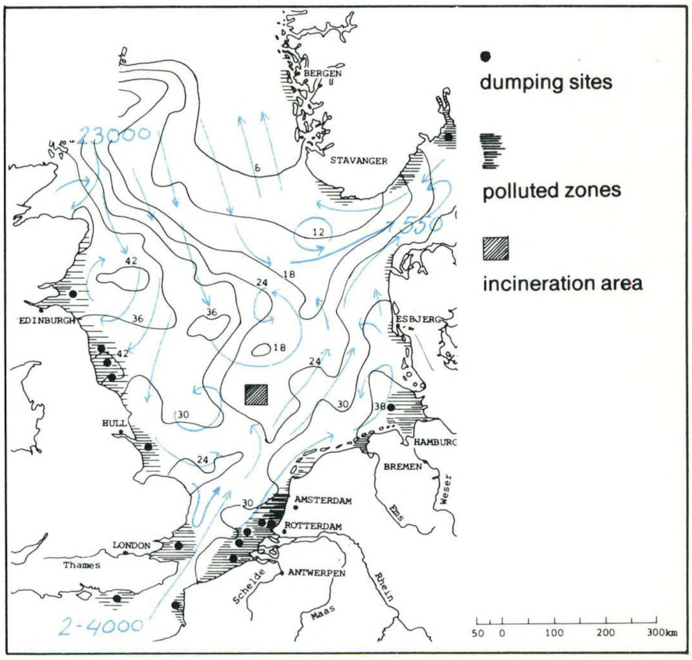


Estimated entry of heavy metals: lead, copper, chromium and cadmium (no. 26: estimated **maximum** entry through incineration at sea)

The approximate composition of the waste gases during the incineration of organochlorine waste with a high chlorine content (50-60 weight / vol):

Oxygen	10% vol / vol
Carbon dioxide	10% vol / vol
Carbon monoxide	5-30 ppm
Hydrochloric acid	5% weight
Water	6% weight
Nitrogen	70% vol / vol
Chlorine	traces?
Organic chlorine compounds	traces
Nitrogen oxides	traces
Metals	max: a few milligr. / m³

Conclusion: The entry of pollutants into the North Sea through waste incineration on ships is negligible, and it can easily be worked out that biological effects of waste incineration at sea on the North Sea ecosystem are below the detection level of the present day ecotoxicological field tests.



The North Sea with the incineration area, the most important dumping sites and the most polluted zones. The numbers show the residence time of the water at the respective places in months. The large blue numbers show the water inflow in km³ per annum (rain: 400; rivers: 150)

Toxic metals:	**zinc,**	all sources	31.000 t/yr
		sea incineration	**max.** 50 t/yr
	6 other metals*)	all sources	32.500 t/yr
		sea incineration	**max.** 210 t/yr
Organohalogen:	**volatile**	all sources	500-1000 t/yr
		sea incineration	**max.** 5 t/yr
	non-volatile	all sources	5-10.000 t/yr
		sea incineration	**max.** 1/2 t/yr
Acids (as H^+)		all sources	**min.** 96.500 t/yr
		from the atmosphere	**min.** 80.000 t/yr
		dumping	15.000 t/yr
		sea incineration	**max.** 1.500 t/yr
Tank residue from chemical tankers			31.000 t/yr
		sea incineration	none
Shipping movements - tankers:			50.000/year
	of which chemical tankers		10.000/year
	of which loaded incineration ships		60-70/year

*) mercury, cadmium, lead, copper, chromium, nickel.

Comparison of the estimated entries of selected pollutants and the risks for the North Sea (estimates according to various sources)