CHAPTER 104

An Automated Measuring System to Registrate and Balance Suspended Sediment and Associated Parameters

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The automated measuring system Oortkaten (AMO) was established in order to determine the balance of suspended sediment and associated parameters. Morphological and velocity weighted averaged samples are taken using the newly developed MOSTRA-Method. This results in a cross-sectional average value.

Introduction

Suspended sediments in rivers and estuaries are a nature phenomenen, but since one knows that this suspension is the carrier of heavy metals and other aggressive material, the answer to the question of its origin and behaviour becomes more and more important. In the beginning, measurements of suspended material and the estimation of transport rates were conducted by single measurements or by monitoring a river-section for a few days. Today we know that this kind of measuring cannot yield the results we need to estimate loads of suspended matter over long periods or even offers insights into the relations between suspended matter and associated parameters, such as temperature, oxygen, river discharge or current velocity.

The main problems for measurements in navigable waterways and the interpretation of data, in the past and even nowadays, are aggreviated by interuptions of passing ships, high costs for staff and material, especially for ship capacities, a lack of data to interpolate between single measurements and last not least inhomogeneities for example in the current velocity profiles or in other distributions in the river-cross-section.

In line with a KFKI-Projekt** permanent measurements of suspended matter should make it possible, to compute transport rates through a cross-section of an estuary. At the same time parallel measurements of associated parameters should answer the question as to their influence on changes in the suspended matter concentration data. Because no instrumentation was available to perform this tasks, an own system was developed, the Automated Measurement Station

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Oortkaten (AMO). Figure 1 shows the station during ebb.

Figure 1. Automated Measurement Station Oortkaten (AMO)

Location and Boundary Conditions

The operation position of the measurement device AMO is in the river ELBE near the village Oortkaten at streamkilometer 607.5. This location is on the West-German part of the river shortly before the splitt of the river into two river arms with the most important West-German harbour, The Hamburg Harbour, in between. (Figure 2). Here the river has a width of 525 m and a maximal depth of about 10 m.

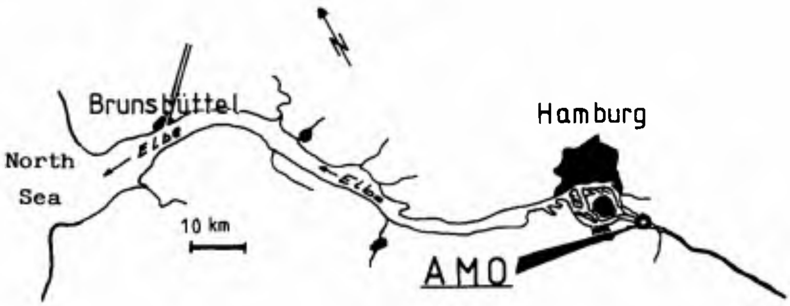

Figure 2. Location of the AMO.

The boundary conditions are important by using automatically working systems. For the location of the AMO the boundary condition are the following ones :

The M 2-tide is dominant, but the tide is influenced by the river-discharge. This leads to a mean duration of ebb for eight hours and four hours for flood. The mean tidal range is 3 m. The ebb current velocity in on an average of 0.9 m/sec with extrem values of 1.5 m/sec. During flood these values are 0.4 and 0.9 m/sec. The mean annual value for the river discharge is 700 m^3/sec, but in times of high water, values up to 3900 m^3/sec were measured. The water temperature is 0 to 25 degree Celsius, depending on the season, and normally there is ice on the river from January until the end of February. The concentration of oxygen varies from 5 - 11 g/m^3 and the suspended sediment concentration range is 15 - 35 g/m^3 with a part of ignition loss, which is with 35 %(+/-5 %) a very constant value.

Measurement Method

Besides waterlevel, current velocity and current direction, concentration of oxygen, pH-value, conductivity, optical attenuation and temperature, the system computes the discharge through the cross-section of the estuary. Watersamples are taken and analyzed seperately in a laboratory on suspended sediment concentration, grainsize distribution and ignition loss. These parameters respectively samples, are measured or collected by a new method called MOSTRA which stands for morphological and current velocity adequated measurement method.

By this method the measuring data of the parameter respectivly the samples are related to the water volume that passes through those parts of the river-cross-section, for which the measurement should be representative (Figure 3).

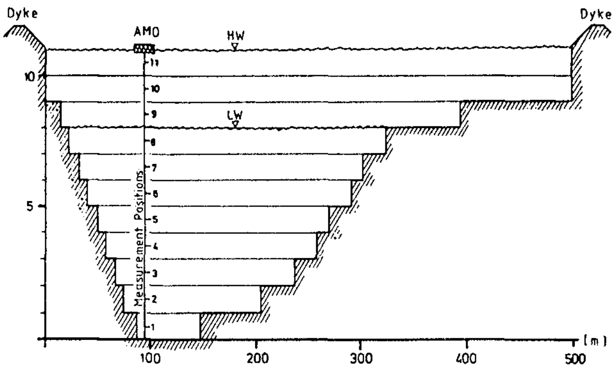

Figure 3. Schematical cross-section of an estuary.

The smaller the cross-section-part, for which the measurement should be representative, the better the dataone measure. If the distributions of the hydrographical parameters in the cross-section are very heterogenous, than it is necessary to measure in more than one profile. In any case representative measurements are necessary. These controls have to be conducted as often as possible with multi-point-measurements.

The knowledge of the cross-section-plane as a function of the water depth, as well as the current velocity for each single measurement position, are necessary requirements for the computation of the measured data. The function for the schematic cross-section (Fig.3) is shown in Figure 4.

For each single measurement position the measured data of the parameters are weighted by the relevant cross-section-plane (Fig.3) and the current velocity. In this way the measured data are related to the water volume, that passes through the relevant river-cross-section part during the measurement.

After having completed measurements at all positions of the profile, the data for each parameter are added and computed to mean values. The result are averaged data vertically integrated and related to the actually transported water volume.

The taking of samples must be related to the cross-section-plane only, because the sampling, depending on the current velocity -so called isokinetic sampling of water- is carried out by a system unit itself. The taking of samples according to the measurements of parameters is being achieved at every measurement position of the profile by the duration of the sample time (Fig.5). Figure 5 shows the extrem differences to an unweighted kind of taking water samples. The greater the gradient of a parameter in the vertical profile, the greater are the differences between the results of the different measurement methods. The complete mathematical background of this method is published by NEUMANN (1985).

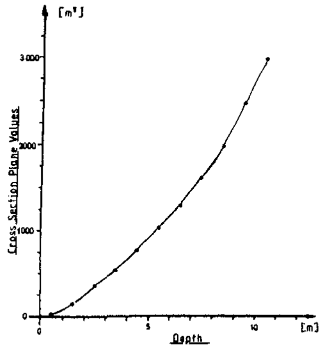

Figure 4. Cross-section-plane, function of waterdepth.

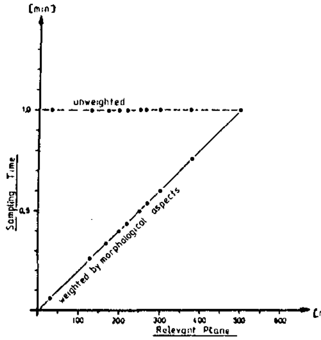

Figure 5. Sample time as a function of the relevant plane

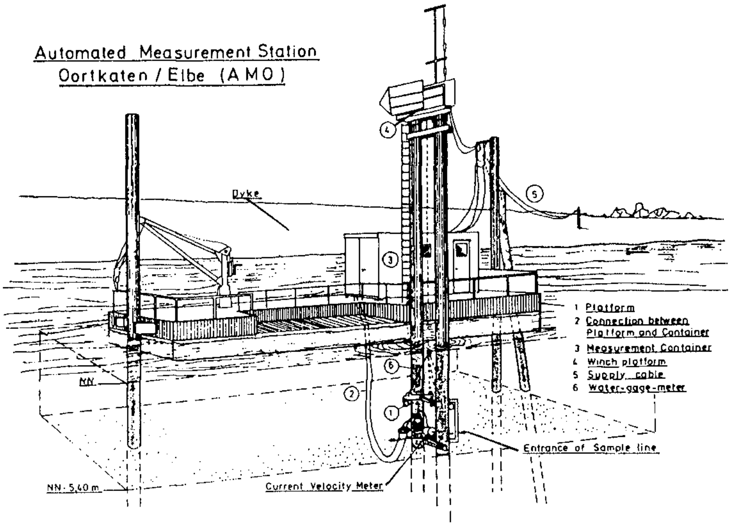

Figure 6. Principle view of the AMO.

Technical System

The Automated Measurement Station Oortkaten consists of several units (Fig.6). The sampling unit is placed on a platform, which is held between two piles and moves, operated by a winch up and down between surface and ground. From here a supply cable and two tubes cimbine the sampling unit through a pontoon with a container. This connection has a length of 18 m. Inside the container all other system are integrated. These are the units to store the samples, measure the parameters and a process-computer-system for operation control and data processing. The 20-feet-container is linked to the shore, which is 50 m away by supply cable for fresh water, electricity and telefon.

The sampling unit on the platform was developed to take the samples isokinetically, measure the current velocity and current direction. The entrances of the sample tube are fixed in the main directions of the river currents. This ensures the position of the AMO, where only alternating current directions occur. For measurements in regions with unsteady directions, a self-directing platform construction is necessary.

To reach the same current velocity at the entrances of the sampling tube as in the river, it is necessary to pump isokinetically. This is important, because flow behaviour of water is different from that of suspended particles. The water velocity is measured with an accoustic current velocity meter, type ME -SM 125, which controls a pump. At the AMO a NETZSCH- mono-pump type 3-NU/10 is installed, which has an almost linear pumping characteristic between the pumping volume of 0 - 1000 cm^3 per minute. Based on this pattern a linear relation between the pumped water volumes and the current velocities are achieved.

Unit No.2, the sample collection-unit is installed insite the container. All mechanic equipment, as well as tanks and sample bottles are installed in one big box. The interior of this box is cooled down to 4 degrees Celsius to stop biological acticities in the samples. Inside the box several valves direct the water either to one of the collection tanks or back into the river. Two tanks are available and each of them has a capacity of 180000 cm^3. To seperate the suspendion of water and solid material a centrifuge is used. This ceperator type ALFA LAVAL LAPX 202 has a seperation-degree of 0.45 µm grainsize by 6000 rotations per minute. Beneath the tank and the centrifuge an assembly line, with 750 cm^3-sample-bottles is installed. It has a capacity of 64 bottles which garantuees a one-week-working-period of the AMO, because 2 bottles are filled after every half-tide.

The measurement of the parameters temperature, conductivity and pH-value occurs inside the container. The sensors of a multi-parameter-measurement-unit are provided with river water by one of the tubes, coming from a seperate pump, fixed on the moving platform.

The operation control of the single units of the AMO and their working together is aided by an integrated process-computer-system. The computer is in line with a telefon modem which gives the opportunity to control and change the working processes, or have a look at the measured data from a terminal at any place, where a telefon is available.

Sampling Process

Water sampling and measurement of associated parameters are taken every 20 cm between surface and ground of the river. These are done under the use of the MOSTRA-Method. From the platform, schematically shown on the left hand side in the figures 7a,b,c, river water is continuously pumped into the container. If the plateform reaches a measurement position, it stops and the water flow is being directed through an overflowtank or bypass back into the river, until the platform reaches the next position. According to the current velocity, the tank will be filled during a half-tide with 100 - 180 dm^3 river water.

When the current direction changes, the river flow is being directed to tank No.2 in the same way then before into No.1 (Fig.7a). Shortly before and after slack water it is possible that both velocity directions occur in different water depths. In this case the water flow is directed either into tank No.1 or No.2, according to the direction of the current.

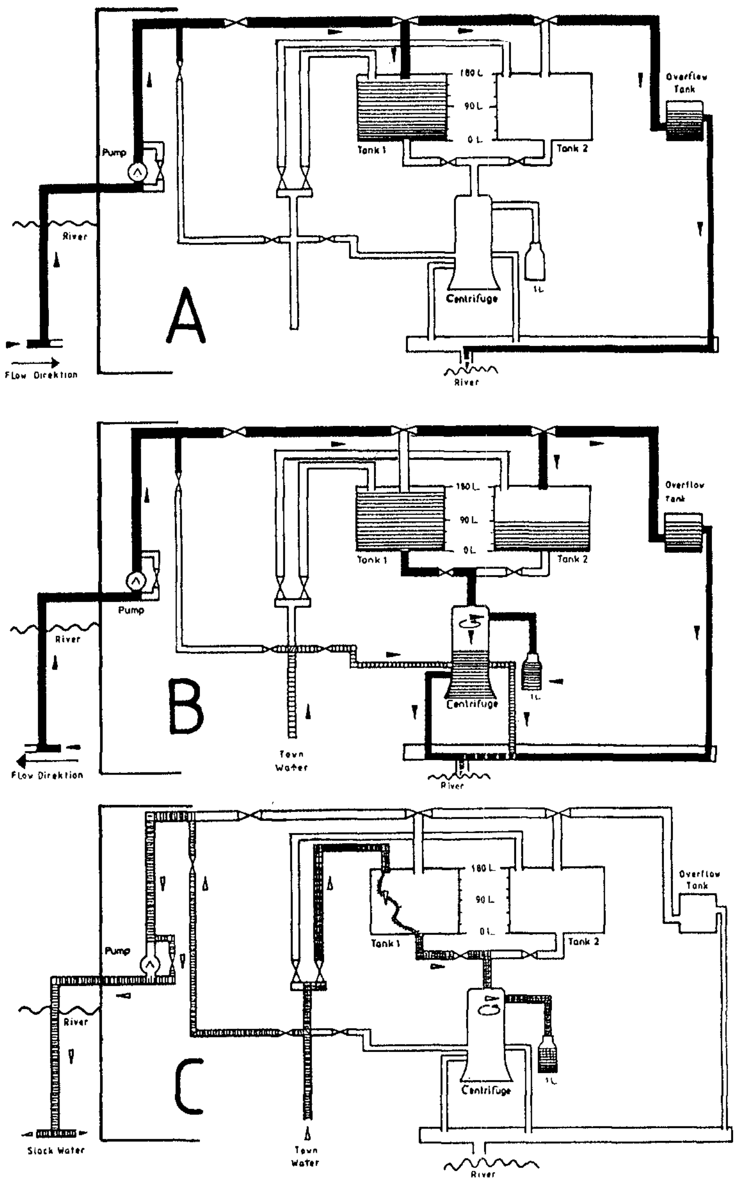

Figure 7. Sampling process of the AMO
a. Sampling of water
b. Centrifugation of sampled water
c. Washing and cleaning of the system

This interplay continuous until the new direction is measured at all measurement positions. Now the water flow is only being directed to tank No.2 and the bypass. Tank No.1 is now ready to be emtied.

In this moment, the centrifuge is started by the computer and the tank outlet-valve is opened. After the tank is completely emptied, the centrifuge content (a substratum of 0.5 dm^3) is filled into a sample bottle. An engine now starts the assembly line and a new bottle is placed beneath the outflow of the centrifuge (Fig.7b).

Tank No.1 and the centrifuge will now be washed with town water (Fig.7c) and the rinsing water is filled into the second sample bottle. After a new bottle has been brought into position, the cetrifuge will be switched off, and the tank outlet-valve be closed.

The whole process last 30 minutes, depending on the content in the tank. Parallel to the tanks the sample tube down to the platform in the river will be washed against the pumping direction to avoid obstructions.

All single phases of the process are computer aided and may be changed in every manner, so that shorter times for taking samples or other interferences are possible.

Recommendation

In line with a KFKI-projekt (CHRISTIANSEN, 1985) an automated measuring system (AMO) was established in order to determine the balance of suspended sediment and associated parameters. Morphological and velocity weighted averaged samples are taken using the newly developed MOSTRA-Method. This results in a cross-sectional average value.

The data of the system afford better answers about transport rates through the cross-section of a river, because the system even works in extrem situations, such as high water, stormy weather and heavy traffic.

References

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