MONITORING ENVIRONMENTAL CONDITIONS IN MUUGA HARBOUR USING ENVISAT MERIS AND ASAR DATA

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1. INTRODUCTION

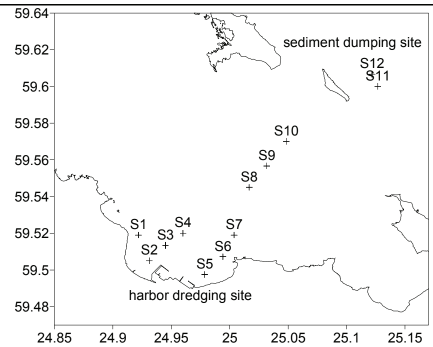
One of the main challenges identified by the European Sea Ports Organization (ESPO) in its environmental code (ESPO, 2003) was the sustainable development of sea ports. Remote and continuous monitoring is a key aspect to improve the understanding of port environmental conditions; therefore the development of these methods is encouraged.

One of the important environmental impacts that port development and dredging operations cause is increased load of SPM into the water column. Use of remote sensing and point sampling for monitoring the suspended matter concentration during the dredging works have been discussed in our previous study [8]. The other important environmental aspect that needs continuous monitoring is oil pollution caused by illegal discharges. Many studies have proved that radar images can provide information on possible location and extent of oil spills [2,4,6].

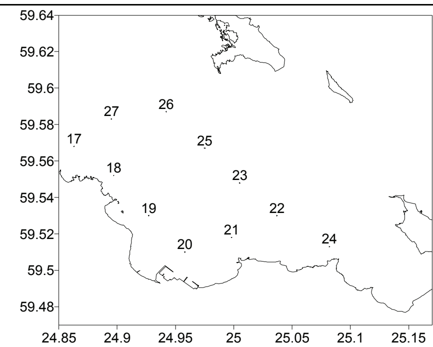
The scope of the current study was to evaluate the use of MERIS FRS data for monitoring of suspended matter load to the coastal sea during the harbor dredging, and to estimate the use of Envisat ASAR data for oil spills detection. The study site was Muuga bay in the Baltic Sea where one of the biggest commercial harbors in located.

2. METHODS

The field measurements of inherent optical properties were performed in Muuga Bay on 9.09 2009 and 30.05.2007. Also water samples from surface layer were taken for further laboratory analysis. In September 2009 the dredging works had lasted for a week before the measurements were performed. The sampling stations on 9.09.2009 are shown figure 1a. In May 2007 a slick of ballast water discharge was detected at the time of sampling for water quality monitoring in Muuga Bay. The sampling stations on 30.05.2007 are shown on figure 1b.



a) Sampling stations on 09.09.2009



b) Sampling stations on 30.05.2007

Figure 1a)b) Sampling stations.

From water samples the concentrations of SPM (in mg/L) were determined using dry weight method and the concentrations of Chlorophyll *a* (in µg/L) were determined using spectrofotometric method. The concentration of oil products was determined by gas chromatography.

The vertical profiles of absorption (a) and attenuation (c) coefficients at wavelengths (λ) 402-730 were measured with the WetLabs ac-spectra instrument. The corresponding scattering coefficient was calculated as follows:

$$b(\lambda) = c(\lambda) - a(\lambda) \qquad (1)$$

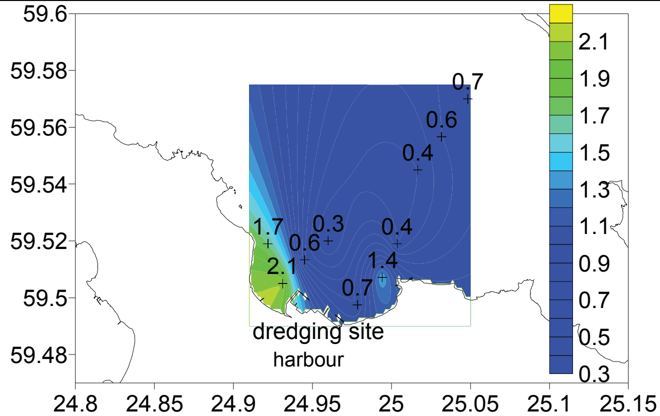
MERIS FRS image from 09.09.2009 was processed using BEAM software. Case-2 regional processor [3] was used for receiving the atmospherically corrected reflectance's and concentrations of SPM.

The ENVISAT SAR Wide Swath product with 75 m pixels spacing from 30.05.2007, 11.45 a.m. was analyzed. The wind conditions were suitable for slick detection during the acquisition (wind speed up to 7 m s^{-1}), For the reduction of noise a 3 by 3 Local Sigma filter was implemented on the image. Georeferencing of image pixels was carried out before the amplitude values were obtained from a single polarization (VV) ground range multi-look image.

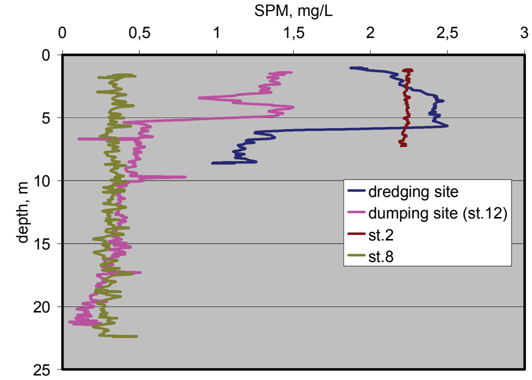
3. RESULTS

3.1. Monitoring of SPM during the dredging 9.09.2009

The suspended matter concentration determined from the surface water varied from 0.4 to 2.1 mg/L (figure 2a). The higher concentrations were at the dredging site and western part of the bay. The SPM distribution at that time resulted from the easterly wind that transported the sediment bloom to the west coast of Muuga bay. We analyzed the ac-spectra data from which we calculated the vertical profiles of SPM concentration. The vertical profiles of SPM at 4 stations are shown on figure 2b. At the dredging site the concentration of SPM increases to the depth of 6 meters where it reaches the maximum value of 2.5 mg/L.



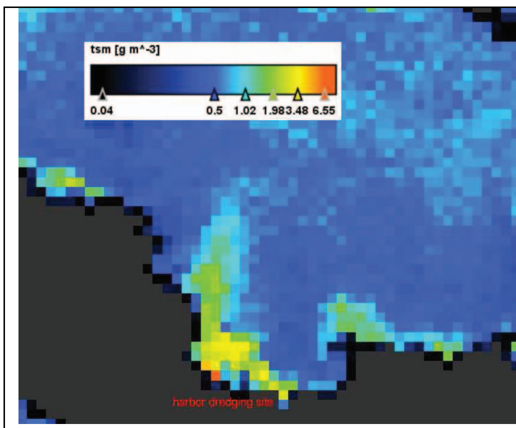
a) Concentrations of SPM (mg/L) on surface



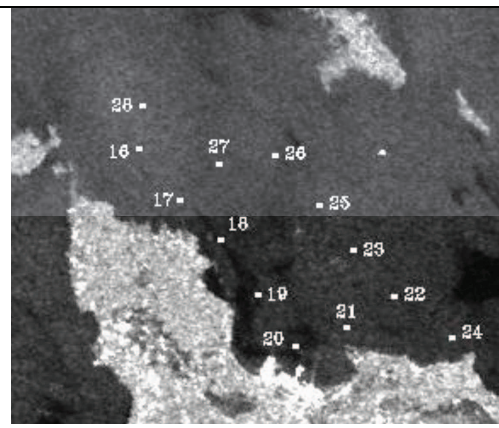
b) Vertical profiles of SPM (mg/L)

Figure 2. a) Concentrations of SPM (mg/L) on surface b) Vertical profiles of SPM (mg/L)

On figure 3a) the SPM concentration retrieved from MERIS L1 image using the case-2 regional processor of Beam software is shown. The SPM bloom is clearly seen on MERIS image near the harbour site and in western part of the bay. The correlation coefficient between the SPM determined from the water samples and calculated from MERIS image was 0.93.



a) SPM from MERIS data 09.09.2009



b) ASAR image from 30.05.2007

Figure 3. a) SPM from MERIS data b) ASAR image from 30.05.2007

3.2. ASAR data analysis for oil spill detection

The SAR (active sensor) measures the backscatter of microwave from the surface. The main factor that influences the backscatter from the sea is surface roughness due to Bragg waves [5]. Previous studies [7] have shown that the most suitable wind speed for oil detection from SAR images is above 3 m s^{-1} as the Bragg wave field has fully developed in the case of this speed. In addition to oil slick there are natural phenomena (local low wind area, algae, upwelling, internal waves, etc.) that appear as low backscatter areas on the sea surface. Therefore, an important part of oil spill detection is separation of oil slicks from look-alikes. The ASAR image from Muuga Bay on 30 May, 2007 is shown on figure 3b). Visual examination of the image indicated the presence of several dark structures.

We examined ASAR data correlated with surface temperature, Chl *a* concentration, SPM concentration, and the concentration of oil products in the sampled stations in Muuga Bay. Regression analysis of the SAR data and SST data showed no correlation (R = 0.16). Also, the organic films caused by phytoplankton are a known source of look-alikes on SAR images [1,2]. Our data form Muuga Bay did not show high correlation (0.34) between SAR and Chl *a* content. The correlation coefficient for SPM concentration and SAR data was 0.64. The highest correlation (0.71) was obtained between the oil products and SAR data although the concentration of oil products was relatively low 0.001–1.72 ppm. The results show that weather conditions at that day enabled to detect even a small concentration of polluted water from the SAR image.

4. CONCLUSIONS

The SPM bloom near the harbour site and in western part of the bay where the wind transported the sediments from dredging site were clearly identified from MERIS FRS image. The correlation coefficient between the SPM determined from the water samples and calculated from MERIS image was 0.93 showing the reliability of the Beam case-2 regional processor for estimation of SPM concentration from MERIS data.

The correlation between the SAR backscatter data and oil products was checked in Muuga bay when the ballast water discharge was found during the sampling. The high correlation (0.71) was obtained between the concentration of oil products and SAR data, although the concentration of oil products was relatively low 0.001–1.72 ppm.

5. REFERENCES

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