AN ANALYSIS OF DIFFUSION CHARACTERISTICS IN THE HARBOUR AREA (SPLIT HARBOUR, ADRIATIC SEA)

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Abstract

An experiment, including measurements of physical, chemical and biological properties, was conducted in the Split harbour area (Middle Adriatic) in order to investigate the diffusion there. After the tracer (RHODAMINE-B) had been ejected into the sea, the oil spill was followed using three theodolites from the land and by photographing the area. The horizontal diffusion coefficient, calculated from the simple one-dimensional Okubov model, had values between 0.3 and 1.1 cm/s. Seasonally, the diffusion coefficient had higher values during summertime, while during winter it had lower values as a result of the influence of current field.

Keywords: Adriatic Sea, coastal process, sewage pollution

Introduction

Split harbour is placed on the east coast of the Middle Adriatic. The harbour is covering 0.6 km^2, with a mean depth of 5.4 m. The south entrance communicates with Bra_ Channel with maximum depths of about 70 m. The depth falls from the entrance (12-15 m), to shallow parts on the northern side (less than 2 m).

In the Adriatic Sea the diffusion studies were rare, and in one [1] the experiment was held in the area near Dubrovnik (South Adriatic). There were used two models to parametrize the diffusion: i - Joseph-Sendner approximation [2] gave the values of diffusion parameter between 0.07 and 0.10 cm , while ii - Neuman-Pierson [3] approximation gave the diffusion parameter between 0.9 and 1.9 cm/s.

Data collection

The experiment was organized in 1996 during three different seasons: in February when typical vertical isotherm is formed, in July with strong vertical stratification, and in November/December when the sea cooling is in progress. The measurements comprised the collection of CTD at 23 stations, oxygen at 7 stations and current data at 2 stations, whereas diffusion measurements were performed at three stations (D1, D2 and D3, located inside the harbour) in the way that 50 l of sea water, containing 30 g of the tracer RHODAMINE-B and diluted by 300 ml methanol and 100 ml acetone, were ejected into the sea. After the ejection, the oil spill was monitored and measured using 3 theodolites stationed on the high positions on the buildings in the harbour. Moreover, the oil spill was photographed regularly in time. The experiments were held during calm winds in order to minimize the influence of winds, waves and currents.

It should be pointed out that the experiment was organized with lots of difficulties, because the Split harbour is the second major port in the Croatian part of the Adriatic. Consequently, the ship and ferry traffic was very intensive and influenced the experiment organization. For example, the first idea was to lay two AANDERAA current meters at the entrance of the harbour, what was done during February. But, local ferries didn't pay attention to them at all, so they simply destroyed one of them and moved the other one for almost 50 km by the propeller (fortunately we have found it).

Results

The analysis of diffusion will be based on the theory developed by Okubov [1,3], and it is based on the equation for instantaneous source. It introduced diffusion coefficient a by using the parametrization done by Joseph and Sendner [2]. Thus, the diffusion is stronger the diffusion parameter is lower and vice versa.

The diffusion experiment was performed three times: on 13 February, 4 July and 9 December 1996. The diffusion parameter is calculated from the data of the spot area from two near-time geodetic measurements, and is given in Table 1.

In February at station D1 spot stretched very quickly and disappeared after 11 minutes, while at D2 and D3 remained at least 20 minutes. The influence of currents was manifested as extensive along-current stretching. Diffusion parameter had values from 0.28 cm/s at D3 (strong diffusion caused by strong currents) to 0.77 cm/s at D2 (the currents were weaker).

In July the oil spot remained between 14 and 17 minutes, with diffusion parameter values between 0.34 cm/s (at D1) and 1.12 cm/s (at D2 and D3). The influence of currents is obvious at D1, increasing the diffusion process, while at D2 the values are more realistic and representative for the summer period.

Table 1. Diffusion coefficient a measured in February, July and December 1996 at stations D1, D2 and D3.

STATION	Time slice (min)	^{a}February (cm/s)	^{a}July (cm/s)	^{a}December (cm/s)
	3 - 7	0.47	0.39	0.71
D1	7 - 13	-	0.34	0.65
	13 - 17	-	-	0.60
	3 - 7	0.77	1.12	0.88
D2	7 - 13	0.51	0.81	0.80
	13 - 17	-	-	0.73
	3 - 7	0.28	1.04	0.95
D3	7 - 13	0.28	0.82	0.7
	13 - 17	-	0.74	-

In December the diffusion had the values between 0.60 cm/s and 0.95 cm/s. The currents at measuring points were relatively weak, so that the quality of data was high with the diffusion parameter span lower than during February and July. The oil spot remained at least 17 minutes at all stations.

The span of diffusion parameter is lowest at station D2, which is positioned inside the small shallow sub-basin at the top of the harbour, so the currents were weaker here. Consequently, the quality of the results is the best. On the contrary, at D1 and D3 the ventilation is higher as a result of stronger current fields.

The diffusion was directly influenced by currents, being higher when stronger currents occurred (lower diffusion parameter a). During winter it had the values between 0.28 and 0.95 cm/s, while the summer values were between 0.34 and 1.12 cm/s. Currents were lowest at station D2, so there was the lowest diffusion span (between 0.51 and 1.12 cm/s). These results can be useful for the future works on diffusion, especially in the Adriatic Sea where only a few such experiments were made.

References

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