CHAPTER 64

FIELD INVESTIGATIONS OF SUSPENDED SEDIMENT

by

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ABSTRACT

A radiometric probe and sand traps have been applied to measure a distribution of the suspended sediment in a vertical profile.
The first stage of investigations, comprising the laboratory tests and first experiments in the Baltic Sea, were carried out in 1973.
As results of the above experiments calibration curve for radiometric probe has been obtained and some weak points of the method have been overcome.

Six sand traps of bamboo type were situated in different distance from a shoreline and by turns perpendicular or parallel to the shoreline. It enables the determination of percentage distribution of suspended sand in vertical profile and along a bottom profile during a wave cycle.

1. Introduction

The paper presents the results of field investigations concerning the vertical distribution of suspended sediment in the surf zone. The investigations were carried out in 1973 in Coastal Research Station at Lubiatowo in Poland.
The shore profile there has a mean slope about 1:95 with three bars and average grain diameter D_{50}=0,15 mm.
Two methods have been applied during investigations - the radiometric method with the use of radiometric probe and the method with the use of sand traps.

The experiments concerning the radiometric method are to be carried out in two stages.
The purposes of first stage were as follows:

- to come to know the measurement technique
- to determine the weak points of the probe
- to determine the magnitude of expected errors.

The experiments concerning the first stage have been completed.
In the second stage we intend

- to determine the vertical distribution of suspended sediment concentration
- to determine the thickness of sand layer which moves close to the bottom
- to determine the changes of bottom compactness caused by wave action.

All above experiments are to be carried out in early autumn 1974 together with the simultaneous measurements of the wave height, wave amplitude, wave period, angle of incidence and position of breaking line and measurements of bottom profile perpendicular to the shoreline.

2. Radiometric method

2.1. Principle of measurement.

Concentration of suspended sediments in water may be determined by absorption of gamma radiation. Intensity of gamma radiation passing through the absorber of the thickness l is described by the well know formula:

$$I = I_o e^{-\bar{\mu} l} = I_o e^{-\rho \mu l} \qquad /1/$$

where: I_o - incident radiation intensity,
I - intensity of radiation passed by the absorber,
$\bar{\mu}$ - linear absorption coefficient,
μ - mass absorption coefficient,
ρ - absorber density,
l - absorber thickness

The above formula describes the absorption of the narrow beam of monoenergetic gamma radiation. Both the source and the detector should be collimated but if discrimination level of the detector is choosen for registrating the photons of primary energy only, the beam collimation is unnecessary, and the same results as for collimated beam would be obtained.

Mass absorption coefficient μ does not depend on the absorber density, it depends only on its chemical composition. If the chemical composition of absorber does not change and absorber thickness is constant, then the formula /1/ may be expressed as follows:

$$I = I_o e^{-C\varrho} \qquad /2/$$

where: $C = \mu l$.

Solving equation /2/ for density one obtains:

$$\varrho = \frac{1}{C} \ln \frac{I_o}{I} \qquad /2a/$$

Density of the mixture of water and sand depends on the concentration of sand. Knowing the mixture density one can calculate the concentration of the sand in the mixture.

2.2. Probe construction.

The probe have been designed and carried out by the Institute of Physics and Nuclear Techniques in Krakow, Poland, according to our requirements. The probe consists of radioactive source which is Co^{60} with activity 5 mCi and a counter with the scintillation crystal, photomultiplier and electronic part where there is input amplifier, discriminator and output amplifier.
Impulses occurs at the discriminator output only when the amplitude of input impulse is higher than the choosen discrimination level.
The probe is supplied with high voltage and low voltage but the impulses are transmitted by the individual cables.
Probe dimensions are as follows: length - 880 mm, diameter - - 36 mm, weight - 15 kG.
The impulses from the probe are transmitted to the laboratory building and counted by the scaler.
The radioactive source and the counter are placed inside two vertical aluminium tubes of 40 mm in internal diameter and 50 cm in external diameter [fig.1].
The tubes are attached to the platform construction that way to ensure constant distance of 46 mm between them [fig.2].
The tubes are driven into the sea bottom and are filled up by sea water though they are closed at the bottom.
The source and counter may be lifted up or lowered down by the help of electric lift directed from the laboratory. The movement is simultaneous and the line connecting the sensitive area of the counter and source is always horizontal. The velocity of the movement is 2.2 cm/s in both directions and the probe position is always known owing to two selsyn motors and counters.

2.3. Probe calibration

The readings of radiometric probe doesn't depend only upon the suspended sand concentration but also on:

- natural gamma radiation
- variable chemical composition of sea water
- variable chemical composition of sediment.

The influence of the above factors should be taken into consideration but some of them may be neglected.

For instance in Lubiatowo region changes of chemical composition of sea water and sediment are slight. According to carried out investigations the changes of water density caused by temperature have almost no influence on probe readings [1].
The probe calibration may be carried out in laboratory in tanks where instead of suspended sediment there is a chemical solution of known density or when there is controlled volume of suspended sediment.
It is also possible to perfom calibration in the field by simultaneous measurements of sand concentration and sampling.

The calibration of our probe was made in the tank full of water where the distance between source and counter was the same as for field measurement [fig.3].
The perspex sheets were placed between tubes in order to introduce sand into the space between the sheets.
By changing the distance L it was possible to obtain different thickness of sand layer which was to simulate the sediment concentration.
As a result of such procedure a calibration curve has been obtained [fig.4]. In order to check the extreme points of the curve which is a straight line in semilogarithmic system the measurements of the saturated sand density and sea water density have been performed at Lubiatowo.
The results of those measurements coincieded with the calibration curve.
Right now we have also results of measurements taken in translucent water during calm sea which may be treated as a basis for relative measurements.
Using the same tank as for calibration purposes the tests concerning the resolution power of the probe have been also carried out.
The vertical resolution for water-sand contact is about 3.5 cm and for water-air coutact about 3.0 cm [fig.5].

2.4. Experiments in the Baltic Sea.

During the first experiments which were performed in the sea in 1973, we met some difficulties. At first the difference of 4 mm between tube diameter and probe diameter was to small causing the probe wedging.

Moreover the electrochemical corrosion of internal surface of aluminium tubes caused a deposit which also diminished the tube diameter.
Under the waves action the platform together with the attached tubes was strained what brought about the leakages at the tubes joints. The small perticles of sand got into the tube and setteled down making the probe movement difficult.
Then fouling occurred at the tubes surface.
All those difficulties have been overcome but it had taken much time and doesn't allow to obtain results as quick as it was planned.

3. Sand traps method.

The second method which have been applied to investigate the vertical distribution of suspended sediment consisted in using sand traps.
Such sand traps have been already used in Japan [2] and because they were made of bamboo and had articulated joint at the bottom, they were subjected to oscillatory currents and were unable to assume vertical position.
The hydraulic model investigations of those sand traps have been also carried out in Japan and some empirical formulae have been determined.

The applied sand trap was designed and made according to the bamboo samplers.
It has a length of 3 to 4 m and consists of elements made of perspex tube with internal diameter 40 mm and external diameter 50 mm. Every element has a length of 20 cm and two openings with the dimensions 1 cm x 5 cm [fig.6] .
In 1973 several experiments were carried out with the use of such sand traps. The purpose of experiments in Lubiatowo was the determination of percentage distribution of suspended sand in vertical profile and along a bottom profile during a wave cycle. The wave cycle is deemed as whole wave field during a passage of an atmospheric pressure system.
The experiment No.1 have been performed during the period of 5 days. The wind velocity was up to 14 m per sec and the maximum wave height measured at the depth of 3.4 m was 1 m [fig.7] .
The openings of all six sand traps were situated by turns perpindicular or parallel to the shoreline.
The experiments results were as follows.
The sediment movement in suspended form begins between the second and third bar.
At the third bar the suspended sediment appears only near the bottom in the layer of several centimetres.
Between second and third bar the volume of suspended sediment transported in perpendicular or parallel direction is the same and 60 percent of total volume is transported in the layer of 40 cm from the bottom.
The total suspended sediment transport rate between first bar and second one is much higher than between second and third bar and longshore direction of sediment prevails.

In the vicinity of first bar suspended sediment transport is most intense and takes place in whole cross-section.

The experiment No.4 have been carried out during the period of 7 days, but the waves were much higher than during the experiment No.1 [fig.8] . The investigations with the use of sand traps have also been performed in Libya to determine a vertical distribution of suspended sediment at site of designed sea water intake [fig.9] .

On the basis of carried out experiments it may be concluded that sand traps present a cheap and quick way to determine a distribution of the suspended sand transported in a vertical profile and through the profile perpendicular to a shoreline.

References

1. Florkowski T., Cameron I.F. - A simple radioisotope X-ray transmission gauge for measuring suspended sediment concentrations in rivers. Radioisotope instruments in industry and geophysics, IAAE, Vienna, 1966.

2. Fukushima H., Kashiwamura M. - Some experiments on bamboo samplers. Coastal Engineering in Japon, vol.1, 1958.

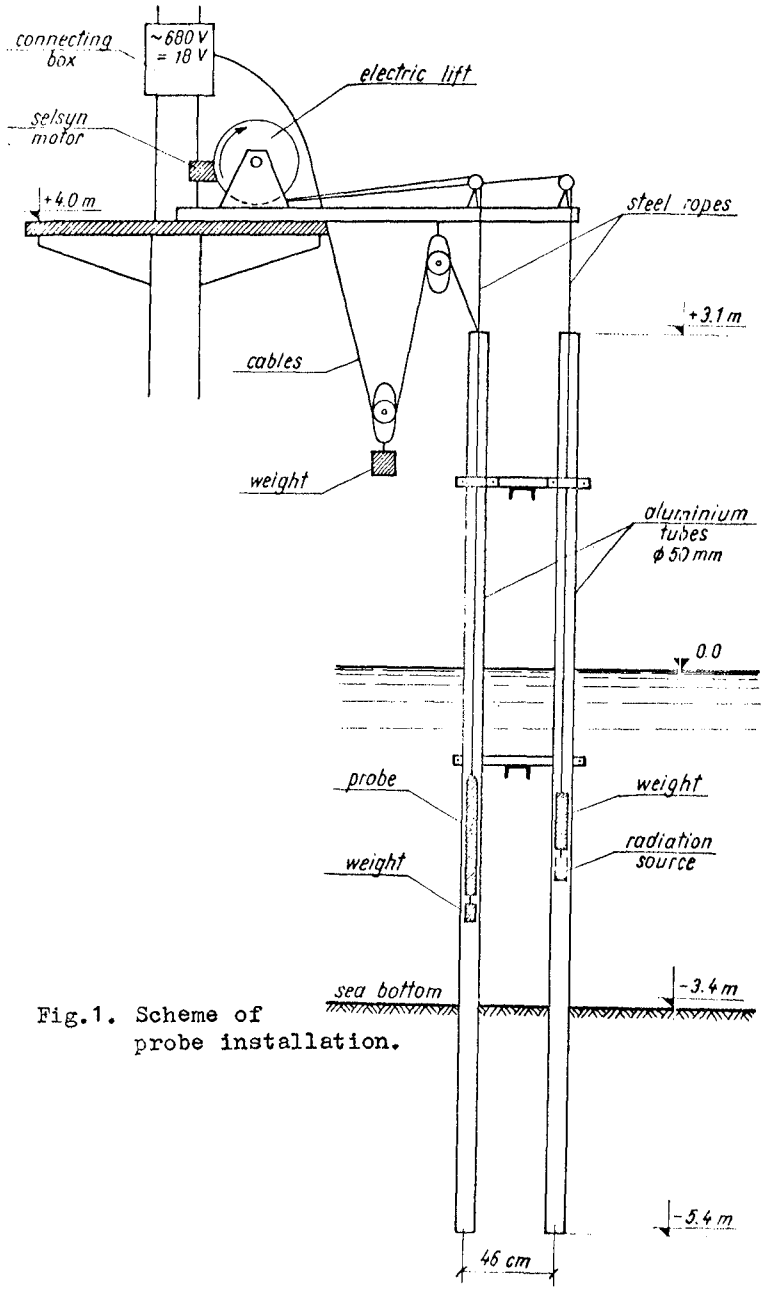


Fig.1. Scheme of probe installation.

Fig.2. Measuring island with probe installation.

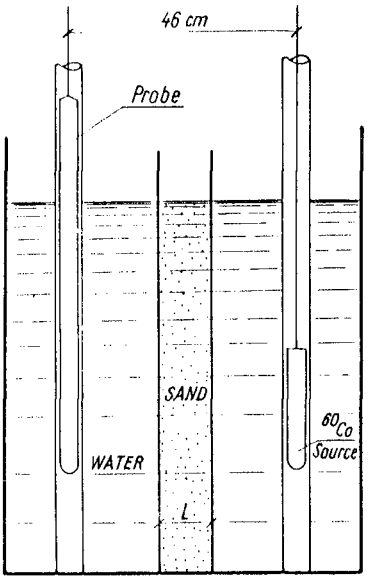


Fig.3. Tank for probe calibration.

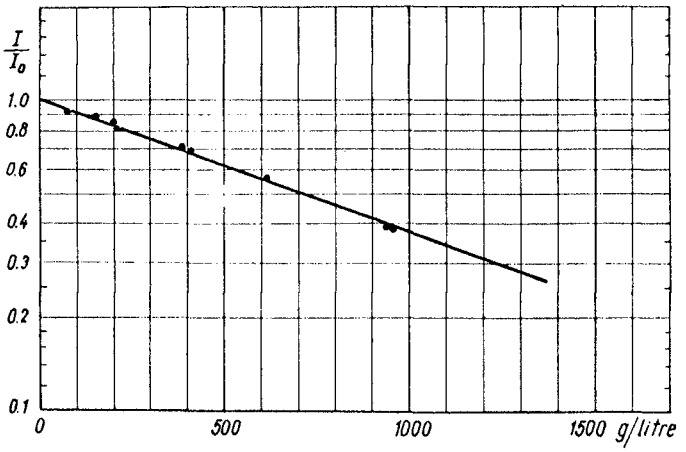


Fig.4. Calibration curve.

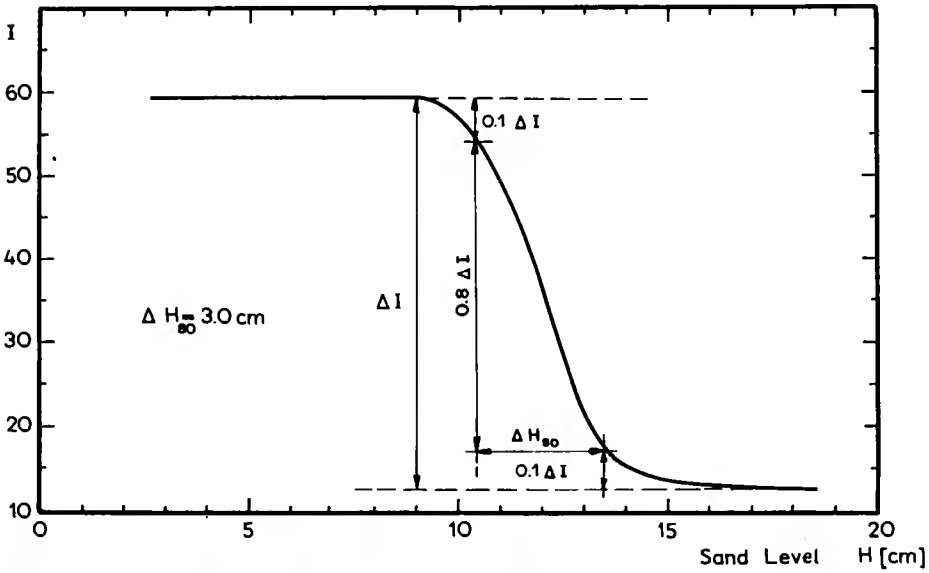


Fig.5. Resolution for water-sand contact.

Fig.6. Sand trap.

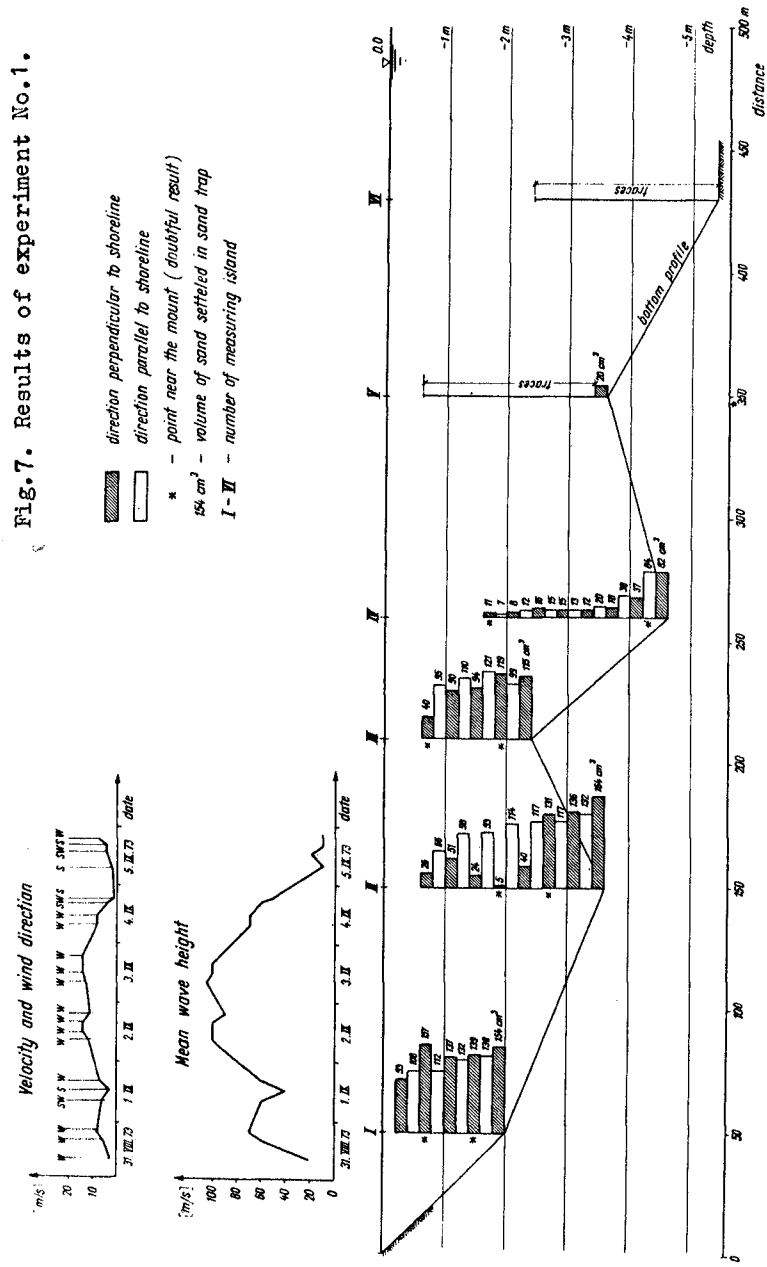
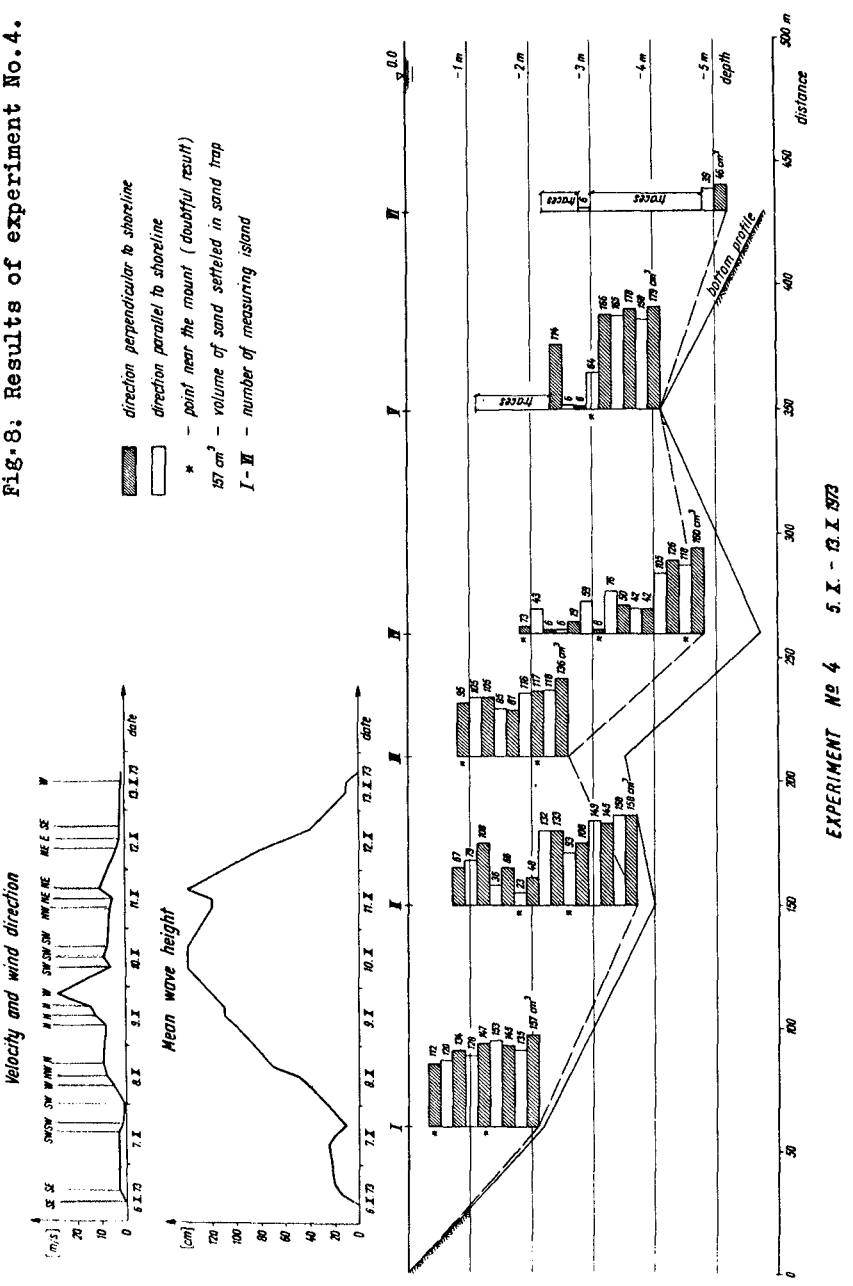


Fig.7. Results of experiment No.1.

Fig.8: Results of experiment No.4.



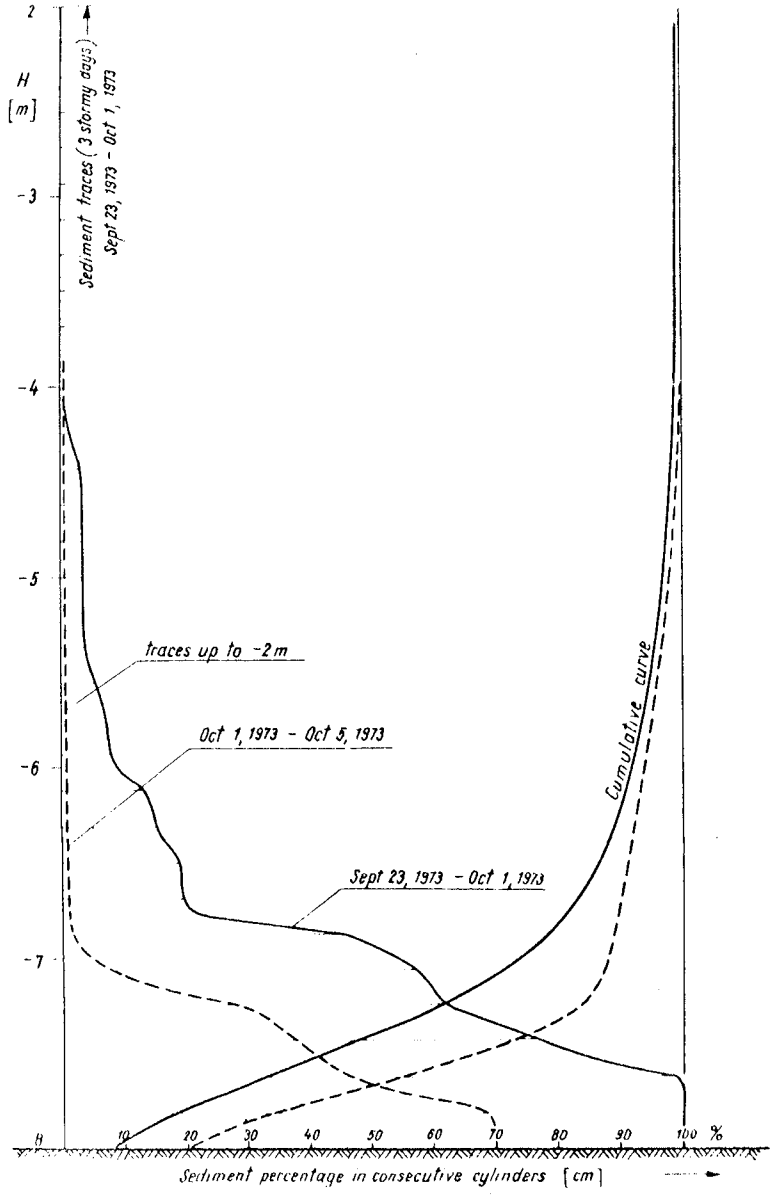


Fig. 9. Results of experiment in Libya.