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WATER QUALITY SURVEYS

(RIVERS, LAKES, ESTUARIES, COASTAL WATERS)

by

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I INTRODUCTION

Results obtained by regularly performed water quality investigations, summarized and presented in a concise form, give a clear idea of water quality and its changes at a given point or a given reach of a water course. Once this data is available, the changes of water quality occurring at points important from the viewpoint of water use and pollution can be taken into consideration.

The value of the results obtained by water quality investigations depend on several factors. Apart from hydrological and meteorological factors, the quantity and type of pollution, the method and frequency of the investigations play an important role.

Full information should be gathered on pollutants reaching the river. Collection of samples of the waste effluents at their outfall to the river should be made. There may be wide variations in quantity and

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quality of the effluents (either treated or untreated) in the course of a day (e.g. that of textile factory) or a week, or even during the different seasons (e.g. that of canning factory). Days in mid-week would seem to be most suitable for sampling, which must be a composite one of at least four- or preferably two-hourly samples. The discharges should be properly recorded.

II SAMPLING METHODS

1. The location of the sampling points is of extreme importance. Sampling should be done at as many points along the river as are necessary to obtain sufficient information on the pollution load and on the extent of self-purification. When the sampling points have been selected, the cross-sectional location of the sampling has to be determined. The best method is to take samples from the middle of the current (not that of the stream), approximately half a metre below the surface to avoid collection of floating matter. For determining the oil content, the sampling method, where surface sampling is also important, must be specially worked out.

2. The proper intervals for sampling should be carefully determined. In general it may be seasonal, monthly, weekly or daily. The most sophisticated method is the automatic sampling station with continuous recording. With the present means available in most countries, this is not usually available and the right policy would be to organize smaller stations but with sampling at proper frequencies (night sampling is as important as day sampling), at least once a week. In any case, sampling should be done at least monthly. If samplings are infrequent, less than twice weekly, a time adjustment for the velocity of flow should be allowed between the samplings at two neighbouring stations so that the same water would remain under observation during its entire course downstream.

3. Regarding the method of collection, samples may be taken by hand or automatically. Non-composite samples are best collected by hand.

Composite samples can also be done by a single person, if individual samples are taken every six hours. The volume of samples is determined by the analysis required.

4. The volume of the samples is determined by the quantities necessary for the determination of the individual components. For a brief analysis generally one litre of water sample is sufficient. For detailed analysis, however, usually two litres of water are needed. In case of special investigation even more water may be necessary.

5. The most suitable materials for sampling containers are bottles of glass or synthetic material, the basic conditions for which are chemical stability, i.e. the contents should not dissolve and no absorption should take place. Sealing of samples in the case of bottles made of synthetic material should be effected with a rubberlined screw stopper; if glass bottles are used, glass or rubber stoppers or any other spring-fitted rubber padding may be used. Samples requiring special treatment (dissolved oxygen-contents, BOD_5 biologic samples, etc.) should be put in smaller bottles or ampoules sealed with ground-glass stoppers.

6. For the cleaning of sampling containers - both glass and synthetic bottles - concentrated technical hydrochloric acid should be used. According to the prevailing practice, for degreasing some detergents will meet the purpose.

7. Normally, the sample has to be put into several sampling containers, for this purpose a pail of tin or any other material which can be fitted with counterweights for an easier handling on one side is needed. In case the site of sampling can be approached directly but with difficulty, it is expedient to tie the pail on a string or a pole. When dividing the sample into different containers due care should be taken that the sample is homogenous, i.e. floating materials should be avoided.

8. In case of water-sampling from a pre-determined depth a Meyer-type bottle or similar equipment should be used.

9. Preservation of the sample is necessary if the components to be determined are liable to change with time, if the analysis cannot be carried out without delay on the spot or on the same day in the laboratory. Components which change within a very short time, e.g. water-diluted gases, have to be determined on the spot or else the sample must be preserved.

10. On account of the changing stability of the components, there are no general rules as to preservation and there appears to be no all-round material for such preservation. At the same time one must take into account the fact that use of preserving material does not give full protection against changes in the components, therefore preserved samples should be analyzed either on the day following the sampling or at the latest within three days. Prescriptions applying to preservation are given in the patent-draft according to water-quality components.

11. Transport of samples - The period of time elapsing between the sampling and the start of the analysis can be shortened in different ways. The most advantageous is to set up the laboratory near the sampling site. Though mobile laboratories are often advantageous, they do not always offer a satisfactory solution because their equipment may not be as comprehensive as in a proper laboratory. If simplified analyzing methods are applied, they necessarily diminish the reliability of the results. Thus transport of samples has to be effected quickly and at the same time with extreme care. Transport is effected in delivery boxes divided by partitions and strictly controlled by the laboratory personnel. In cold weather the glass bottles have to be very carefully protected from freezing. In hot climates they should not be allowed to get warm during transport. In the time interval, due to transporting the samples to the laboratory and starting the analyses, it is necessary for them to be stored in a refrigerator.

III DATA PROCESSING

Water quality, changes in quality with the lapse of time and along the water course, can be numerically demonstrated on the basis of a synoptic and graphical processing of the data of annual time-series obtained by investigations carried out at a given point of a water course with appropriate frequency, or by a longitudinal representation of the survey results of samples taken less frequently but at several points of a given reach on the same day.

Data on water quality investigations in surface water can be processed by the following methods.

1. Setting up of annual time-series concerning points where samples are generally taken weekly.

(a) Synoptic resumé of all survey results obtained from samples investigated during the year, with separate headings for the best, worst and critical values.

(b) Representation in columns of the time-series (measured values) of the most important water quality factors.

(c) Plotting of duration figures on the water quality factors mentioned in point (b).

The processing of the annual time-series covers water quality components, depending on the water quality requirements of users, together with hydrological and meteorological factors that belong to these components.

(a) The synoptic resumé includes the following components:
- type of water stage changes (flow fluctuation)
- water stage (flow)
- weather
- temperature of water

- oxygen consumption
- BOD_5
- oxygen saturation
- carbonate hardness
- total hardness
- total dissolved matter
- total suspended solids
- NH_4^+
- NO_3^-
- PO_4^{3-}
- phenols
- anionactive detergent
- natrium percentage

(b)-(c) The setting up of time-series and duration figures covers the following components:

- daily mean-flow
- oxygen consumption
- BOD_5
- total hardness
- total dissolved matter
- total suspended solids
- NH_4^+
- NO_3^-
- phenols
- anionactive detergent
- natrium percentage

Selection of components depends on local conditions and needs.

In Figure 1 the top diagram shows the daily mean-flow during the year investigated. Diagrams representing the values of water quality components are given after the time-series in Figure 1. This method permits to consider and evaluate water quality components in the function of hydrological and meteorological factors.

Water quality duration figures can be drawn from the results of water quality studies performed during the investigated year. In Figure 2 one of the duration figures shows the ten years' (1956-1965) average mean-flow values and those of the investigated year (1968).

2. Longitudinal representation of survey results of samples taken at several points along the water-course.

(a) Computation of the values of water quality changes and loads due to waste-water effluents and their synoptic resumé on the basis of the characteristic water quality components.

(b) Representation of water quality along the water-course on the basis of samples taken at different points on the same day.

The computation and representation of water quality changes along the water course covers the component important from the viewpoint of the type of pollution and from the viewpoint of users.

(a) The computation of water quality changes and loads due to waste-water discharges and effluents covers the following water quality components:

- oxygen consumption
- BOD_5
- oxygen saturation
- total hardness
- total dissolved matter
- total suspended solids
- NH_4^+
- phenols
- anionactive detergent.

The study (computation) of water quality changes along the water-course compared to the boundary section should be performed on the basis of survey results obtained from samples taken at places below important discharge points and affluent inlets. For this investigation, it is necessary to compute an average value weighed proportionally to water flow according to the following relationship.

$$\bar{Y}_Q = \frac{\sum Y \cdot Q}{\sum Q}$$

$\bar{Y}_Q$ = average value weighed with water flow
Y = measured value of the water quality component
Q = water flow at the time and place of sampling

The connexion of the results of water quality studies to quantitative conditions is more suitable for a numerical demonstration of water quality changes, than a characterization without water quantity.

The changes shown by the comparison of two sampling points on the basis of the average values of water quality components weighed with water flow can be negative or positive, depending on the wastes load (effluent load) and self-purification, and the changes of water quality can be determined in a given reach of the water-course (between the entering and exit-border-sections).

(b) Representing the changes in water quality along the water-course (longitudinal section) figures may cover the following components:

- oxygen consumption
- BOD_5
- oxygen saturation
- total hardness

- total dissolved matter
- total suspended solids
- NH_4^+
- oils
- phenols
- anionactive detergent
- natrium percentage

The selected components may be different in accordance with the function of the water-course and local conditions.

In Figure 3 the arrows in proportion to the quantity of waste-water shown at the top of the longitudinal section indicate the more important discharge points. Lower down on Figure 3, the affluents and sampling places can be seen marked according to points that served as a basis for plotting. Water quality changes are shown in the diagrams of water quality components.

The graphical representation of average values, weighted with the water flow, is suitable for the study of water quality changes in a yearly period. The representation - completed with the best and worst values measured at sampling points during the investigated year and with the limit-values serving as a basis for classification marked with the dotted lines of the class - gives a complete picture of the water quality changes in the course of the year.

The computed (positive or negative) values of changes - between two sampling points - compared to the entering section of the watercourse can be represented as well.

IV SPECIAL SURVEY METHODS IN ESTUARIES AND COASTAL WATERS

1. Types of Survey - Surveys of estuaries may be divided roughly into two groups: those covering only a limited area - as when determining the effects of pollution on a bathing beach or oyster bed - and those designed to cover a large part of an estuary.

Cross-Sectional Variations - In estuaries generally the water may be well mixed over any cross-section, so that concentrations of dissolved constituents do not vary greatly over the depth or width of the estuary. Samples taken a few feet below the surface in midstream can then be considered as approximately representative of the whole cross-section, but even in a well-mixed estuary it is inadvisable to estimate the average composition of the water from samples taken very close to the bed or to the banks; it is also inadvisable to sample too close to the water surface when there is a possibility of thermal stratification.

Other estuaries might be highly stratified and examination of samples taken at a standard depth in midstream is misleading. The methods adopted for studying such an estuary must depend on the constituents examined, the purpose of the survey, and the magnitude of the vertical and lateral variations.

2. Constituents Examined - The constituents examined will depend on the purpose of the survey. If the effect of pollution on fish is important it will be essential to know whether the water contains toxic substances. The quickest way of finding this out is to observe directly the toxicity to fish of large samples of the water.

It is nearly always worthwhile to determine the salinity (total salt content) of all samples taken.

The temperature of the water at the time of sampling should always be noted.

The constituent of most interest is generally dissolved oxygen.

When pollution is so excessive that part of the estuary is devoid of a measurable amount of either dissolved oxygen or nitrate, reduction of sulphate occurs, and estimation of the sulphide content of the water (preferably soluble as well as total sulphide) immediately after samples are taken, will then be of interest.

When it is known that acid or alkaline effluents are discharged to an estuary, pH estimations should be made. Unpolluted sea-water usually has a pH of 8.0-8.4, whilst in an estuary the pH is generally within the range 7.0-8.2 Variation in the pH of sea-water can be brought about by photosynthesis or by respiration.

Useful information is also provided by determinations of nitrogen compounds, such as ammoniacal nitrogen, albuminoid (or organic) nitrogen, nitrite and nitrate. In badly polluted estuaries containing no nitrate or dissolved oxygen, sulphide can be formed by reduction of sulphate by sulphate-reducing bacteria (which require anaerobic conditions).

3. Comparison of Results - Care is necessary in comparing the results of surveys of an estuary since, besides seasonal variations in temperature and fresh-water flow, tidal effects have to be allowed for.

Since the current system in an estuary is oscillatory, the composition of samples taken a few hours apart at the same position may be very different. Given sufficient boats and observers, samples could be taken simultaneously at a number of points, but it is usually more practicable to take samples from a boat passing through the estuary - the times and positions being noted.

4. The Tracing of Sources of Pollution - It is sometimes necessary to follow water movements in an estuary or the sea, to study the dispersion of sewage from an outfall, or to trace a source of pollution which may be finding its way underground to a river. Characteristic constituents which are easily detectable in minute amounts can often be used for these purposes; examples are ammonia, phosphate, and synthetic detergents in the case of a sewage discharge, and cyanide or phenols from certain trade wastes. In general, however, it is advisable to use specific tracers and the following are particularly useful:

(a) Fluorescein
(b) Rhodamine B

This substance is tetra-ethyl rhodamine hydrochloride and is a bluish-red dye with a strong yellow fluorescence.

(c) Common salt

(d) Lithium sulphate

This last compound can be used instead of common salt, the lithium being determined spectroscopically or by means of a flame photometer. It has the advantage over dyestuffs that it does not discolour the water.

(e) Radioactive and bacterial tracers

Radioactive labelling of the sewage discharge can be done with ammonium dihydrogen phosphate containing phosphorus 32, and the activity of the sea-water at various points can then be determined from a boat and from shore stations with the aid of Geiger counters.

REMARK: This paper was developed from relevant studies and instructions of the Hungarian National Water Authority, the Water Pollution Research Laboratory, Stevenage, United Kingdom, and the World Health Organization.

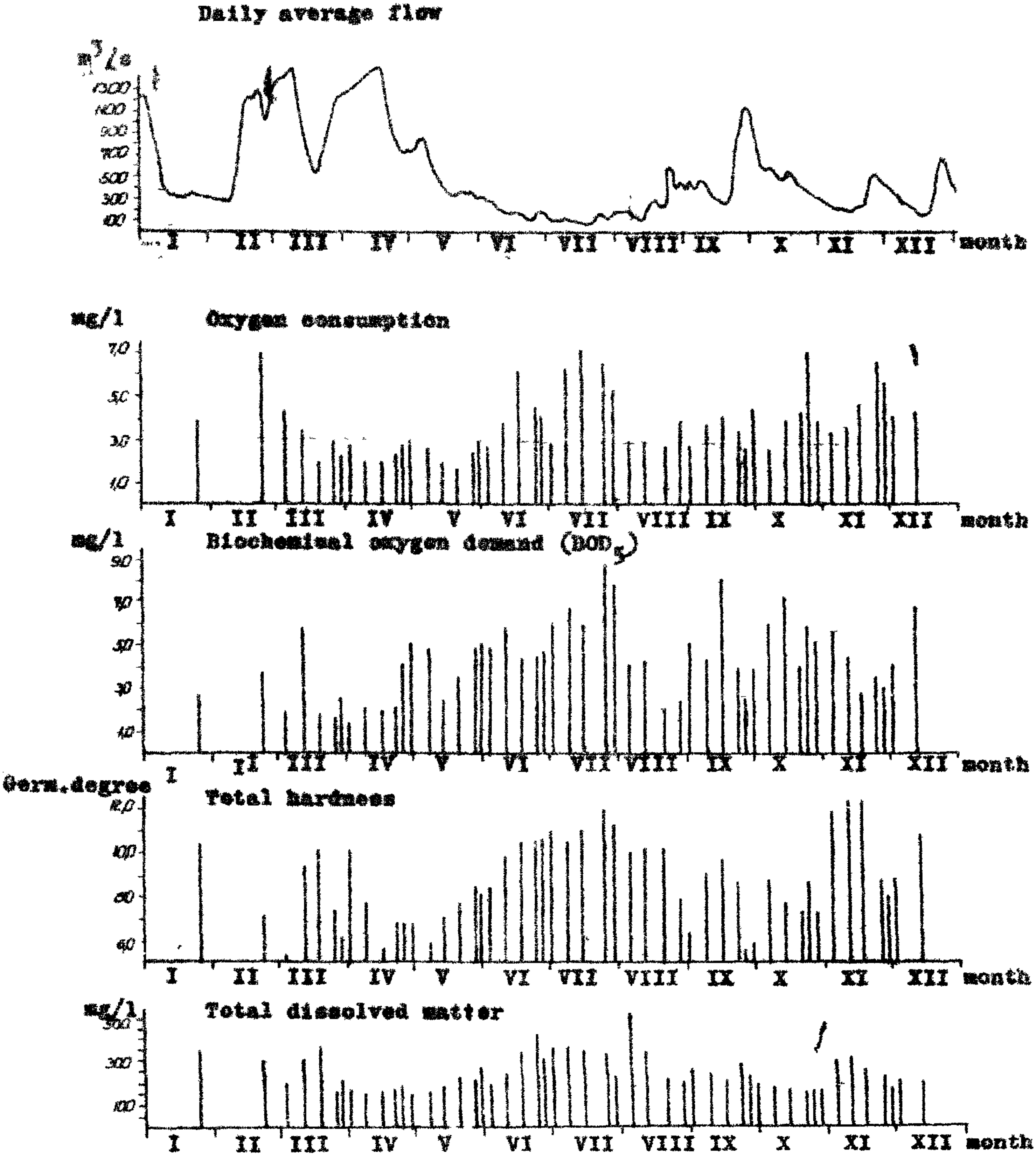
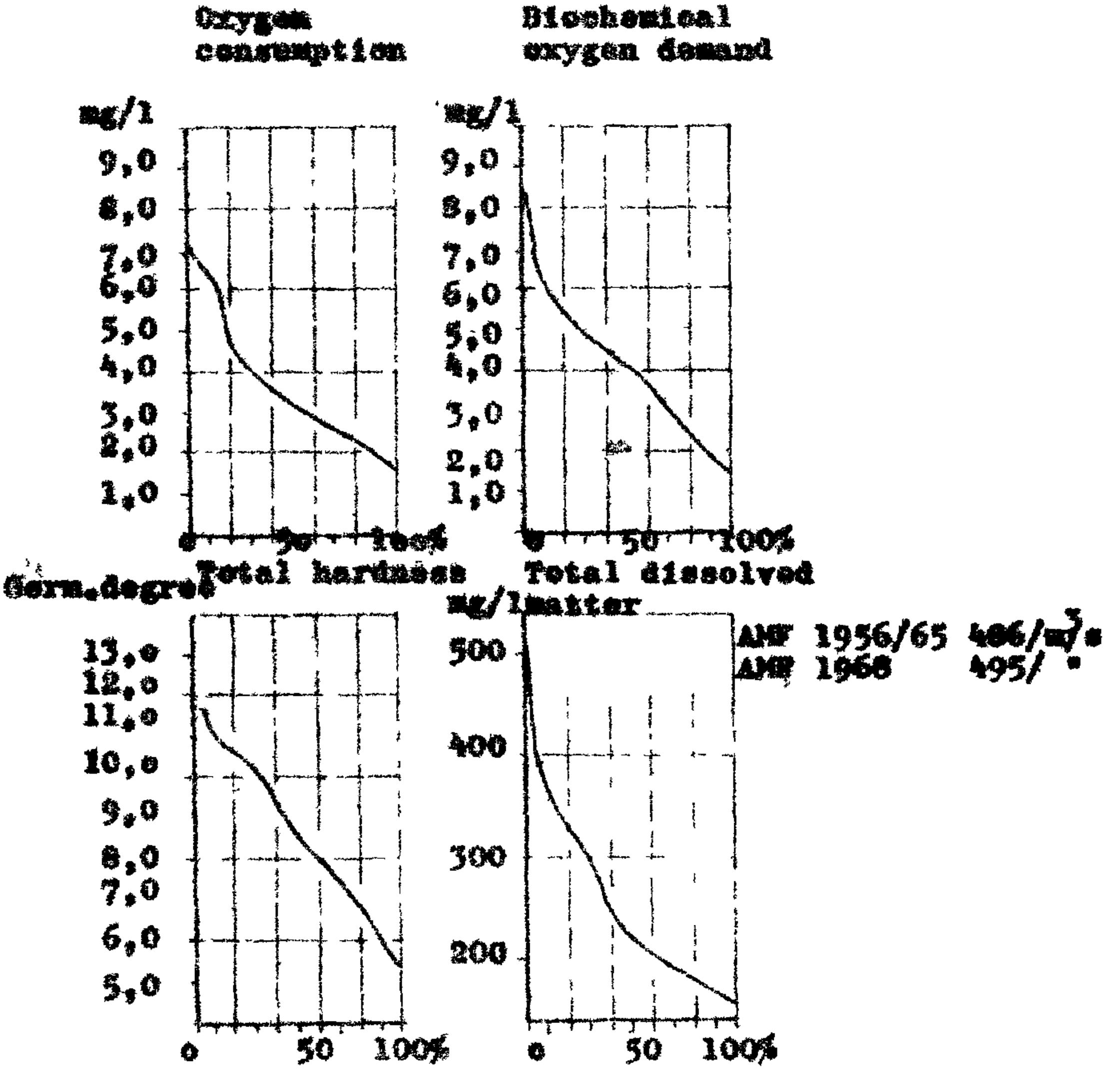
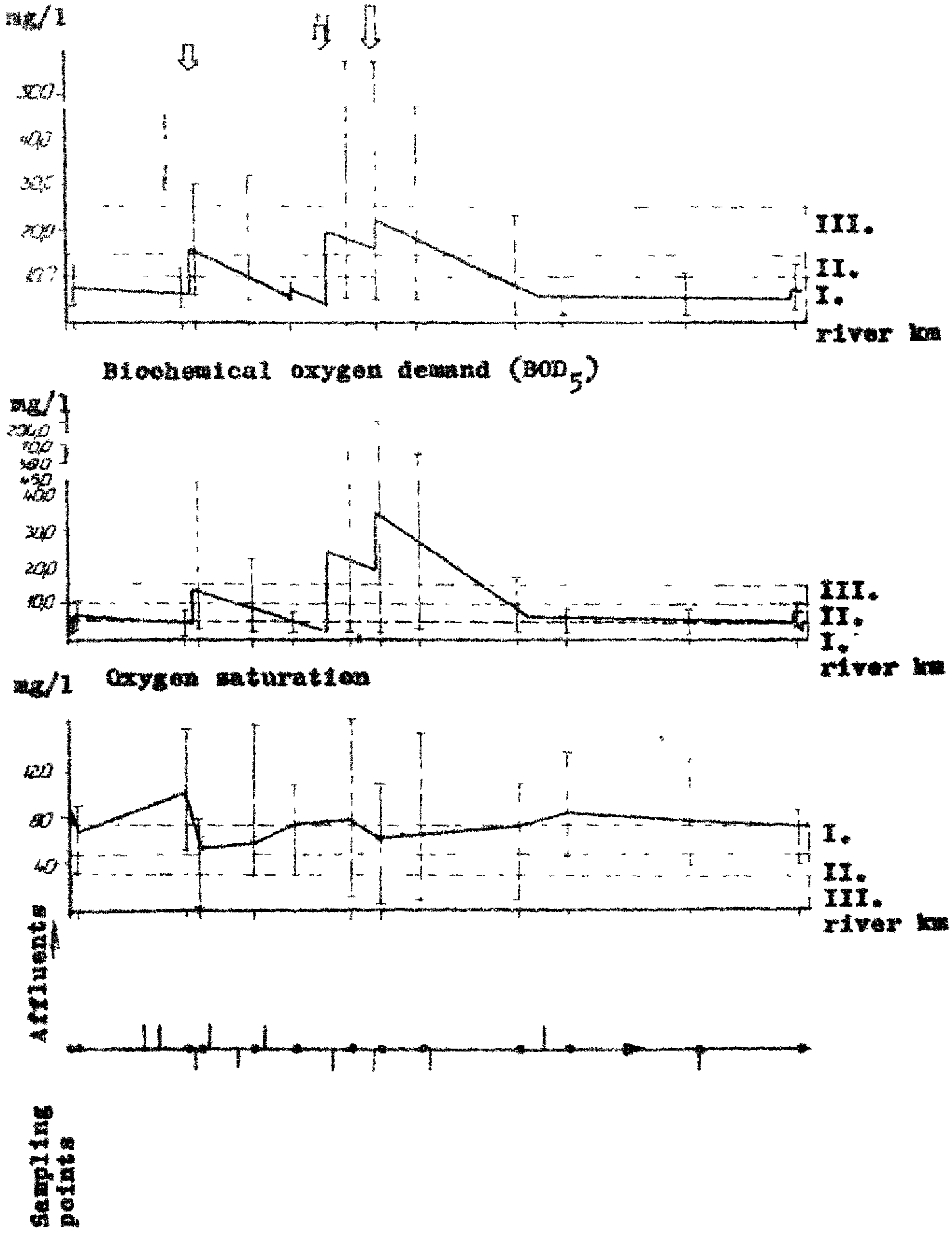


Fig.1 Annual time-series data processing of water quality



AMF = average mean flow

Fig. 2 Duration graph of water quality parameters in the Tisza River, at 26 river km, 1968


Oxygenconsumption

Biochemical oxygen demand (BOD_5)

Oxygen saturation

Fig.3 Longitudinal section of various water quality parameters of the Zagyva river (Hungary)