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BIOTA AND ABIOTIC ENVIRONMENT IN THE WESTERSCHELDE ESTUARY *

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ABSTRACT

An estuary such as the Westerschelde is a highly dynamic environment, both on an ecological time scale where climatic and hydrodynamic forces, mainly the tides, shape a very variable environment and on a geological, evolutionary time scale, since estuaries are young and very unstable habitats.

Low species diversity and high adaptability of the resident animal and plant populations are characteristic of estuarine habitats where large fluctuations in submersion, salinity, temperature etc. occur. The existing biota are therefore resilient to environmental stress and effects of the important influx of anorganic and organic pollutants from the river Schelde and its tributaries on the biota in the estuary are not easy to detect.

Although water movement and sedimentation patterns in the Westerschelde are relatively well known, there exists little information on important ecological processes such as primary production and heterotrophic metabolism in the estuary.

INTRODUCTION

Estuaries are zones where the sea and the rivers meet and they are characterized or defined by this mixing of water types. A well-known definition is that by PRITCHARD (1967) : 'An estuary is a semi-enclosed coastal body of water, which has a free connection with the open sea, and within which sea water is measurably diluted with fresh water derived from land drainage'.

Water movement is the all important key factor that governs estuarine processes. In the Westerschelde, the impact of the tides is dominant. It is one of the longest tidal rivers in Europe and contains vast intertidal areas where large amounts of mud and organic matter are deposited.

The tidal forces are also at the origin of the estuary. About 2000 years ago the coast north of Cap Griz Nez was a wadden sea bordered with many islands separated by channels through which the tides could enter, creating gullies in the wadden sea. When such a tidal channel caught the basin of a major river, the tides could penetrate much deeper inland and the estuary was created and maintained. This process, together with the rising sea level over the past few thousand years, has created a very dynamic environment that has only very recently been controlled by man.

THE WESTERSCHELDE ESTUARY

PETERS and STIRLING (1976) divide the Schelde in three zones. In the maritime zone, about 70 km long including the part submerged in the North Sea, complex sediment transport occurs through a system of flood and ebb channels in constant evolution. Because formerly important sea arms have been closed naturally or artificially, deep and large channels have developed separated by large sand banks. Mixing of the water is intense and in most circumstances there is no stratification of salinity or current. The central zone of the estuary is about 50 km long. In this zone mixing between fresh and sea water is only partial and more saline waters occur near the bottom. A turbidity maximum and flocculation zone exist close to Antwerp. The fluvial zone of the estuary is still characterized by a rapid and large penetration of the tides.

Despite this important water movement in and out of the estuary, the actual net displacement of the water is relatively small. The total volume of the estuary between the mouth and the Dutch-Belgian border is 2.5 billion cubic meters. From the Schelde there is a water flow of 105 m3/sec on average, about 9 million m3 per day. This indicates that the residence time of the water in the estuarine zone is about 75 days or 150 tides, a long time compared to the daily displacement of water with the tides.

SEDIMENTATION

Fine sedimentary deposits are a highly characteristic feature of estuaries and they are derived both from the sea and from land. Their deposition is controlled by current speed and the smaller particles will only settle at slack water at high tide over the intertidal areas. These particles are unable to settle within one tidal cycle, but the speed of settlement may be increased by flocculation of clay particles in salt water forming larger particles that sink faster. The middle reaches of an estuary are therefore characterized by a turbidity maximum (POSTMA, 1967) where the inward flow of sea water along the bottom stops and the sediments rise to mix with the surface fresh water. WOLLAST (1976) has estimated that from a total of 1.52 million tons of material of continental origin 1.2 million tons are accumulating in the landward zone; in the seaward zone a further 200.000 tons are deposited so that only 120.000 tons reach the sea. However in this zone a further 800.000 tons of marine sediments are deposited.

To the suspended matter that sedimentates heavy metals and organic matter is absorbed. Sedimentation inside the estuary thus limits the output to the sea but has important consequences for the estuary itself since these substances may be incorporated into the food web; resuspension in periods of high freshwater flow may occur and dredging of this material presents another possible hazard.

THE CHEMICAL ENVIRONMENT

Physical and chemical characteristics of the water are modified by the mixing of fresh and sea water. These modifications entrain a series of transformations of the chemical species present in the water which affects their distribution. These chemical changes are enhanced because of the long residence times in the estuary. The heavy load of organic matter in the Schelde catalyses an intense heterotrophic bacterial activity which rapidly exhausts the oxygen in the river. Other oxydants are used for anaerobic respiration : manganese, nitrate, iron and sulphate. When all electron acceptors are exhausted, sulphate reduction thus may become the dominant metabolic process in the river. When the organic matter content of the water decreases due to flocculation a strong decrease in bacterial activity occurs. The process is equivalent (BILLEN *et al.*, 1976) to two successive titrations of Schelde waters : the first of the oxydants by organic matter catalyzed by the heterotrophic activity in the water and the second of the reductants by oxygen catalyzed by reaeration and autotrophic reactions with an increase in the redox potential.

THE BIOTA

We have only rough estimates of primary production in the water column in the Westerschelde. On the basis of monthly samples through 1983, BILLEN *et al.* (1985b) estimate a total annual production of 225 g $C.m^{-2}$ in the river upstream Antwerpen and only 85 g $C.m^{-2}$ in the mixing area around the Dutch-Belgian border. Two other, potentially important, sources of organic matter have not been studied yet : the production by higher plants in the salt marshes along the river banks and the production by benthic autotrophs, mainly diatoms, in the intertidal areas.

Nitrogen in the Schelde is probably never limiting. BILLEN *et al.* (1985a) estimate that about 82.000 tons of nitrogen enter the river each year but due to denitrification about 55.000 tons disappear as nitrogen gas to the atmosphere. The total output of the Westerschelde to the North Sea would be around 27.000 tons of nitrogen per year.

Most of the organic matter produced *in situ* or imported from upstream is deposited in the sediments and fuels benthic metabolism. Estuarine benthos is generally well known and predictable, poor in species but with a high biomass. It is often used for purposes of ecological monitoring but there has been no recent thorough survey of the benthos in the river Schelde, though some occasional observations indicate that benthic fauna is absent or extremely scarce even in intertidal areas (MOERLAND, 1987; HUMMEL *et al.*, this volume). On the other hand, the fauna in the estuary downstream the Dutch-Belgian border is similar to the fauna in other estuaries, with some possible exceptions such as the scarcity of Harpacticoid copepods in sediments (VAN DAMME *et al.*, 1984) and the recent disappearance of the polychaete *Scoloplos armiger* (HEIP *et al.*, 1986).

Because of the long residence time and rapid mixing the dilution of seawater is gradual and stable. Salinity zones in the estuary are relatively stable and are maintained in more or less the same position throughout a tidal cycle. Over the year there may be larger changes according to the amount of the freshwater flow. This is one of the important factors why an autochtonous plankton can persist in the estuary, *e.g.* the dominant diatom *Coscinodiscus commutatus* and the copepod *Eurytemora affinis* (DE PAUW, 1975). Nevertheless, one of the evident characteristics of the estuarine flora and fauna is its low diversity. Only a few species are found and they are characteristic for this environment. It has long been thought that this is due to the physiological problems an organism has to face in an environment with a changing salinity. However, in stable and long existing environments, a diverse and rich brackish water fauna has developed and it appears that the low diversity of the fauna in tidal estuaries is mainly due to their unstable geological history. There are some considerable scientific advantages in the study of this system since many of the dominant species have been well studied and a lot of information is available on the physiology and ecology of many estuarine animals and plants. Since they are not numerous and since their distribution is quite predictable, physical forces may be important (BAKKER and DE PAUW, 1974; 1975) and biological interactions are relatively unimportant or easily studied.

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