Med. Fac. Landbouww. Univ. Gent, 63/1, 1998

COLOUR MEASUREMENTS ON MARINE SEDIMENTS OFF THE BELGIAN COAST AS A MEANS FOR ESTIMATING GRAIN SIZE

W. VYNCKE & H. HILLEWAERT
Ministry of Middle Classes and Agriculture
Fisheries Research Station (CLO Gent),
Ankerstraat 1, B-8400 Oostende, (Belgium)

ABSTRACT

Median grain sizes of marine sediments from seven inshore and four offshore stations were compared with the colour co-ordinates L*, a* and b*. There was a good correlation with the parameter a*. The colour of the sediments appeared to be mainly determined by the relative percentages of the 125-250 and 250-500 μm fractions. In most cases, a* could be used instead of grain size analyses to follow trends in sediment composition.

INTRODUCTION

Besides fisheries, two main anthropogenic activities related to the seabed are taking place in Belgian coastal waters. In the western part (sand banks off Nieuwpoort), important sand dredging operations are carried out. In the eastern part (Zeebrugge area) large quantities of dredge spoils from harbours and navigation routes are dumped. These operations, which disturb bottom sediments, can endanger marine life, especially bottom dwelling species and hence cause harm to commercial fisheries. It should be emphasised that Belgian coastal waters are important nursery grounds for several fish species.

In order to evaluate the risks for the marine ecosystem, monitoring programmes are being conducted comprising physicochemical analysis of the sediments and determination of possible detrimental biological effects. In the framework of the physicochemical programme of our Research Station it was decided to include colour measurements, as recommended by ICES (1994). The aim of this paper is to evaluate the usefulness of these measurements for the monitoring programme more specifically as a possible alternative to the grain size analysis.

MATERIALS AND METHODS

Sediment samples were taken from 1979 to 1994 two to three times per year with a Van Veen sampler in eleven sites (Fig. 1). Stations Dumping Oostende, Zeebrugge 1, Zeebrugge 2 and Zeebrugge East are dumping areas for dredge spoils. Stations Westdiep, Steendiep and Oostende bank are situated near the coast. Sediments in both categories of areas consist of varying mixtures of sand and silt. Stations Schar bank, Bligh bank, Goote bank and East Dyck

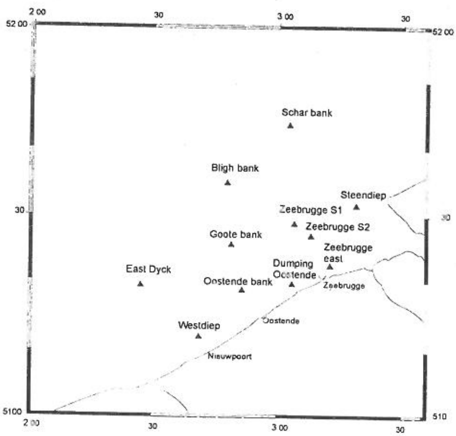

Fig. 1: Sampling stations

are offshore sites with a high percentage of sand. The last station is situated in a sand extraction area. All samples were kept at -28°C until analysis.

Grain size

The <63 μm fraction was separated by wet sieving. The other fractions (63-125; 125-250; 250-500; 500-1000; 1000-2000 μm) were separated by dry sieving. The fraction >2000 μm (mostly less than 1 %) was discarded. The median value was computed from the cumulative curve of these fractions (Inman,1952).

Colour

Colour measurements were performed on the dry sediments with a portable colorimeter Minolta CR 2000 using the co-ordinates L*, a* and b* of the "Commission Internationale de l'Eclairage" (CIE). These parameters represent respectively the black-white chromaticity ("lightness"), the red-green ("redness") and the yellow-blue chromaticity ("yellowness"). Munsell values often used by geologists can automatically be computed from these parameters.

Statistical analysis

Linear or non-linear correlations, according to the best fit, were calculated with the computer programme Prism (Graphpad Software, San Diego, USA).

RESULTS AND DISCUSSION

As the composition of the sediments appeared to change slowly over the years in most sites (Table 1), the whole set of data from 1979 on was not appropriate for calculating mean values and variation. Instead, the pooled data of the last five campaigns covering a two years' period (September 1992, March and October 1993, March and September 1994) were considered to be representative of the present mean composition of the sediments.

Table 1: Temporel trends 1979-1994 for grain size fractions and colour a* (a)

Zone	Grain size				Colour a*
	<63 μm	125-250 μm	250-500 μm	Median	
Zeebrugge 1	-0.752***	+0.899***		+0.847***	-0.395*
Zeebrugge 2		+0.710***	-0.672***	-0.546**	- 0.649***
Zeebrugge East					-0.574**
Westdiep		+0.771***	-0.419*		-0.430*
Schar bank		+0.485	-0.873***		
Oostende bank		+0.840***	-0.803***	-0.651***	-0.428*
Bligh bank		+0.625***	-0.511**	-0.422*	-0.349*
Goote bank		+0.731***	-0.298	-0.486**	-0.622**

(a) no asterisk : $p<0.1$; * : $p<0.05$; ** : $p<0.01$; *** : $p<0.001$

Figure 2 shows the mean values and standard deviations of the colour parameters and of the two main parameters defining sediment composition, i.e. the silt fraction (< 63 μm) and the median grain size.

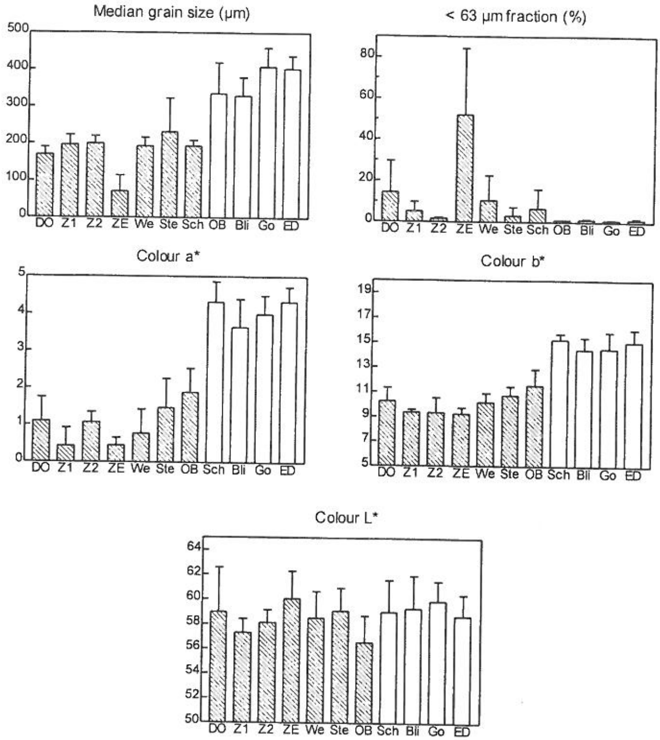

Fig. 2. Median grain size, < 63 μm fraction and colour parameters 1992-1994 (average and standard deviation). DO = dumping Oostende, Z1 = Zeebrugge 1, Z2 = Zeebrugge 2, ZE = Zeebrugge East, We = Westdiep, Ste = Steendiep, Sch = Schar bank, OB = Oostende bank, Bli = Bligh bank, Go = Goote bank, ED = East Dyck. Filled bars : inshore stations; unfilled bars : offshore stations.

L* values were not markedly different among the stations under investigation, indicating this colour component to be less valuable. With both a* and b* values, a quite similar pattern as the median value could be observed, especially between the offshore and inshore sampling stations. Co-ordinate a* however appeared to be more sensitive, the difference between the lowest and the highest measurements being about 4 against 1,5 for b*. The good relationship between the median and a* was further shown by a correlation analysis performed on 275 data gathered in the period 1979-1994. The correlation coefficient r was 0,870 ($p < 0.001$) (Fig. 3).
The large standard deviations of the sediment parameters measured should be stressed. This is due to the fact that in the shallow parts of the North Sea, sediment movements occur frequently, owing to strong wind-induced and tidal currents (North Sea Task Force, 1993). This means that for monitoring purposes, frequent sampling and the use of a sufficient number of replicates are necessary. In this respect, colour measurements, which take only a few minutes, are advantageous.

Data on Fig. 3 are individual measurements. Although there is a good relationship, the scatter of these data makes it difficult to "predict" median grain size from a* values with an acceptable accuracy. This is however possible with a fair approximation when enough replicates are taken. Fig. 4 illustrates this. The average values of the five measurements made in 1992-1994 (Fig. 2) were plotted against the average median particle size of the sediments.

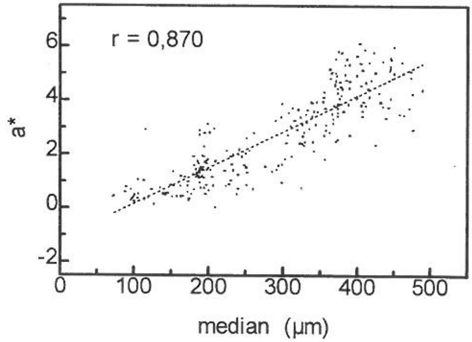

Fig. 3: Correlation between median grain size and colour value a* (individual date)

To gain a better understanding of the influence of each grain size fraction on sediment colour, correlations with a* were calculated (n = 275 ; Fig. 5). The <63 and 63-125 μm fractions contributed to a decrease of the a* values. This influence however was limited to about 5 % of the respective fractions. The opposite effect was noted for the upper grain size categories 500-1000 and 1000-2000 μm also limited to about 5 % of the fraction. The colour of the sediments appeared to be mainly determined by the relative percentages of the 125-250 and 250-500 μm fractions, which respectively decreased and increased a*.

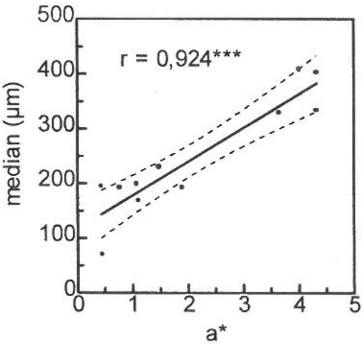

Fig. 4: Correlation between median grain size and colour value a* (average of five replicates)

The use of colour parameter a* also allowed to follow temporal changes in the seabed sediments. Two examples are described here. In most areas off the Belgian coast, a decrease in grain size was noted the last fifteen years. This is probably caused by intensified dredging operations to deepen navigation channels but further discussion on this issue is not within the scope of this paper. Time trends were observed mainly in the 125-250 and 250-500 μm fractions (Table 1). The dumping site Zeebrugge 1 formed an exception. Here the 125-250 μm fraction also augmented, but at the cost of the silt fraction, resulting in an increase of the average grain size.

On the majority of sites, the same trend could be seen, except on Zeebrugge 1, where a* decreased notwithstanding an increase in median particle size. A possible explanation is that the 125-250 μm fraction influences a* more than the others. Whatsoever, when a significant relationship is established between grain size and colour parameter a* for a particular site, a* could be used instead of grain size analysis.

The second example relates to the sand extraction area East Dyck. From 1981 to 1988, a significant increase in median grain size was noted, probably due to the washing out effect followed by sedimentation of coarser particles during the sand extraction operations. From 1989 on, these activities became more irregular. This was reflected in large fluctuations in grain size of the seabed sediments (Fig. 6). The same pattern however was obtained with colour component a*, showing that this parameter could be used for monitoring that particular area.

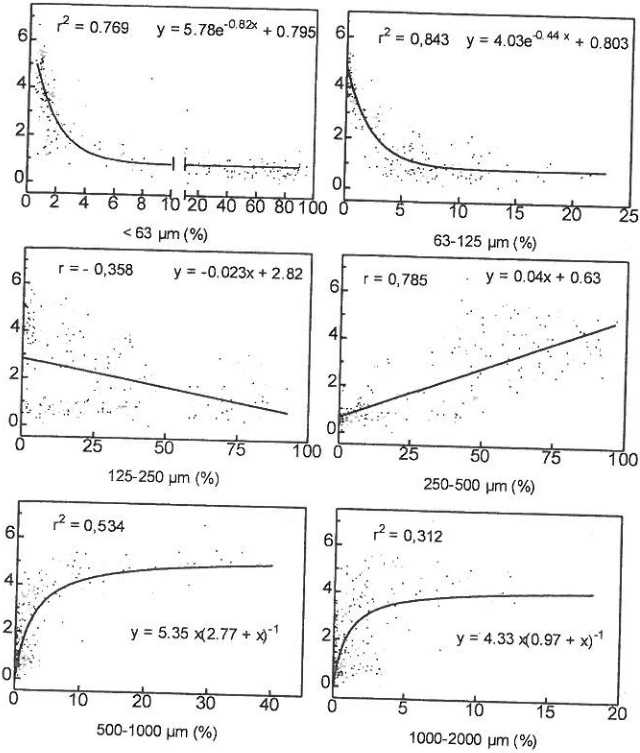

Fig. 5: Correlation between particle size fractions and colour a*

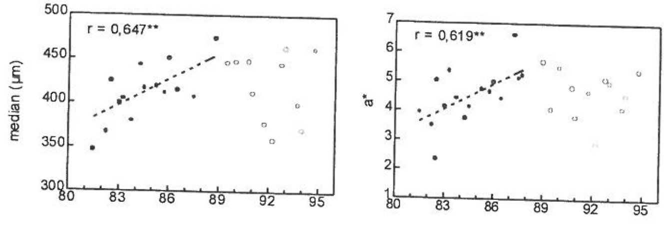

Fig. 6: Temporal trend 1981-1994 of median grain size and colour a* on sand extraction area East Dyck

Table 2 shows the Munsell values for the last monitoring campaign (September 1994). Averaging data is not possible with this colour annotation method. A clear distinction between inshore and offshore stations could be observed. All inshore sites were in the hue category Y (yellow) whilst the offshore areas were in YR (yellow-red). Variations among values were also less pronounced in the latter stations.

Colour measurements, especially component a*, appear to be a useful tool for monitoring sediment characteristics. Further work however is necessary to investigate if this is valid for all types of marine sediments.

Table 2: Munsell values (September 1994)

Dumping Oostende	0.6 Y/5.6/1.7
Zeebrugge 1	3.0 Y/5.6/1.3
Zeebrugge 2	1.6 Y/5.6/1.4
Zeebrugge East	2.2 Y/6.2/1.3
Westdiep	2.8 Y/5.6/1.4
Steendiep	0.9 Y/5.9/1.6
Oostende bank	1.0 Y/5.4/1.7
Schar bank	8.9 YR/5.8/2.5
Bligh bank	8.4 YR/6.0/2.6
Goote bank	8.6 YR/5.9/2.3
East Dyck	9.9 YR/5.8/2.2

ACKNOWLEDGEMENTS

The study was partially funded by the Ministry of the Flemish Community, Department of the Environment and Infrastructure, Administration for Waterways and Nautical Affairs.

REFERENCES

ICES (1994). Guidelines for the use of sediments in marine monitoring in the context of Oslo and Paris commissions programmes. In *Report of the ICES Advisory Committee on the Marine Environment, 1993*. ICES Co-operative Research Report No 198 pp. 45-57. International Council for the Exploration of the Sea, Copenhagen.

INMAN, D.(1952). Measures for describing the size distribution of sediments. J. Sediment. Petrol. 22, 125-145.

North Sea Task Force (1993). *North Sea Quality Status Report 1993*. Oslo and Paris Commissions, London, 132 p.