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INVESTIGATION OF THE SEWAGE POLLUTION ZONE IN THE MARINE COASTAL WATERS BY CHEMICAL AND BACTERIOLOGICAL INDICES

Contents:

1. INTRODUCTION

The high costs of full sewage purification are the reason for the growing tendency to design discharges of partially-purified sewage into marine coastal waters. With the standard of knowledge at its present level, it is technically and technologically possible to introduce almost every enterprise in the universal utilization of sea water. The basic condition for execution however, is to learn the laws of the processes occurring in the sea. A region about which little is known is the surf zone and the adjacent shallow transient area.

Investigations conducted by many countries have helped to explain many important elements, but have not facilitated the formulation of the proper model defining the mechanism of processes and enabling the forecasting of intensity and character for different practical purposes. Theoretical problems connected with mathematical models describing the processes of dispersion of sewage and self-purification of sea water are being worked out at present, but there is a lack of examples of application to experimental data [2, 8, 14, 18, 22].

Theoretical and empirical investigations of sea turbulence are poorly developed in Poland as yet and it is impossible to obtain an overall opinion on conditions and the degree of dispersion of pollution.

The first contemporary Polish paper on random hydrodynamic processes was published in 1975 by Zeidler, who analyzed the factors influencing the transportation, dilution and decay of sewage and heated water in the near-shore zone of the sea.

It is planned to build several large collective sewage treatment plants disposing sewage to the near-shore zone on the central Polish coast, by 1990. This has necessitated the presentation of the existing background of pollution of nearshore waters, adjacent to inflows from the land and empiric investigations of the range of dispersion in the near-shore zone on the central coastal area. Based on field-laboratory observations in 1960—1975 and on analysis of wind conditions, it was attempted to link the occurrence and range of particular levels of pollution of near-shore waters with that of rivers and port channels, as well as submarine discharge of sewage. The results are important for recreational and thalassotherapeutic purposes, as well as economic and investment prognoses.

2. THEORETICAL ASSUMPTIONS

2.1. CHARACTERISTICS OF THE SOURCES OF POLLUTION OF THE SOUTHERN BALTIC

About 140 million people inhabit the Baltic basin, which is the source of about 15% of the world's industrial production and in which intensive land cultivation takes place. It results from the analysis of the source of pollution in the Baltic given in the ICES Working Group Report [12] that of the total quantity of municipal wastes discharged into the Baltic as BOD_5 (biochemical oxygen demand) in tons/year directly (298,300) and indirectly (94,500), Poland's share is 6,200 and 3,600 tons BOD_5/year.

The purity of Poland's near-shore waters in the southern Baltic depends mainly on the discharge of impurities from the Odra and Vistula and to a lesser extent the rivers of the western coastal region. As compared with the impurities carried by the Vistula and Odra, amounting to 414,977 kg BOD_5/d, the rivers of western Przymorze are [21].

Parsęta	35,736 m^3/d sewage with 13,983 kg BOD_5/d
Wieprza	15,132 m^3/d sewage with 4,050 kg BOD_5/d
Słupia	45,739 m^3/d sewage with 15,341 kg BOD_5/d.

2.2. METHODS OF DETERMINING THE SPREAD OF RIVER WATERS INTO THE SEA AND THE SEWAGE POLLUTION ZONES IN THE MARINE COASTAL WATERS

The hydrological influence of river waters on the nearshore zone of the sea depends mainly on the quantity of influx, depth of shelf and meteorological conditions existing.

To facilitate the assessment of the influence river waters have on near shore waters, the spatial value of the coastal zone which the river waters alone would occupy over the period of a year is defined, assuming that these waters branch out radially to the estuary. According to Mikulski [23] this space is defined by the volume of a section of a cylinder with a radius equal to the reach of the river waters and bottom slope angle:

$$V = \frac{2}{3} hr^2 = \frac{2}{3} r^3 \tan \alpha \quad (1)$$

hence the radius can be calculated

$$r = \sqrt[3]{\frac{3}{2} \cdot \frac{V}{\tan \alpha}} \quad (2)$$

Given the most frequent bottom inclination of 1% in our nearshore zone ($\tan \alpha = 0.01$) we obtain

$$r = \sqrt[3]{\frac{3}{2} \cdot \frac{V}{0.01}} = \sqrt[3]{150 \cdot V} \quad (3)$$

The radius for various capacities of river influx can be calculated from the above formula

V km³	0.5	1.0	5.0	10	30
r km	4.2	5.3	9.1	11.4	16.5

(4)

It seems therefore, that apart from the Vistula and Odra, the range of Poland's other rivers into the sea is a bare several kilometre section of the near-shore zone.

To give an approximate image of the spread of inland waters in the sea, Majewski [20] proposes to take the lower salinity of water relative to the average existing in the given region of the Baltic. Applying a 7‰ isohaline he marked out an approximate belt of the near-shore zone subject to the influence of river waters. From this it results that the river waters have the greatest effect on the Gulf of Gdańsk, where they reach as far west as Łeba. A substantial part of the Bay od Pomerania is also affected by river waters inflowing from the Szczecin Lagoon, but the reach of river waters in the stretch of the central coast is not very great.

Due to the dynamics of sea water in the near-shore zone, and also for measurement-technical reasons, the salinity is not such a good index of the surface reach of inland waters into the Baltic.

The hydrological spread of river waters into the sea, defined by various methods, is not equivalent with that of the impurities and pollution carried by them. The discharge of sewage into the sea or rivers flowing into it, results — depending upon local conditions — in the occurrence of polluted near-shore zone of varying reach.

The self-purification processes of sea waters are more complicated and less understood than analogous processes taking place in inland waters. Several authors are of the opinion that the ability of sea water to purify itself is much less, due to the lower (by about 20%) oxygen content as compared with fresh water of the same temperature [6, 23].

The nitrification processes in the biochemical oxydation cycle are delayed and slower. In view of the greater amount of dissolved substances, sea water is less able to absorb components originating from sewage than is fresh water. The survival, in sea water, for long periods, of bacteria from the coli and Salmonella group [7], is stressed and the mechanisms of bionecrosis of bacterial flora are not yet well understood. Mitchel and Morris's [24] studies indicate that the speed of necrosis of sewage organisms increases with the increase in population of indigenous marine microflora. At least two groups of bacteria related to the necrosis of Escherichia coli have been found. The first group, Pseudomonas causes death by enzymatic decomposition, the second — Bdellovibrio — is a parasite of the coli group organisms, utilizing the whole cell as a source of carbon.

In investigations of the phenomena of the mixing and retention of sewage in coastal waters, it is recommended that such trace elements as radioactive markers ^{82}Br [4], ^{131}J and fluorescent stains as rhodamine B or its derivatives [3], be used. Iwai [13] proposed a mathematical model of pollution dispersion based on investigations using fluorescent stains. Comparison of aerial photographs of the propagation of stain clouds, with the results of an analysis of its concentration in water established the reliability of both methods. The use of fluorescein in such investigations is criticised, however, in view of the rapid break-down as the effect of insolation (50% in 3 hours). Aitsam [1] used stochastic models to forecast the quality of sea water polluted by sewage.

Most researchers, however, define the spread of sewage pollution transported by sea currents or the mixing of water layers by the occurrence of certain chemical microelements or bacteriological indices of intestinal organisms — mainly Escherichia coli. There is no doubt that E. coli as fecal micro-organisms isolated in sea water, are brought there with river waters or sewage; they are thus allochtonic, invasive, with short-term development possibilities.

Coli bacteriophages [17], bacteria of the Salmonella group [5] and viruses of the alimentary duct [10] are detected to investigate the range of transportation of impurities other than E. coli. The test for the presence of B. coli of the fecal type is one of the most accurate of to-day's tests for the detection of fecal pollution of water.

The first to determine the reach of near-shore sewage pollution zones from the coli index on Poland's central coast, were Korzeniewski and Korzeniewska [15, 16], who indicated a correlation between the presence of sewage and the prevailing wind directions.

3. MEASUREMENT METHOD

Bacteriological analyses and chemical analyses of trace substances were applied to determine the range of propagation of sewage pollution in coastal waters. The chemical analyses consisted in the detection of specific substances present in industrial sewage of low biodegradation (phenols, detergents), as compared with the total organic substances expressed by the BOD_5 index. Anion active detergents (D) were determined by colorimetric method in the presence of methylene blue, phenols (Ph) colorimetrically with 4-amino-antipyrine after introducing coloured compounds to the chloroform layer. *Standard Methods* [29] were applied for all determinations.

The bacteriological analysis of water consisted in determining the total quantity of psychrophyllic and mesophyllic bacteria in 1 cbcm of water and the detection of coli-group bacteria [31]. Examination of the total number of bacteria was by plate method on standard agar at a temperature of 20°C for 72 hours, (psychrophylls) and 37°C for 24 hours (mesophylls).

The coli group bacteria were detected by test-tube fermentation method in four stages:

1. preliminary investigations on a modified Eijkman medium for 24 or 48 hours;

2. corroboration tests following positive or doubtful preliminary investigations, on an Endo medium at a temperature of 37°C for 24 hours, on a medium with brilliant green at 44°C and on peptone water;

3. supplementary tests, adopted in cases when untypical bacteria suspected of belonging to the coli group appear on the Endo medium (oblique agar, microscope preparation, medium with lactose and Andrade reagent, test for cytochrome oxydase);

4. final test consisting in establishing whether or not the bacteria which do not indicate the ability for gas fermentation of lactose belong to the coli group.

The results are given in coli titres. All water samples taken direct from the sub-surface to a sterile bottle with a ground in stopper, were diluted to 0.0001 cbcms and cultivated in two parallel volumes.

The research group had the „Kontroler-25" patrol boat belonging to the Maritime Office in Słupsk at its disposal and bearing stations ashore directing the vessel to permanent sampling stations. The measurement points were distributed in the corners of grid squares with 1 mile sides (1,52 metres), also at contact points between water and land.

4. RESULTS AND DISCUSSION

Of the quantity of investigations characterizing the process of propagation of pollution in the 150 km belt of nearshore waters analyzed, three sets of data have been chosen, these referring to the propagation of sewage:

1. industrial — from the Fibreboard and Chipboard Factory at

Karlino, discharged into the sea by an 800-metre long submarine sewage drainage channel under Ustronie Morskie — about 4,200 cbm/day;

2. municipal — about 8,00 cbm/day discharged into the sea down an 80-metre long submarine sewage drain at Grzybowo to the west of Kołobrzeg;

3. discharged with the waters of the River Parsęta.

As no systematic measurements of wave elements or current characteristics are conducted in the region investigated, the results of research were compiled with the system and velocity of winds and their recurrence over periods of several years. The data from Tables 1—2 give some idea as to the frequency with which winds from particular directions occur during the year, separately for each of the four seasons (Admiralty sailing directions for the Baltic 1969). During the summer, for instance, 42.6% of the winds in the Kołobrzeg region were N-NW and W and at Ustka — 48.7%. Table 3 gives the winds on the central coast according to their speeds.

In the region of the submarine discharge of sewage from the Fibreboard and Chipboard Factory, the propagation of pollution in the near-shore waters was investigated by bacteriological methods (the total number of psychrophyll and mesophyll bacteria as well as coli titre), also chemical methods (BOD_5, phenols). Chemical methods could be applied in view of the homogeneous, average composition of the sewage. The characteristics of the waste discharged by the factory, to the sea, were: $BOD_5 \pm$ 8,700 kg/0_2/d, oxygen consumption $\pm$ 9,100 kg/0_2/d, suspended matter $\pm$ 2,600 kg/d, phenols $\pm$ 5.8 kg/d.

Table 1

Tabela 1

Winds on the central coast (*Admiralty sailing directions for the Baltic*) [19]
Percentage (mean) according to direction of winds in Kołobrzeg

Wiatry przy wybrzeżu środkowym (*Locja Bałtyku*) [19]
Podział procentowy (średni) według kierunków występowania w Kołobrzegu

Months Miesiące	Wind directions Kierunki występowania wiatrów								
	N	NE	E	SE	S	SW	W	NW	cisza
December — February Grudzień — Luty	3,9	7,2	9,0	12,7	15,6	26,8	13,4	7,2	4,2
March — May Marzec — Maj	13,6	19,4	8,5	8,5	6,0	10,5	17,7	9,0	6,8
June — August Czerwiec — Sierpień	9,6	14,8	5,9	4,1	7,3	16,8	24,2	8,8	8,5
September — November Wrzesień — Listopad	5,6	7,5	9,3	11,4	14,8	23,2	13,5	8,1	6,6

Table 2

Tabela 2

Winds on the central coast *(Admiralty sailing directions for the Baltic)* [19]
Percentage (mean) according to direction of winds at Ustka

Wiatry przy wybrzeżu środkowym *(Locja Bałtyku)* [19]
Podział procentowy (średni) według kierunków występowania w Ustce

Months Miesiące	Wind directions Kierunek występowania wiatrów								
	N	SE	E	SE	S	SW	W	NW	cisza
December — February Grudzień — Luty	6,0	5,0	8,4	12,5	19,3	23,4	13,7	9,1	2,6
March — May Marzec — Maj	9,8	18,8	9,8	9,3	8,3	9,5	19,7	10,2	4,6
June — August Czerwiec — Sierpień	7,5	14,3	6,4	5,5	7,8	12,1	26,5	14,7	5,2
September — November Wrzesień — Listopad	7,1	5,3	8,3	10,4	18,5	21,9	13,6	10,6	4,3

Table 3

Tabela 3

Winds on the central coast *(Admiralty sailing directions for the Baltic)* [19]
Percentage according to wind velocities at Ustka (U) and Kołobrzeg (K)

Wiatry przy wybrzeżu środkowym *(Locja Bałtyku)* [19]
Podział procentowy wg prędkości wiatru w Ustce (U) i Kołobrzegu (K)

Months Miesiące	Wind velocity in m/sec. Prędkość wiatru w m/sek											
	0		0—2		2—5		5—10		10—15		15	
	U	K	U	K	U	K	U	K	U	K	U	K
December — February Grudzień — Luty	2,7	4,1	19,9	23,7	11,1	39,2	31,6	28,5	3,9	3,6	0,8	0,9
March — May Marzec — Maj	4,6	6,8	23,7	26,0	46,5	40,0	23,8	25,4	1,1	1,7	0,3	0,1
June — August Czerwiec — Sierpień	5,2	8,5	29,6	33,0	43,8	41,4	19,9	16,4	1,2	0,7	0,3	—
September — November Wrzesień — Listopad	4,1	6,4	26,5	29,5	42,4	39,7	23,3	21,5	2,9	2,6	0,8	0,3

Fig. 1 illustrates the level of BOD_5 per mgO_2/dm^3 in the Baltic in the region of the Fibreboard and Chipboard Factory submarine sewage discharge at Karlino. Tests at four stations situated at each side of the sewage outfall at a distance of about 200 m., did not indicate any substantial pollution. Arithmetic means from 10 measurement series conducted in the years 1974—1976 in the region of sewage discharge, indicated a value of 6.2 mg O_2/dm^3, but this dropped to 2.0 mg O_2/dm^3 0.25 miles from each side of the outfall. At station 1, 2 miles to the west, and station 6, 5 miles to the east, similar BOD_5 values were noted with an average of 1.8 mg O_2/dm^3. There was a rapid drop in the BOD_5 to the

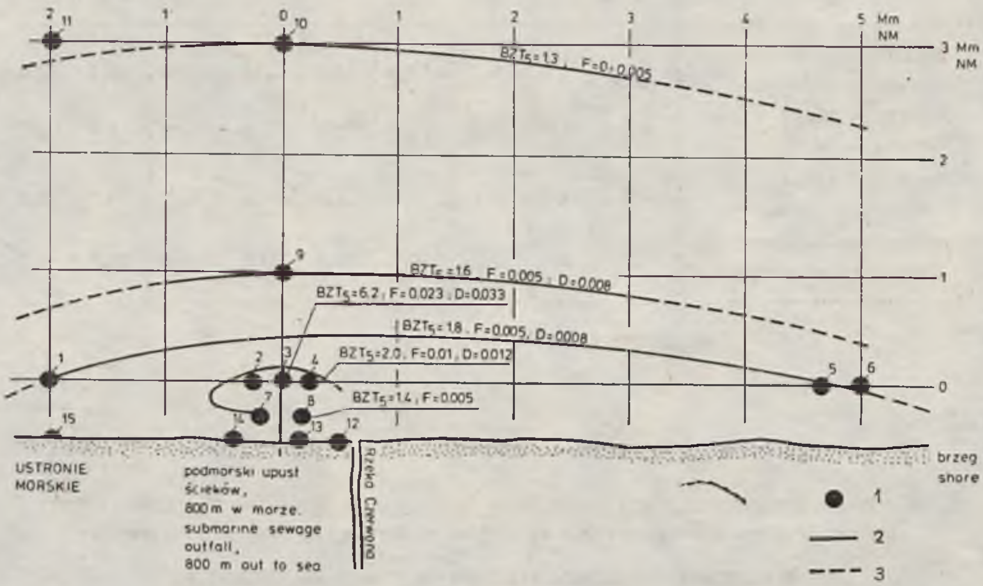

Fig. 1. Level of biochemical oxygen demand — BOD_5, phenols — F anion active detergents — D in mg/dm^3 in the Baltic, in the region of the submarine sewage outfall at Ustronie Morskie

Legend: 1 measurement stations, 2 — contents established experimentally, 3 — probable contents

Ryc. 1. Poziom biochemicznego zapotrzebowania tlenu — BZT_5 fenoli — F, detergentów anionoaktywnych — D w mg/dm^3 w Bałtyku, w rejonie pomorskiego upustu ścieków pod Ustroniem Morskim

Legenda: 1 — stanowiska pomiarowe, 2 — zawartość stwierdzona doświadczalnie, 3 — zawartość przypuszczalna

north and this amounted to 1.6 mg O_2/dm^3 at station 9, 1 mile distant from the outfall. Exceptionally low BOD_5 values were found at station 8 — 1.4 mg O_2/dm^3 on average — as well as other pollution factors, probably due to the influx of less contaminated waters from the River Czerwona.

The contents of anion active detergents indicated a similar band-like character of pollution propagation (Fig. 1). When the winds are N.NW or W, the concentration of anion active detergents (0.012 mg/dm^3)

is similar at station 2, 0.25 miles to the west, as at station 6 — 5 miles to the east. The mean from 10 measurement series at the outfall of the sewage, indicated a detergent concentration of 0.033 mg/dm³. The quantity of detergents was low — 0.008 mg/dm³ on average, at station 1 — 2 miles to the west, station 9 — 1 mile to the north, and 200 metres from the shore.

The mean concentration of phenol at the outfall was 0.023 mg/dm³, at stations 2 and 4 less than 0.010 mg/dm³, from 0 to 0.005 mg/dm³ at the remaining (Fig. 1).

These results of chemical investigations indicate that over an area of about 1 sq. mile in the immediate vicinity of the sewage outfall and at certain stations — 2, 3, 4 and 7 (Fig. 1), the Baltic waters reach the limit of class II purity (Council of Ministers' Decree of 9 VI 1970). Outside this zone the Baltic waters come within the upper limits of class I purity.

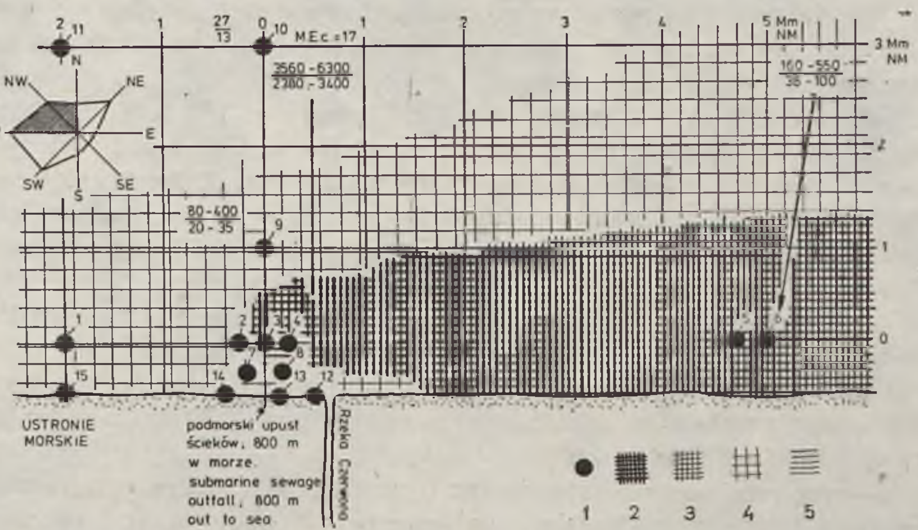

Fig. 2. Propagation of pollution in the region of the submarine sewage outfall at Ustronie Morskie, based on bacteriological investigations

Legend: 1 — measurement stations, 2 — very highly polluted water (E. coli titre of the circular type 0.0004), 3 — highly polluted water (E. coli titre of the circular type 0.004), 4 — polluted water (circular type E. coli titre 0.04), 5 — II class purity water (circular type E. coli titre 0.1); In the upper corner — a wind rose for Kołobrzeg, based on data from periods of many years, denoting the wind direction during water testing. Total number of bacteria $\frac{\text{psychrophyllic}}{\text{mesophyllic}}$ in 1 cm³ water

Ryc. 2. Rozprzestrzenianie się zanieczyszczeń w rejonie podmorskiego upustu ścieków pod Ustroniem Morskim na podstawie badań bakteriologicznych

Legenda: 1 — stanowiska pomiarowe, 2 — woda bardzo silnie zanieczyszczona (miano E. coli typu kałowego 0,0004), 3 — woda silnie zanieczyszczona (miano E. coli typu kałowego 0,004), 4 — woda zanieczyszczona (miano E. coli typu kałowego 0,04), 5 — woda zgodna z normami II klasy czystości (miano E. coli typu kaowego 0,1); U góry, w rogu, róża wiatrów dla Kołobrzegu na podstawie danych z wielolecia, z zaznaczeniem kierunków wiatrów, przy których dokonywano badań wody. Ogólna ilość bakterii $\frac{\text{psychofilnych}}{\text{mezofilnych}}$ w 1 cm³ wody

Bacteriological analyses of water samples from the same 10 measurement series showed a much worse situation of the promulgation of pollution from the sanitary point of view. The high pollution zone (coli titre 0.004—0.00004) was also of a band-like character along the line of stations 3—6 and reached out 5 miles to the east (Fig. 2). The quantity of psychrophyll bacteria which fluctuated between 3,560 and 6,300 at the outfall site (station 3), fell to 160—550 at station 6, 5 miles to the east. The total number of mesophyll bacteria at station 3 was between 2,380 and 3,400, dropping to 38—100 per cb. cm. at station 6.

Studies on the bacteriological pollution of sea water in the submarine region of sewage discharge in 1974—1975, established that:

— there is a distinct effect of sewage on the concentration of psychrophyllic and mesophyllic bacteria in water, mainly on the E. coli titre,

— the reach of excessive pollution of sea water depends upon the quantity and quality of sewage or waste discharged into the sea and also the meteorological conditions.

As the intensity of phenomena established was not to be explained by the technology applied in the Fibreboard and Chipboard factory at Karlino, a series of investigations on the metabolism of the microflora in the sewage from the point of origin to the outfall in the sea, was conducted in 1976. Preliminary findings (investigations are being continued) showed that:

— the factory takes in technological water highly contaminated by bacteria from the River Parsęta, below the influx of other municipal and industrial sewage. The total quantity of psychrophyllic bacteria in this water reached 80,000, that of mesophyllic — 30,000 per cm^3 of water with a coli titre of 0.001;

— the retaining of water in the technological and firefighting tanks for 5—6 hours increases the total number of bacteria and coli titre tenfold,

— technological waste is an excellent medium for the growth of E. coli in view of the presence of carbohydrate constituents of wood. The acidifying of the medium facilitates the cleavage of hemicellulose into numerous carbohydrates. Prior to discharge into the pipes, the waste is mixed with sanitary sewage which has typical microflora (total number of psychrophylls and mesophylls $\pm$ 2—2.5 million per cm^3 and coli titre of $1 \cdot 10^{-8}$,

— there are simpler methods of radically improving the microflora composition of sewage discharged into the sea and thus diminish the zone of polluted sea waters.

In the region of the submarine outfall of municipal sewage from Kołobrzeg at Grzybowo, the propagation of pullution in the near-shore waters was investigated by bacteriological methods. The characteristics of the pollution transported to the sea was $BOD_5 \pm 2{,}000\ kgO_2/d$, oxygen consumption $\pm 1{,}000\ kg\ O_2/d$, suspended matter $\pm$ 1,800 kg/d, phenols 80 kg/d, fats 380 kg/d.

The zone of highly polluted waters (coli titre of over 0.0004) was bound by stations 2, 3, 4, 12, 13 from the outfall to the north-east, to 2 miles from the coast (Fig. 3). The reach out to sea was not very deep and 1 mile to the north, the coli titre dropped to 17. The number of psychrophyll bacteria in the highly polluted water zone fluctuated between 1100—2100 and mesophylls 220—900 bacterial/cm³ of water. The number of psychrophyllic and mesophyllic bacteria decreased slowly with the distance from the sewage outfall in a northeasterly direction and 3 miles away fluctuated correspondingly between 320—360 and 65—75. The above can be explained by the short distance of submarine discharge and the high contents of biogenous substances in the sewage.

The propagation of pollution in the estuary of the River Parsęta was also investigated by bacteriological methods. The River Parsęta has a flow of 23.5 m³/sec., which means about 0.8 km³/ year. Majewski (1972), who conducted detailed research in this estuary in 1962—1970, established, on the basis of water salinity, that the river waters did not usually reach further out to sea than 1—2 miles from the coast. The effect of sea water in the area of the Parsęta estuary was very strong, however,

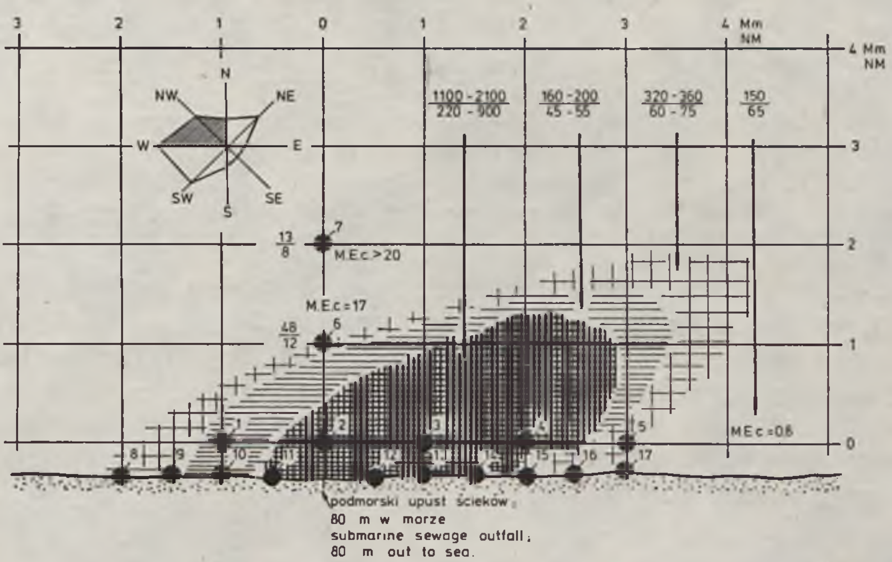

Fig. 3. Propagation of pollution in the region of the submarine outfall of sewage from Kołobrzeg at Grzybowo, based on bacteriological investigations. Explanations as in Fig. 2

Ryc. 3. Rozprzestrzenianie się zanieczyszczeń w rejonie podmorskiego upustu ścieków z Kołobrzegu w Grzybowie na podstawie badań bakteriologicznych. Objaśnienia jak przy ryc. 2

thanks to the vicinity of the deep Bornholm Basin waters. The salinity of water along the shore often exceeded 10‰. A wedge of salty water also reaches up river to the port area, accelerating mixing. The interaction of fresh and salt waters presented here in simplified form, must have a favourable effect on the dilution of the impurities discharged to the sea by the River Parsęta [25].

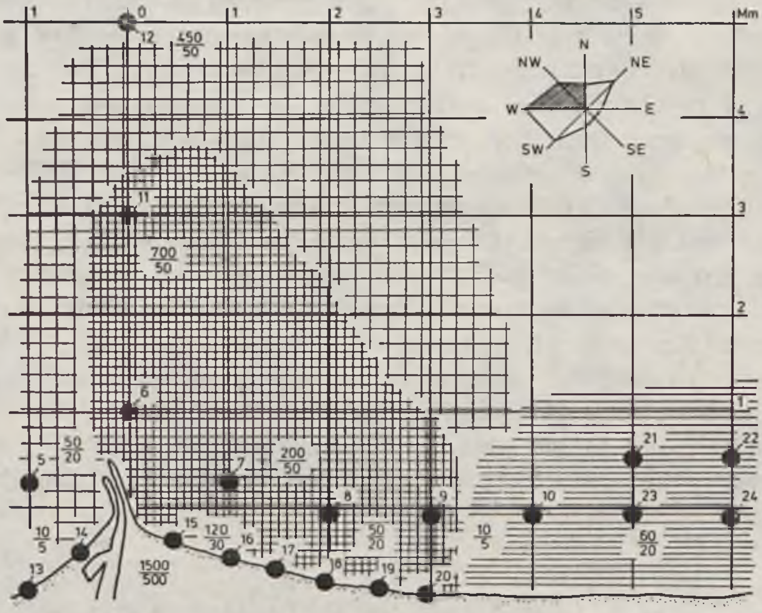

Fig. 4. Propagation of pollution discharged by the River Parsęta in Kołobrzeg, based on bacteriological investigations. Explanations as in Fig. 2

Ryc. 4. Rozprzestrzenianie się zanieczyszczeń wprowadzanych rzeką Parsętą w Kołobrzegu, na podstawie badań bakteriologicznych. Objaśnienia jak przy ryc. 2

In the Parsęta estuary, the zone of highly polluted waters (coli titre 0.04) was bound by stations 14, 11, 9, 18 reaching 3—4 miles to the north and east and covered an area of about 9 sq. miles (Fig. 4). The number of psychrophyllic bacteria dropped from 1,500 in the river estuary, to 700 and 450, 3 and 5 miles from the shore respectively. The number of mesophyllic bacteria fluctuated between 500 in the Parsęta estuary, to 50/cm³ 5 miles to the north.

5. CONCLUSIONS

The systematic increase in outfalls of various kinds of impurities and pollution to rivers and the Baltic as the result of the intensive development of all fields of economy and the growing population of Baltic countries, is creating a growing threat — directly to the marine environment, and indirectly to man exploiting this. The Baltic is particularly susceptible to this type of external interference in view of its specific hydrological system which disqualifies it as a discharging area for impurities and sewage.

The results of empiric investigations on the propagation of pollution discharged into the sea from the land presented in this work, indicate the greater suitability of bacteriological methods. Most of the chemical components rated as impurities, occur in the marine environment in infinitesimal quantities, difficult to detect analytically, but often noxious due to their bioaccumulation capacities.

The test for fecal type B. coli commonly applied in many countries, is one of the most accurate of those at present available to detect fecal contamination of water and can be applied with a scale of grades similar for both inland and sea water [9, 11, 28].

The distribution of water measurement stations in a grid with sides 1 mile in length facilitated the accumulation of data to work out mathematical models for the prediction of near-shore water quality (purity).

The results obtained enabled the determination of the pollution zone of sea water near-shore and relate this to the quantity of impurities discharged by rivers and submarine sewage outfalls.

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BADANIA STREF ZANIECZYSZCZENIA ŚCIEKOWEGO PRZYBRZEŻNEJ WODY MORSKIEJ ZA POMOCĄ WSKAŹNIKÓW CHEMICZNYCH I BAKTERIOLOGICZNYCH

Streszczenie

Przedstawiono istniejące tło zanieczyszczeń przybrzeżnej wody morskiej na polskim wybrzeżu środkowym, w sąsiedztwie dopływów z lądu, określono ładunek zanieczyszczeń dopływających podmorskimi upustami ścieków i ujściami rzek. Wyniki badań nad zasięgiem rozprzestrzeniania się zanieczyszczeń z lądu zestawiono z kierunkami i siłą dominujących w tym rejonie wiatrów. Róże wiatrów z wielolecia pozwalają stwierdzić, jak często w poszczególnych porach roku występują analogiczne warunki przemieszczania się zanieczyszczeń w przybrzeżnej wodzie morskiej.

Spośród różnych sposobów badania zasięgu rozprzestrzeniania się zanieczyszczeń w morzu stwierdzono największą przydatność metod bakteriologicznych, a szczególnie testu na obecność Bacterium coli typu kałowego.

Próby pobierano ze statku badawczego naprowadzanego stacjami namiarowymi z lądu na stałe punkty pomiarowe, rozmieszczone w narożnikach siatki kwadratów o boku 1 Mm, oraz z lądu, na styku wody i plaży.

W pracy stosowano analizę chemiczną substancji śladowych wprowadzanych ze ściekami (fenole, detergenty) na tle ogólnej zawartości substancji organicznych, wyrażonych biochemicznym zapotrzebowaniem tlenu (BZT_5), oraz analizę bakteriologiczną, obejmującą oznaczenie ogólnej ilości bakterii psychrofilnych i mezofilnych w 1 cm^3 wody i miano coli typu kałowego.

Przedstawiono trzy zbiory danych odnoszące się do rozchodzenia się ścieków: a) przemysłowych, wprowadzanych do morza długim podmorskim upustem ścieków (800 m w morzu), b) komunalnych, wprowadzanych do morza krótkim upustem ścieków (80 m w morzu) i c) wprowadzanych razem z wodami rzeki Parsęta.

Rozmieszczenie stanowisk w narożach sieci kwadratów o boku 1 Mm przy naprowadzaniu z lądu na stałe punkty stwarza możliwość gromadzenia danych do opracowania modeli matematycznych prognozowania jakości wód przybrzeżnych. Stwierdzono, że test na obecność Bacterium coli typu kałowego stanowi najbardziej dokładny z dostępnych dziś testów wykrywania zanieczyszczenia kałowego wody. Miano coli daje się stosować przy jednakowej skali liczbowych ocen porównawczych jako wskaźnik zanieczyszczenia zarówno do wód śródlądowych, estuariów, jak i przybrzeżnych wód morskich.

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