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Preliminary Investigations to Determine Biological Indicators of Sea Water Pollution by Diatoms - Bacillariophyceae

by

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Summary

In order to study the biological evaluation of pollution of the coastal zone in the Puck Bay in the region of Mechelinki, where the municipal wastes of Gdynia are discharged, preliminary investigations were undertaken to select biological indicators of the diatom group. An empiric method was employed, using as a temporary pollution indicator species of diatoms which developed most numerously in a said polluted area, even if they appeared also in other areas.

Diatoms growing on microscopic slides were investigated. Three glass plates were exposed for a fortnight, five times during the vegetative period 1966.

Already the first studies indicated that nearly all investigated species of diatoms reflect rather the grade of eutrophication of the water environment. This means that they depend directly on the concentration of biogenic salts and therefore develop numerically in relation to the increase of the available nutrients.

The investigations were carried out during the ice-free period andno polysaprobic zone has been found which is due to a very good oxygenation of the water, both by atmospheric and biogenic oxygen. Anyway, the alfa mesosaprobic zone is of a small range, as indicated on Figure 6.

The more important species of diatoms can be provisionally listed according to their indicator value which is given in Appendix I.

Introduction

A comprehensive and accurate estimate of the sea water pollution must be based on complex biological, bacteriological, hydrochemical and hydrographical research. As such a complex research programme requires a great deal of work as well as time and money, it is necessary to look for a simpler method which in relatively short time would supply data for satisfactory estimation of the state of marine environment pollution. We presume that this can be obtained by the biological method. The advantages are - among others - due to the simple and speedy analysis, which even in cases of a single investigation on site, enables to determine the range of the polluted zone and the degree of average pollution over a long period of time, while single hydrochemical and bacteriological investigations specify the water pollution only on the spot of sampling.

Furthermore, a remarkable advantage of the biological method is that it is accepted as a decisive criterion to pass an opinion on the pollution of a water reservoir.

However, in spite of these advantages, no biological method has been elaborated to investigate the degree of coastal sea water pollution, and in spite of the need created by the practice in seaside countries. To meet this need, preliminary investigations have been started to fill gradually this gap in the field of biological analysis. In our opinion, it is necessary to determine the most representative biological indicators of pollution for the respective sea regions. This is of course a very difficult and long-term task, requiring the cooperation of biologists of different specialities, and also hydrochemists, hydro-toxicologists, microbiologists and other specialists. This task can be performed only on the ba is of ecological, biocoenotic investigations carried out in situ and on laboratory experiments with special regard to autecology.

Due to the wide range and the time needed in order to determine the biological indicators of marine environment, pollution in all important taxonomic groups of marine organisms, it is necessary in the first instance to find such indicators from among the most sensitive and at the same time most wide-spread species in the coastal zone which is the one endangered by direct waste discharge in the neighbourhood of big cities.

We are well aware that the most sensitive indicators of the ecological conditions in an aquatic environment are the lower algae which equally well as invertebrates can be used as indicators of sea water pollution or eutrophication.

It is advisable to select in the coastal zone as such indicators of the microbenthonic algae, reflecting the true environmental conditions of the respective local water regions. The marine planktonic algae are less suitable for this purpose due to their continuous dislocation by water currents. They are useful in the open sea, i.e. in regions of great depth, where the microbenthos cannot develop due to lack of light. The typical plankton organisms are useful in the coastal zone only in special hydrographical and meteorological conditions, for instance, during a long calm period and stagnation of waters. As the bibliography specifies, the microbenthos of the coastal zone consists chiefly of diatoms (with a small addition of blue-green algae and other taxons) inhabiting the bottom surface, especially hard bottoms and growing on stones, higher algae, mollusc shells, submerged wood and iron bedding and even on glass. The diatoms grow on the said substances in large quantities and are good indicators of the environment conditions. For this reason, they have been selected as the first subject for preliminary investigations. It was expected to find in this group indicators determining the grade of eutrophication of the coastal sea waters influenced by pollution with municipal wastes, containing a large amount of organic compounds, decomposable in biochemical processes.

Considering the actual protection of the Puck Bay against pollution, the time and technical resources have been limited at the first stage of the investigation for the determination of diatoms occurring in the Puck Bay close to the village Mechelinki, where the municipal wastes of Gdynia are dischared (Figure 1).

The investigation was limited to the identification and quantitative estimation of diatoms growing on microscope slides, exposed five times during about a fortnight in the vegetative period of 1966, from 28 June to 12 July, 8 August to 23 August, 10 September to 19 September, 19 September to 3 October and 14 November to 28 November. In this region, this method was the most representative, since the very mobile sandy bottom deposits destruct a stable growth of bottom diatoms and these have therefore not been considered.

For organisational reasons and because of the need to start another project, up to now only the first stage of the assigned task h's been carried out in the Waters Protection Department of the Water Economics Institute at Gdańsk. The second stage will be undertaken in the Marine Environment Protection Laboratory of the Sea Fisheries Institute at Gdynia where the respective laboratory experiments will also be carried out.

Present state of investigations

It is emphasised that the sea microbenthos algae in general, and especially the diatoms remained until now almost unknown. An initial large elaboration about benthos diatoms of the Black Sea has been prepared by Proskina-Lavrenko (1963) who also investigated the plankton diatoms of that Sea (1955). The same author published together with Alfimov (1954) a paper "About using diatoms for estimation of the sanitary state of sea waters", proving that the benthos diatoms (based on investigatios of one of the Black Sea bays) can be used as indicators of the intensity of water pollution. The authors assume that the sea diatoms had, until their work not been investigated neither in the USSR nor presumably in other parts of the world. However, it should be pointed out that the diatoms determined as indicators by Proskina-Lavrenko and Alfimov for the Black Sea are not represented in our coastal waters, mainly due to lower salinity. Therefore, the determination of similar indicators for the Baltic Sea region along the coast of Poland is still pending.

Simonsen (1962) also states that the knowledge of sea bottom diatoms in general (contrary to the plankton diatoms) has not yet advanced beyond the initial stage. The same concerns the coastal zone of the Baltic Sea. The first note about bottom diatoms of this region was published by Flögel (1873) and the second author to be mentioned is Juhlin-Dannfelt (1881-1882) who included a list of all plankton diatoms and bottom diatoms known at that time from the region. The next publication, in chronological sequence, about diatoms of the Gulf of Kiel is by Karsten (1899). The diatoms of the Gdańsk Bay have also been investigated by Schultz (1926, 1928). Ecological investigations of diatoms from the Finland Bay were carried out by Välikangas (1933) and Mölder (1943) and in the Oresund by Møller (1950). The Swedish Baltic sublittoral zone was investigated by Berg (1952), who also clarified the systematic composition of the diatom flora and determined their biocenotic groupings.

Among the Polish authors, the papers of Mrs Rumek (1948, 1950) deserve to be specially mentioned and also those of Mrs Ringer (now under preparation) who investigated all groups of phytoplankton in the Gdańsk Bay during the year cycle, and works of Mrs Biernacka (1961) about growth on impregnated wood exposed in the water of the Gdańsk Bay.

Other authors have been occupied with epiphytic diatoms, such as Grinbart (1948) and Kucerova (1957). Growth on glass plates and changes in the micro-phytocenoses of diatoms have been investigated at the British shores by Smith (1955), in the Black Sea (Sevastopol Bay) by Dolgopolskaja (1954, 1957, 1959) and in the Odessa Gulf by Lignau (1924-1925).

Works on diatoms as indicators of sea water pollution by Alfimov (1956, 1957, 1959) should also be mentioned.

Hydrological, meteorological and pollution characteristics of the Puck Bay in the region of Mechelinki

The area of the investigated coastal zone of the Puck Bay in the region of Mechlinki in the district of Puck, amounts to 1.5 square kilometres. The length of the water front is 2 kilometres and the outmost station is 1 kilometre off shore (Figure 1).

In the middle of the said water front is the main drain located, discharging the municipal wastes of Gdynia into the Puck Bay. The water front indicated on the drawing is curved with a large diameter. The part to the north of the main drain outlet coincides nearly with the N-S direction, the part south of the main drain outlet is running in the NNW-SSE direction.

The land close to the northern part of the investigated water zone is flat, changing to the south into a cliff, protecting efficiently against the influence of land winds from the west in the section W-SW.

The configuration of the bottom is smooth with small variations. The coastal shelf, about 500 m wide, is sloping by about 10‰, and beyond the 5 m isobath the bottom becomes flat. It is the surf zone.

The maximum depth of the investigated water region is 5.4 m and the bottom is exposed to continuous erosion and accumulation process, caused initially by wave motions. The prevailing bottom soil is therefore sand with a mobility due to wave and current influence which extends to 4 - 5 m depth. This is indicated by the typical bottom ripple marks and fairly large sand grains. It is also important to point out that in the investigated region no waste deposits are observed during the ice-free period. But even when the sea is ice-bound, solid waste matters are deposited only on a small area close to the main drain outlet.

The direction of the current flow in the investigated area depends mainly on the direction and force of the wind prevailing from west. The current direction is in practice the same as the wind direction.

Independently from the force and direction of the wind there is a swell in the Mechelinki region and then in the surface water layer the suspended matter is concentrated in a relatively narrow coastal belt. The width of this belt depends on the angle of the surf to the coast. The smaller this angle is and the grade of surf development, the wider is the zone of concentration of solid matters and vice versa. The belt of concentration is the narrowest, when the surf comes perpendicularly to the shore. For example, on 30 June 1966, the belt was 20 - 30 m wide. At small angles of the incoming surf the speed of the wave current in the sub-surface layer, parallel to the coast, is highest at the same state of surf.

The water temperature in the investigated region of Puck Bay ranged over the year from 19.5°C on 24 July 1966 to 0.5°C on 23 February 1966. During this period there was no vertical gradient of temperature between the surface and 5 m depth. The salinity varied during the investigation period from 5.9‰ on 18 July 1965 to 7.88‰ on 3 November 1966, and the waters of the Puck Bay region was reckoned as alfa-mesohaline. The relatively low salinity of this Puck Bay region has a considerable influence on the scantiness and freshwater maritime character of the diatom species, which were found there.

The water transparency, measured with a Secchi disc, was during the whole period to the bottom. The only exception occurred on 23 February 1966 when it was 0.4 m on Station no 17, close to the main drain outlet. This was caused by a large concentration of solid waste matter. The other regions of the Puck Bay showed a transparency ranging from 4 to 10.5 m during this period.

The bacteriological characteristics , the Coli index of the Mechlinki water region, mean values for three highest measurements (Bacterium Coli number in million per 100 ml) is indicated for all situations investigated in Figure 2. The mean values of the Coli index in millions per 100 ml are specified in Figure 3. The pollution characteristics of the Mechelinki water region are indicated in Figure 4 for all investigated situations, according to mean values of three highest measurements of BOD5 in mg O_2/l. The potassium permanganate oxygen consumption ($KMnO_4$) in mg O_2/l is specified in Figure 5.

Figures 2 to 5 have been prepared on the basis of data furnished by the Waters Protection Department of the Water Economics Institute at Gdańsk, where the biological investigations have also been carried out. Figure 6 specifies the approximate sub-division of the water region into saprobic zones.

Methods of investigation

The periphyton overgrowth on microscope slides, subjected to the preliminary investigations has been collected in the Puck Bay in the neighbourhood of Mechlinki at the stations indicated in Figure 1, with the exception of stations close to the coastline (4, 8, 10, 12, 20, 22, 26, 30). The slides for periphyton investigations have been mounted radially in slots on a large cork threaded on a cord, with a piece of cork fastened at its upper end and a brick or stone at the lower end, serving as an anchor. On stations down to 2 m depth the slides were placed 0.5 m below the water surface. On stations with greater depth, the cord was fitted with another cork with three slides placed 0.5 m above the bottom. The slides were usually exposed for a fortnight, the period being slightly changed during stormy weather. During the year 1966 five such exposures were carried out during the vegetative season. The location of the slides was marked by buoys. The cords with cork were not fastened to the buoys, to prevent knocking off the slides during heavy seas.

Two weeks after they had been set out, the slides were removed and placed in specially covered glass vessels used for dyeing of microscopical preparations. Care was taken to keep the inside of the vessels sufficiently moist during the one hour transport to the laboratory. In the laboratory the vessels were placed with the slides in a refrigerator at a temperature of 4°C. One slide of each exposure level was left for later investigation as a dried preparation. Several hundred such preparations will be submitted to microscopic analysis in the near future. The preparations will be soaked and scraped off into the vessel; organic matter in diatom cells will be removed by oxidation; they will be mounted in pleurax. From the slides designated for immediate investigation after being brought from the sea, the periphyton was scraped with a scalpel and the diatoms flushed into flat-bottomed tubes. The periphyton was designated for preparation of microscopic slides from diatom fustules mounted in pleurax. The species were identified by means of a microscope of 1 500 x magnifying power. Identification keys of the following authors were used : Hustedt (1962-1964), Cleve/Euler (1951-1955), Zabelina et al. (1951), Sieminska (1964), and others.

Review of more significant species

Melosira Juergensi Ag.

To be found in the whole region of Puck Bay, but flourishes in the mesosaprobic region close to Puck, fertilised by municipal wastes at the mouth of Struga Zagórska and in the neighbourhood of Mechlinki, at stations no. 9, 11, 15, 19, 21. Indicates the increase of eutrophication due to pollution of this part of the sea.

Melosira moniliformis (Müll.) Ag.

This species grows in fairly large abundance only close to the waste discharge (stations 11, 17, 18, 19), further off it is gradually replaced by other species. Melosira moniliformis has been found several times by Mrs Biernacka (1961) in the growth on boards exposed at the pier of Sopot. Proskina-Lawrenko and Alfimov (1954) and Alfimov (1956, 1957) have proved that this species grows in very large abundance in bays of the Black Sea which are greatly polluted by municipal wastes and crude oil products. They have included this organism among the polysaprobes. That has, however, not been confirmed by the present investigations, probably because no polysaprobic zone exists in the investigated region, due to intensive mixing of waters and good oxygenation.

Melosira nummuloides (Dillw.) Ag.

This species has been frequently found in the period from spring to autumn together with M. moniliformis in growth in the less polluted betamesosaprobic region of Puck Bay, close to Mechlinki.

Melosira varians Ag.

To be found during the whole year in the Puck Bay zone. However, it is most abundant in the region of medium pollution (about 300 - 500 m) from the waste discharge outlet, which indicates its betamesosaprobic character and is in accordance with the opinion of Hustedt (1962-1964) who considers this species - when in abundance - a typical indicator for medium polluted waters.

Cyclotella meneghiniana Kütz.

Numerously found in the neighbourhood of waste discharge (stations 11, 17, 18, 19) indicating that this species is characteristic of strongly polluted regions (alfamesosaprobic). In the Baltic this species has been found in the phytoplankton of Pojo Bay in Finland, where it had in June 1936 the highest growth (64 800 cells in one litre of water), close to Tenonisaari city which discharges its waste into the said bay (Halme and Mölder, 1958).

Stephanodiscus hantschii Grun.

Has been abundantly found in the considerably polluted region in the belt reaching to about 150 m from the waste discharge outlet. Farther off from the main drain outlet the abundance of this species decreased considerably. It is therefore assumed that the abundant growth of this species indicates the alfa-mesosaprobic character of the water environment. According to Hustedt (1962-1964) this species is widespread both in fresh water and sea water and appears in large quantities in greatly eutrophicated water bodies. In great sub-alpine lakes the distribution of this species is limited to areas highly eutrophicated by domestic sewage.

Actinocyclus Ehrenbergii Ralfs.

Appears in the total region of Puck Bay with the exception of the highly polluted part (in about 200 m distance from the waste discharge outlet at Mechlinki). This species nearly always has been found in a betamesosaprobic and oligosaprobic environment. Proskina-Lavrenko and Alfimov (1954) found it in the Black Sea bays, where the municipal wastes were discharged, however only in parts of medium pollution.

Tabellaria fenestrata (Lyngb/Kütz).

This species has been frequently found in growth of medium polluted parts of the Puck Bay close to Mechlinki (in about 200 - 500 m distance from the waste discharge outlet) in relatively large density. Farther from the pollution source, the abundance of this species decreased considerably. This indicates eutrophic ecological qualities of the species.

Licmophora Ehrenbergii (Kütz) Grun.

To be found in the whole coastal zone of Puck Bay, decreasing gradually until it disappears completely close to Mechlinki when approaching the waste discharge outlet (station 18). Appears quite numerous in the beta-mesosaprobic and oligosaprobic zone. Alfimov (1956, 1957) proved by experiments that L. Ehrenbergii grows most abundantly in sea water which is only slightly polluted and is eliminated from regions polluted by municipal wastes and crude oil products.

Diatoma elongatum (Lyngb.) Ag.

A distinct gradient in abundance in the horizontal distribution of this species has been found in the investigated water region. Maximum growth has been observed in the medium polluted zones, the abundance of the species decrease in a belt beyond 500 m distance from the waste discharge and the species is absent in the alfamesosaprobic zone on station 18, located about 50 m from the main drain outlet. This proves that the D. elongatum should be accepted as a positive indicator of the beta-mesosaprobic zone.

Florin (1957) mentions this species from the brackish waters polluted by domestic sewage in southeast Sweden, close to Södertälje city. Mrs Biernacka (1961) mentions it as a component of growth on boards exposed in the Gdańsk Bay, close to Sopot.

Diatoma vulgare Bory

This species has been found in the periphyton of the investigated region, chiefly in two varieties : var. producta Grun. and var. linearis Grun., which were most numerous in the medium polluted belt. However, they occurred also occasionally close to the waste discharge outlet and is therefore reckoned as betamesosaprobe.

Opephora Martyi Herib.

This species grows most abundantly only in the medium polluted belt where a higher concentration of nutrients stimulate its numerical increase. It has also been found in the oligosaprobic zone, but less numerous. Therefore, its value as an indicator is limited and concerns not exactly the concentrations of organic waste matter as biogenic salts. Anyway this concerns all betamesosaprobic diatoms which are most numerous in eutrophic waters.

Synedra pulchella (Ralfs) Kütz.

This species has been very frequently found in the periphyton close to Mechlinki. The relatively highest density of this species was found in the mesosaprobic zone; in the oligosaprobic zone it was less numerous. Due to this, it is included among indicators increasing eutrophication rather than among saprobity indicators. However, the trophicity and saprobity are inseparable symptoms of production and destruction of organic matter in a water body.

Synedra tabulata (Ag.) Kütz.

In the Mechlinki region, this species is one of the most important in regard to periphyton diatom frequency of appearance and numerical strength. Due to the fertilising influence of sewage, it was most numerous in the betamesosaprobic zone, but in the oligosaprobic zone the periphyton communities decreased considerably. However, it never dropped to zero.

Synedra tabulata does not avoid the most highly polluted zones close to the waste discharge outlet (station 18), where it was quite numerous due to the favourable oxygenation of the water. It should be noted that a high concentration of oxygen in water enables the existence of many species of relatively low saprobity, even in an environment heavily charged with easily decomposable organic matter. It seems also that S. tabulata can be included among the indicators of the betameso-alfa-mesosaprobic zone.

In the Black Sea bays, polluted by municipal wastes and crude oil products, this species appears in the medium polluted zone (Proskina-Lavrenko and Alfimov, 1954).

Cocconois pediculus Ehr.

This species appears frequently in the periphyton of the investigated region and grows fairly well, only in the mesosaprobic zone. In the oligosaprobic zone there are only a few specimens found in the periphyton communities. It seems that it should be included among the betamesosaprobes.

Cocconeis placentula Ehr.

This species has been found close to Mechlinki in largest numbers in the fertilised betamesosaprobic zone. However, C. placentula does not avoid the most highly polluted areas (stations 17 and 18) where it grows fairly numerous. Regarding the ecologic requirements, it is eurytropical.

Cocconeis scutellum Ehr.

The horizontal distribution of this species in the investigated water region close to Mechlinki is marked by a gradual increase in numbers as it approaches the most highly polluted area. It appears however, also fairly numerous in pure water.

Rhoicophenia curvata (Kütz) Grun.

This species is found on all periphyton slides of the investigated area of the water region close to Mechlinki. Maximum growth has been observed in the spring and summer season, in medium and highly polluted zones, which speaks for its betameso-alfa-mesosaprobic character. In the oligosaprobic zone this species developed only in small numbers, but was always present in the periphyton communities.

Diploneis didyma Ehr.

This diatom has been found on all stations of the investigated water region at Mechlinki. It appeared fairly numerous in the polluted zone only, but in the zone of pure water it was found only singularly. The increase of this species in density in the betameso-alfa-mesosaprobic zone for which it is an indicator, is explained by the fertilising effect of wastes and at the same time the favourable conditions of oxygenation of the water which showed nearly 100% saturation during the whole period of investigation.

Navicula cuspidata Kütz

In larger numbers it appears only in the betameso-alfa-mesosaprobic zone. In the other parts of the Mechlinki water region the abundance of this species decreases gradually as one moves away from the waste source in the direction of oligosaprobic waters, where the species appear only singly.

Navicula cryptocephala Kütz

Navicula humerosa Breb.

Navicula menisculus Schum.

Navicula viridula Kütz

These four species are the most numerous ones in the highly polluted zone (stations 11, 17, 18, 19) and occur also quite numerously in a medium polluted zone. In areas of the Mechlinki water region, which are only slightly polluted, and in pure areas they appear only in small numbers or singly. They should therefore be qualified as alfameso-betamesosaprobes.

Navicula rhynchocephala Kütz

The horizontal distribution of this species in the investigated area shows clearly a quantitative differentiation. It avoids the highly polluted zones and forms the most numerous population in the betamesosaprobic water belt and a less numerous population in the oligosaprobic zone. It can therefore be reckoned as a betamesosaprobe increasing in number with higher fertilisation of the marine environment with nutrients. It should be emphasised that this species is an indicator of increased eutrophication in the area of its most numerous appearance.

Amphora coffeaeformis Ag.

This species was most numerous in the medium and highly polluted zones, but in the oligosaprobic zone its participation in the periphyton dropped to single or occasional occurrence. Therefore, *A. coffeaeformis* can be considered as an alfameso-betamesosaprobic indicator.

Gomphonema olivaceum (Lyngb.) Kütz

This species increase in number in the alfameso- and betamesosaprobic zones, where it appeared in great quantities, dominating the periphyton community. This shows that in brackish water a mass appearance of this species is a betameso-alfa-mesosaprobe indicator. In the oligosaprobic zone this diatom appeared also in the periphyton but its participation in multi-species communities was small.

Epithemia sorex Kütz and *E. turgida* (Ehr.) Kütz

These species appear in great numbers only in medium polluted zones, but in highly polluted water regions and in pure waters they occur only occasionally or singly. They are therefore reckoned to belong to the betamesosaprobic group.

Nitzschia dissipata (Kütz.) Grun.

Nitzschia holsatica Hust.

Nitzschia sigma (Kütz.) W.Sm.

These above three species appear fairly numerously in the medium polluted zone and as single specimens in the oligosaprobic zone. Since they avoid higher polluted water regions, they should be described as betamesosaprobic indicators.

Nitzschia palea(Kütz) W.Sm.

Based upon the numerical appearance of this diatom close to the drain discharge outlet, also in the alfa-mesosaprobic zone, and the decrease to single or occasional appearance in areas located farther off the source of waste discharge, it is considered as an alfa-mesosaprobic indicator.

General methodic comments

The initial experience obtained by applying the glass plates has shown that an understanding of the sedimentary populations as well as the dynamics of periphyton development and its periodic changes can be obtained by using the glass plates. This may also be the only method to provide a microscopic verification and record the abundance of species, without disturbing their further development. From the taxonomic composition of diatom populations appearing in polluted and pure water regions - and this should be the basic principle for investigating the state of pollution in any water body - the following regularity is observed. In the pure water zone the taxonomic composition is very diversified and rich, with several tens of species on one microscopic slide. As the source of pollution is approached, the number of species decreases considerably, but the abundance of the remaining species does not diminish, but usually increases due to mass development of one or a few species which can exist in homogenous conditions of the environment concerned. In other words, as the biotope conditions become more extreme, i.e. the more they depart from the optimum for most of the species, the number of species in the community decreases, although the remaining ones may be very numerous. Therefore, with the more diversified ecologic conditions in the area occupied by a specific community, the richer it is in species.

When a water region is influenced by anoverhelming factor (for example wastes) operating continuously during a long period of time, this one-sided influence seems to suppress the effect of the other, weaker factors. This, however, does not mean that they have ceased to operate. The composition of the species community however, do not any longer depend on them, but on the mighty influence of one or a few factors acting without interruption.

Such an ecological situation prevents the development of a diversified community and stabilises a relatively small number of species capable to live under such peculiar conditions. It should be noted that the zone of the phytocenotic optimum for this small number of dominating species do not necessarily agree with their ecologic optimum zone, nor with their phytocenotic area.

For the initial solution of indicator diatoms we have, for practical reasons used an empirical method. When a species of diatoms developed most numerously in a given pollution zone, even if it appeared also in other zones, it has been accepted as indicator for the zone where it was most numerous, since the number of diatoms in the periphyton characterise the class of water purity. At the same time it has been realised that among the diatoms there are strictly speaking no real saprobiants nor even saprophils but really only pseudo-saprophils (usually called saprophils), saproxenic and indifferent forms. The species indicating the respective grades of pollution (saprobes) should have a narrow ecologic specialisation and a known range of tolerance for respective ecologic factors. This will be the object of future investigations. The tolerance for pollution obtained initially by the empirical method is for the time being only of approximate character and must be supported by experiments which will finally reveal their indicatory value.

We realise that nearly all the described species reflect rather the eutrophication degree of the marine environment than its grade of saprobity. This concerns especially the oligosaprobic grade in which there are no real saprobes at all. Only the alfa-mesosaprobic species and such betamesosaprobic ones,the development of which in a suitable pollution zone is explicitly depending on surplus of unstable organic matter or on products of their decomposition, can be considered as real saprobes.

In a quite different way the reconstruction in a biotope of the previously natural community of species should be evaluated and which had previously been eliminated aue to waste effect. Even most of the mesosaprobic species are not direct consumers of organic matter as such but they tolerate it (and the ecologic consequences of its decomposition) better than other species. Therefore, they are free from competition and furthermore they make use of biogenic salts resulting from mineralisation of pollutants (phosphates, nitrates, ammonium salts). Such species are indicators of trophy and have nothing in common with the organic substances and decay. Therefore they are not described as saprobes which are characterised by direct dependence on the organic matter decomposed during biochemical processes. The trophic indicators in the betamesosaprobic zone predominate completely. Proceeding to the oligosaprobic zone, the species are nearly completely trophic indicators, not saprobic ones. Therefore, they do not allow us to estimate whether their optimum conditions are the result of the allochthonal (anthropogenic) pollution or if they originated due to the process taking place autochthonously in situ. Only their appearance in the adjacent area of self-purification in the open sea where it is easy to find a natural point of comparison, indicates some relation of such species to the pollution.

The present initial investigation to select species indicating the grade of pollution of the marine environment seems to confirm the possibility of using diatoms which are very numerous in the sea. Some samples taken for diatom analysis allow for a relatively quick evaluation of the average state of longtime pollution of a sea area.

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Name of Species	Proposed Indicator Value
Melosira moniliformis /Müll./ Ag	- alfamesosaprobe
Cyclotella meneghiniana Kütz.	"
Nitzschia palea /Kütz./ W. Sim.	"
Stephanodiscus hantzsc. ' Grun.	- alfameso-betamesosaprobe
Navicula cryptocephala Kütz.	"
" humerosa Bréb.	"
" menisculus Schum.	"
" viridula Kütz.	"
Amphora coffeaeformis Ag.	"
Synedra tabulata /Ag./ Kütz.	- betameso-alfamesosaprobe
Cocconeis scutellum Ehr.	"
Rhoicosphenia curvata /Kütz./ Grun.	"
Diploneis didyma Ehr.	"
Navicula cuspidata Kütz.	"
Gomphonema olivaceum /Lyngb./ Kütz.	"
Cocconeis placentula Ehr.	- betamesosaprobe /alfameso/
Melosira Juergensi Ag.	- betamesosaprobe
" nummuloides /Dillw./ Ag.	"
" varians Ag.	"
Tabellaria fenestrata /Lyngb./ Kütz.	"
Diatoma elongatum /Lyngb./ Ag.	"
" vulgare Bory	"
Cocconeis pediculus Ehr.	"
Navicula rhynchocephala Kütz.	"
Epithemia sorex Kütz.	"
" turgida /Ehr./ Kütz.	"
Nitzschia dissipata /Kütz./ Grun.	"
" holsatica Hust.	"
" sigma /Kütz./ W. Sm.	"
Actinocyclus Ehrenbergii Ralfs	- betameso-oligosaprobe
Opephora Martyi Hérib.	"
Synedra pulchella /Ralfs/	"
Licmophora Ehrenbergii /Kütz./ Grun.	- oligo-betamesosaprobe.

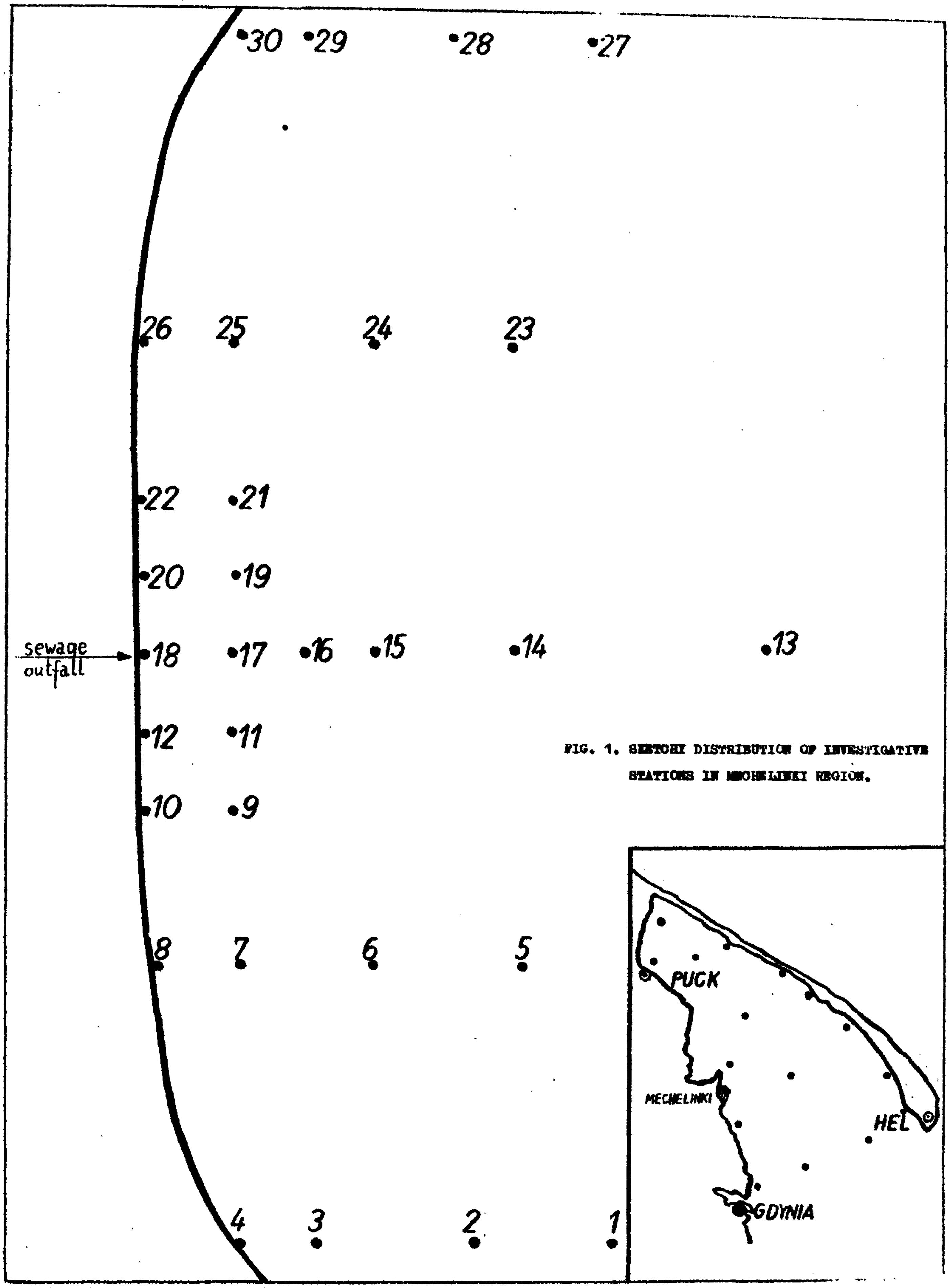

FIG. 1. SKETCHY DISTRIBUTION OF INVESTIGATIVE STATIONS IN MECHELINKI REGION.

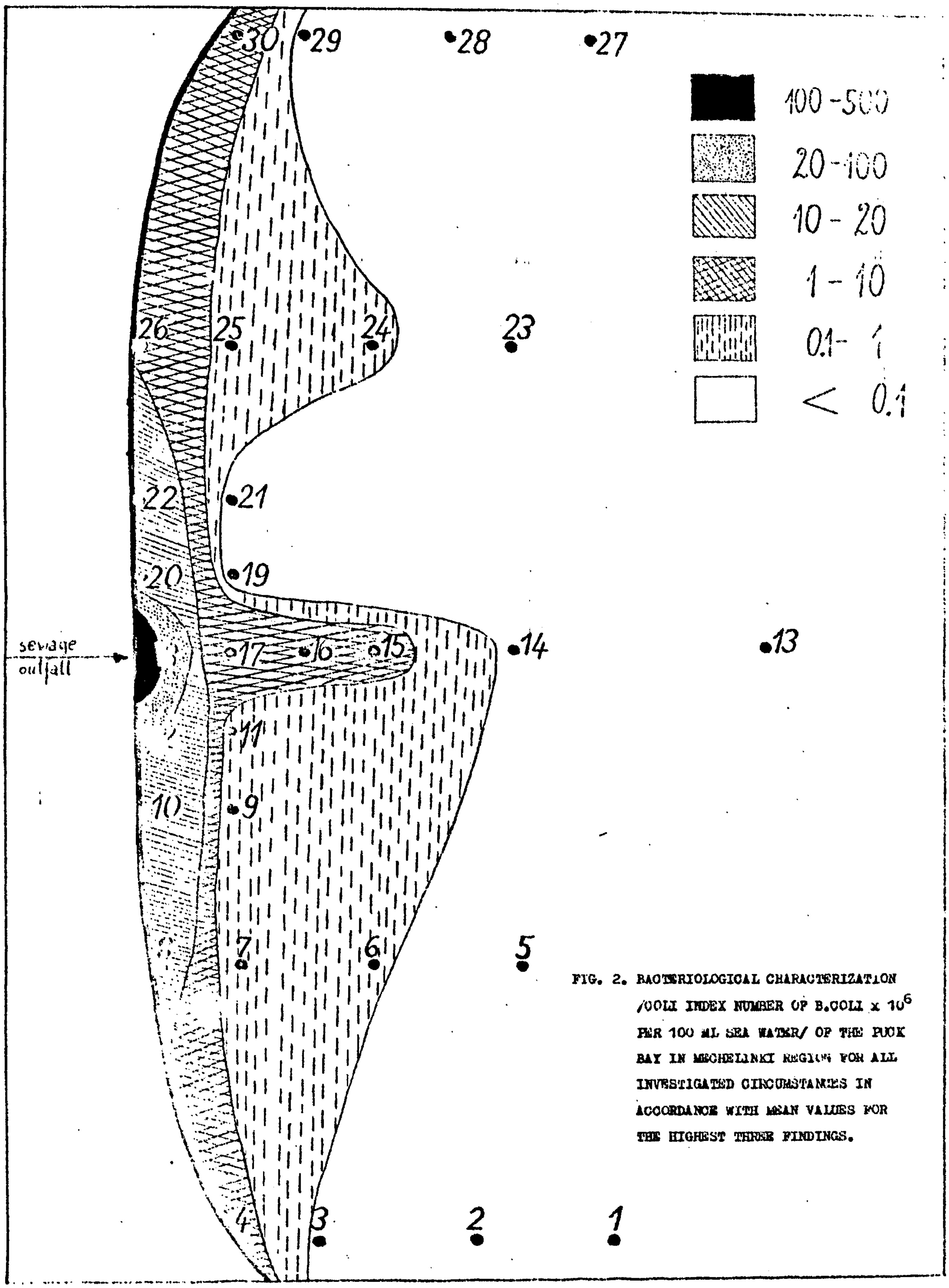

FIG. 2. BACTERIOLOGICAL CHARACTERIZATION /COLI INDEX NUMBER OF B.COLI x 10^6 PER 100 ML SEA WATER/ OF THE PUCK BAY IN MECHELINKI REGION FOR ALL INVESTIGATED CIRCUMSTANCES IN ACCORDANCE WITH MEAN VALUES FOR THE HIGHEST THREE FINDINGS.

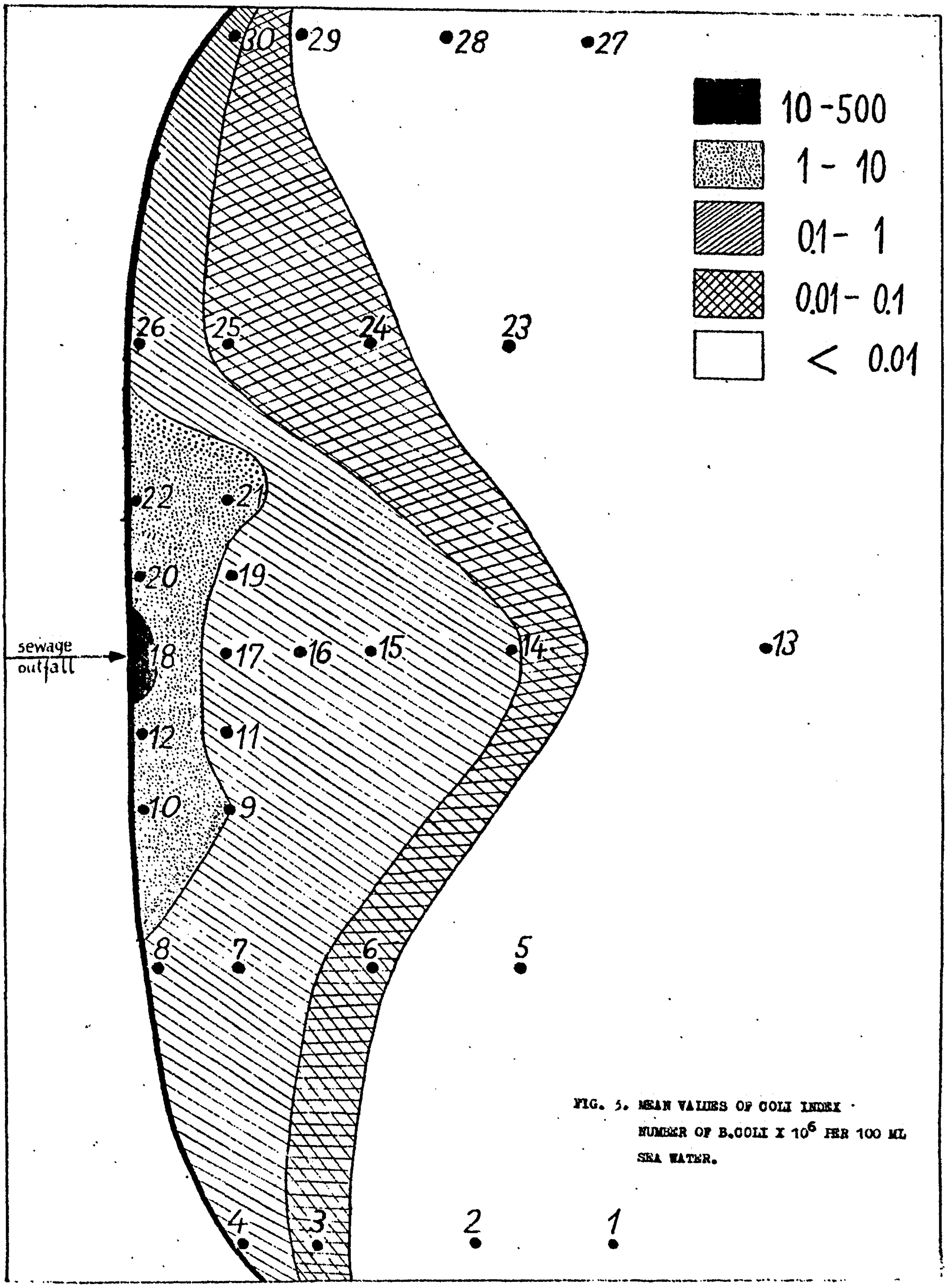

FIG. 5. MEAN VALUES OF COLI INDEX
NUMBER OF B.COLI X 10^6 PER 100 ML
SEA WATER.

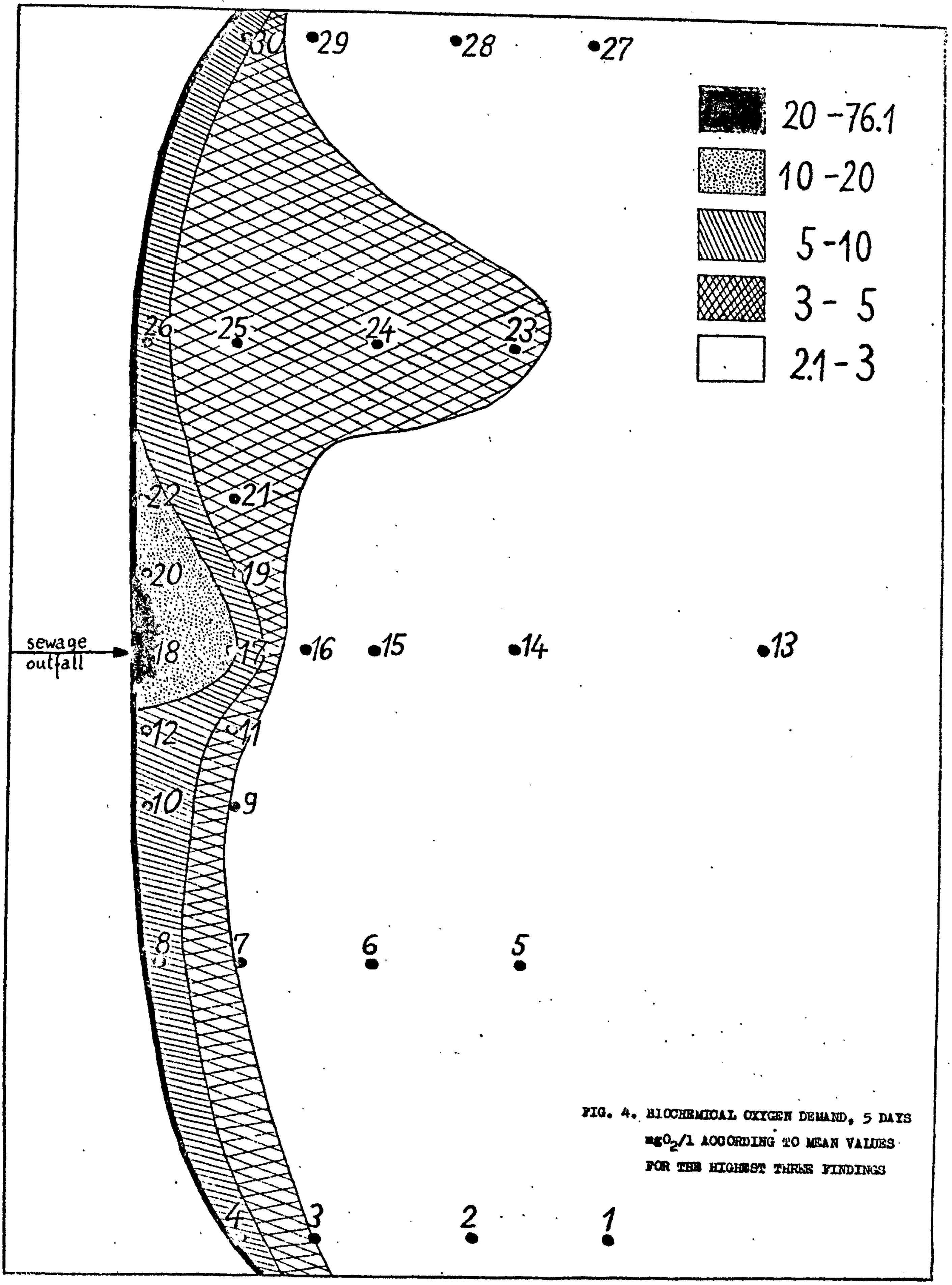

FIG. 4. BIOCHEMICAL OXYGEN DEMAND, 5 DAYS mgO_2/l ACCORDING TO MEAN VALUES FOR THE HIGHEST THREE FINDINGS

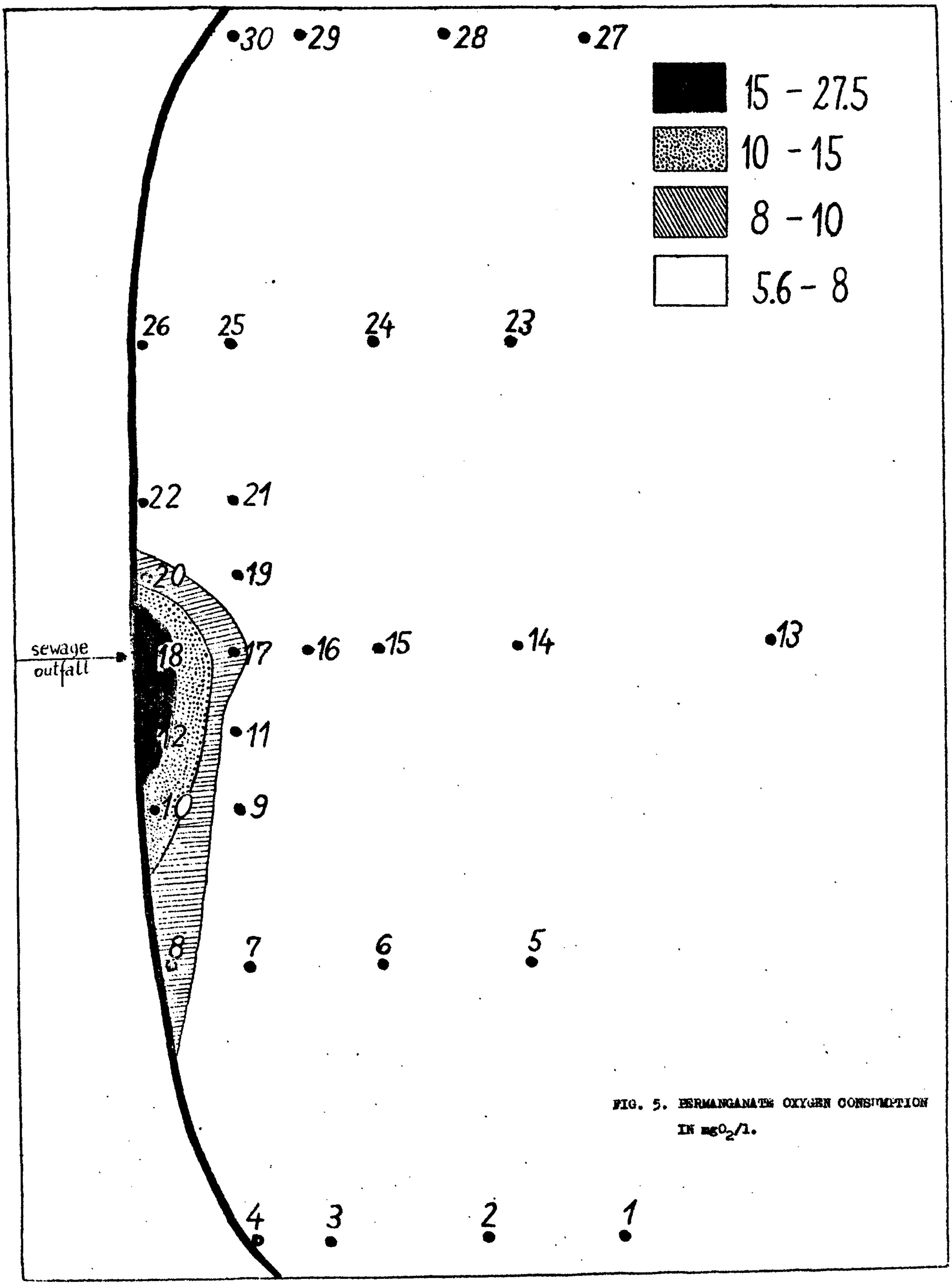

FIG. 5. PERMANGANATE OXYGEN CONSUMPTION IN mgO_2/l.

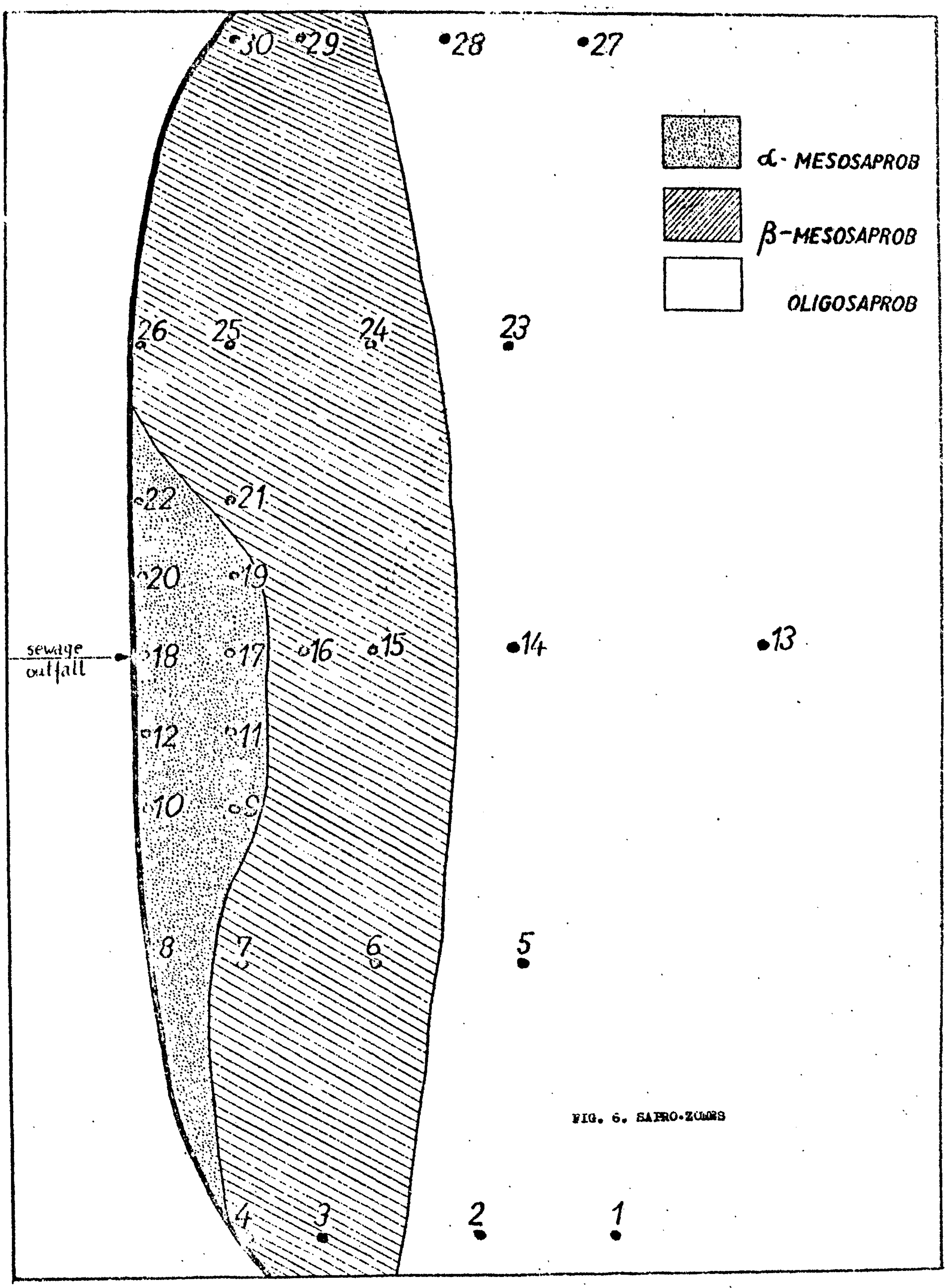

FIG. 6. SAPRO-ZONES