

**QUALITY OF WATERS OF SZCZECIN LAGOON  
AND POMERANIAN BAY**

Jerzy Wira, Daniela Wira

*Department of Water Environment Engineering, Technical University of Szczecin,  
50 Piastów Ave, 70-311 Szczecin, POLAND***Abstract**

Szczecin Lagoon is characterised by the high fluctuations of the chemical composition what is connected with the exchange of its waters with the waters of Pomeranian Bay. Quality of the waters of Szczecin Lagoon is determined mainly by the influence of the river waters, which bring the municipal and industrial wastes as well as the wastes coming from the surface run-off.

At the mouth section of Odra River are disposed the wastes from Szczecin, as well as from Chemical Plant „Police” S.A. (including the city of Police).

Lagoon is the highly eutrophicated water reservoir. It appears here still the high over-oxygenating of the surface layer, connected with the very high level of the primary production. Phytoplankton blooming continues practically for the whole period of studies – from April to November inclusively. It results in the increase of the water reaction and lowering of the limit of penetration of the sunlight in the water.

Shallow waters of Lagoon are subject to the strong mixing processes and they are generally pretty good oxidised. However, in some years for the many years period, oxygen sags were observed in the bottom layers of the fairway. The highest oxygen sag was noticed in 1992 (1,1 mg O<sub>2</sub>/l – 12 % oxygenate).

**Key words:** Odra River mouth, Szczecin Lagoon, Pomeranian Bay, fairway

**SZCZECIN LAGOON [1, 3, 4,]**

According to the studies made for the recent years it has been found the low salinity of the waters of Lagoon (on the average 1.2 ‰).

Since a few years it has been observed the reduction of the contents of nitrates, of total nitrogen and of total phosphorus as well as the inconsiderable increase of orthophosphates contents.

Following the lowering of the nutrient compounds in the waters of Lagoon, it has been also reduced the intensity of blooming, however the observed concentrations of chlorophyll dyes are still high. The highest are observed during the intense phytoplankton blooming.

In summertime months it is observed in those waters since many years the mass growth of blue-green algae *Microcystis aeruginosa*. On the surface of the waters are seen then the very big quantities of cultures of that blue-green algae, and the water surface has become very intensively green-coloured.

Transparency of the waters of Lagoon in periods of the intense blooming shows the minimal values up to 30cm, and pH of the water reaches at that time very high values up to 9.7 pH.

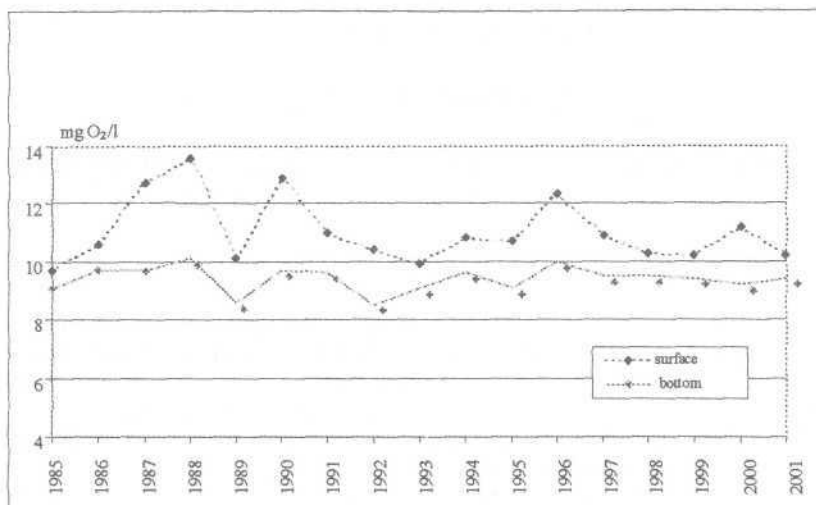


Fig. 1. Dissolved oxygen content in the waters of Szczecin Lagoon in years 1985-2001 – average values [1]

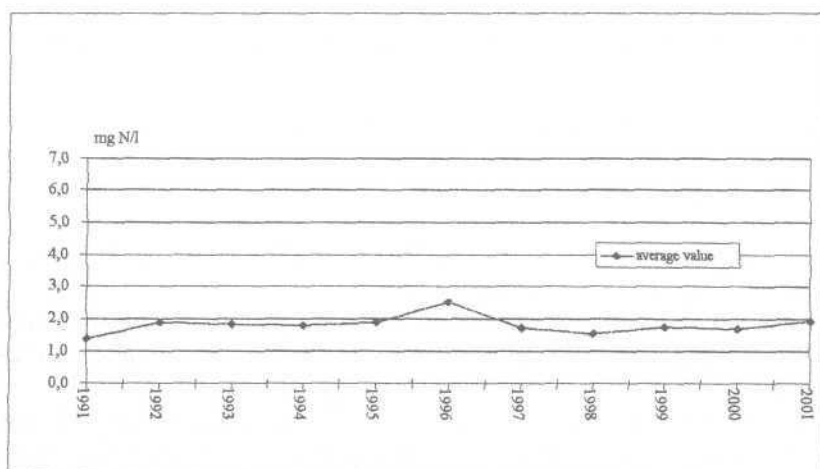


Fig. 2. Total nitrogen content in the waters of Szczecin Lagoon in years 1991-2001[1]

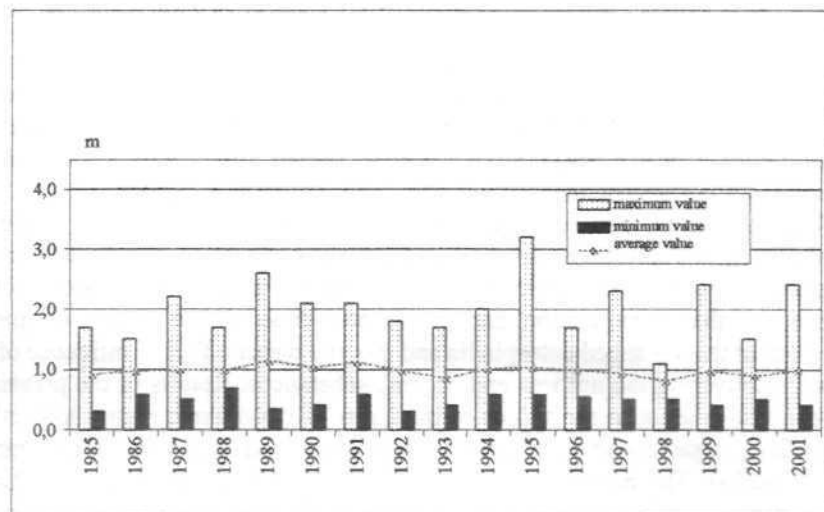


Fig.3. Transparency of the waters of Szczecin Lagoon in years 1985-2001[1]

In the waters of Szczecin Lagoon are also carried out the examinations of the industrial pollutions; phenols which were in sixties a reason of the serious disturbances in the fishing industry on Szczecin Lagoon, now do not constitute any serious problem. According to the many years' studies it has been stated that the contents of arsenic and heavy metals are on the low levels.

### POMERANIAN BAY [1, 2,4,]

The waters of Pomeranian Bay are examined within the frames of the Polish – German co-operation on the border waters as well as obligations of the Polish country issuing from the Convention of Helsinki. The examinations have been performed since 1970 by two laboratories (at the moment – by the laboratory of the Provincial Environment Protection Inspectorate in Szczecin and the State Environment and Nature Office in Stralsund). The examinations cover the coastal zone within the distance of 4.5 nautical miles from the shore, with the relatively shallow shelf waters (up to 12 m deep), showing high eutrophication susceptibility.

Water samples are collected in four measuring – control stations, situated alongside the Polish – German border (see the map in the part – Szczecin Lagoon).

Pomeranian Bay is characterised by the unstable and complicated hydro-chemical conditions caused by the mutual interrelations of the inland and seawaters.

Winds blowing from those directions, mainly during the autumn – wintertime, result in an increase of the salinity of the waters of Zatoka. Predominance of the winds from South and West – South results in the considerable de-salinity of the river waters through the straits of Świna and Dziwna. Influence of the inland waters is particularly noticeable during the springtime run-offs. At the same time, the waters of Szczecin Lagoon flowing through Dziwna and Świna, are the important source of biogens fertilising Pomeranian Bay in the coastal areas. Periodically and in various

intensity, inflows of the Baltic seawaters can reduce the intensity of assimilation through the dissolution of the biogenic compounds

It results from the hydro-chemical examinations made in the period from 1970, that the most characteristic are the changes indicating the permanent eutrophication of the waters of Pomeranian Bay due to the inflowing fertile waters of Szczecin Lagoon. Those changes are not here so visible as in Szczecin Lagoon, but in the coastal waters, nearby the river mouths, their tendency is explicit.

Common feature of the oxygen conditions of the examined region of Bay is the phenomenon of the frequent over-oxidising of the surface layers with the periodical appearance, at the same time, the visible oxygen sags in the bottom zones. Appearance of that phenomenon during the peak-time of the vegetation period witnesses about the advanced eutrophy and it is the direct effect of influence of the river waters delivering the nutrient and organic substances. Results of the prevailing oxygen conditions are also the values of the index of the organic matter load of the waters (BZT<sub>5</sub>), organic carbon content as well as the total contents of the organic matters (UV-254). The noticeable increase of organic matter concentrations during the summertime is connected with their inflow with the Odra River waters as well as with the increasing photosynthesis processes at that period.

Results obtained during the last years of examinations of the waters of Bay have confirmed the above statements as well as the assessment of the good oxygen conditions in the water basin. Shallow waters of Bay are subject to the intense mixing processes and they are generally pretty good oxidised. However, in some years for the many years period, oxygen sags were observed in the bottom layers of the waters. The highest oxygen sags were noticed in 1997 (flood period). The highest sag (13.6% - i.e. 1.2 mg O<sub>2</sub>/dm<sup>3</sup>), registered on 25.08.1997, could be a serious danger for the ichthyofauna. Reason of the oxygen sag on that day could be an inflow from Szczecin Lagoon of the huge mass of the flood waters rich in the organic matters. Analytical examinations performed in September 2001 has shown the return of the generally good oxygen conditions, as observed in that water area before the flood. Diagram of the oxygen content changes in the waters of Pomeranian Bay in years 1985-2001 both in the surface and bottom layers do not show any considerable fluctuations. Considerably lower values of that index were noticed in 1997 (flood period).

System of the mutual influence of the inflowing river waters and seawaters of Baltic Sea has caused in Pomeranian Bay the horizontal and vertical stratification of the waters mineralization (chlorides content, salinity, conductivity). In the surface layer it appears as a rule the waters of the lower mineralization than in the bottom layer. The average salinity of the surface layer amounts to 6.1‰ (3365 mg Cl/l), and the bottom layer to 7.3‰ (3997 mg Cl/l). The annual cycle of changes of the mineralization indices of the waters of Bay is conditioned by the direction and powers of winds as well as by the inflow of the river waters to Bay.

The area in study, covering the coastal part of Pomeranian Bay, is characterised by the increased contents of the biogenic compounds (nitrates and orthophosphates, nitrogen and total phosphorus).

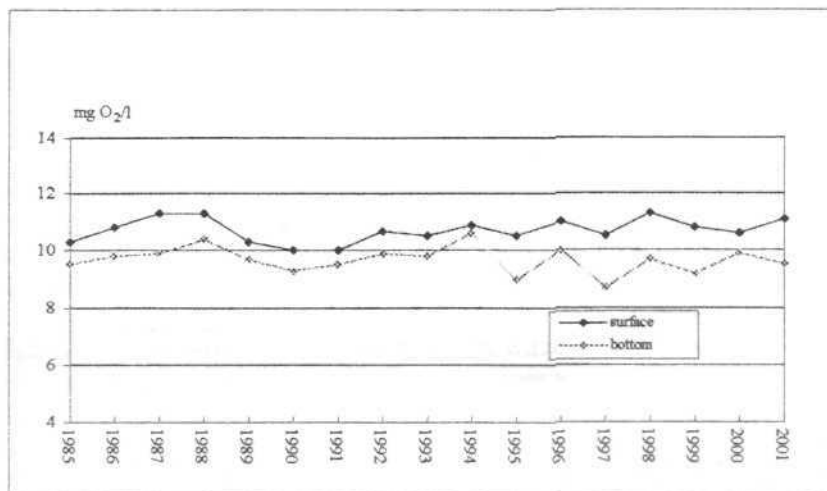


Fig. 4. Dissolved oxygen content in the waters of Pomeranian Bay in years 1985-2001 – average values [1]

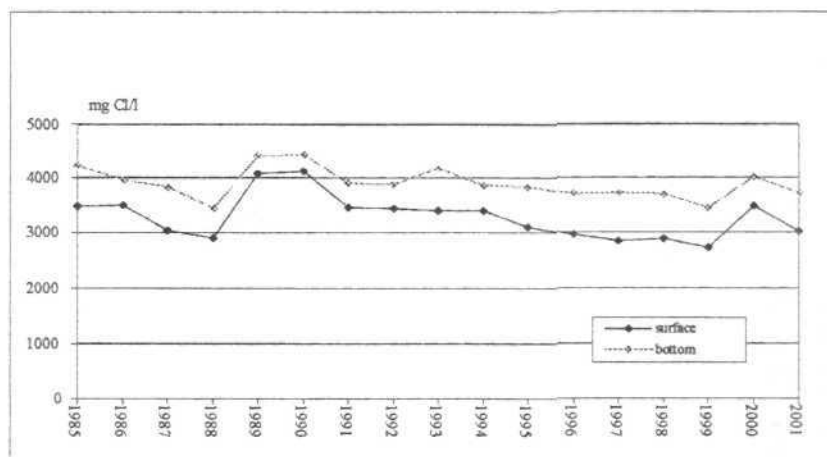


Fig. 5. Chlorides content in the waters of Pomeranian Bay in years 1985-2001 – average values [1]

Since the beginning of nineties we have not noticed the reduction of the contents of nitrates, total nitrogen and it is visible the inconsiderable fall of orthophosphates and total phosphorus.

High chlorophyll concentrations, reflecting the primary production (consumption of the biogenic compounds dissolved in the waters), witness about the eutrophication of the water area in question. The highest concentrations of that index exist during the intense phytoplankton blooming.

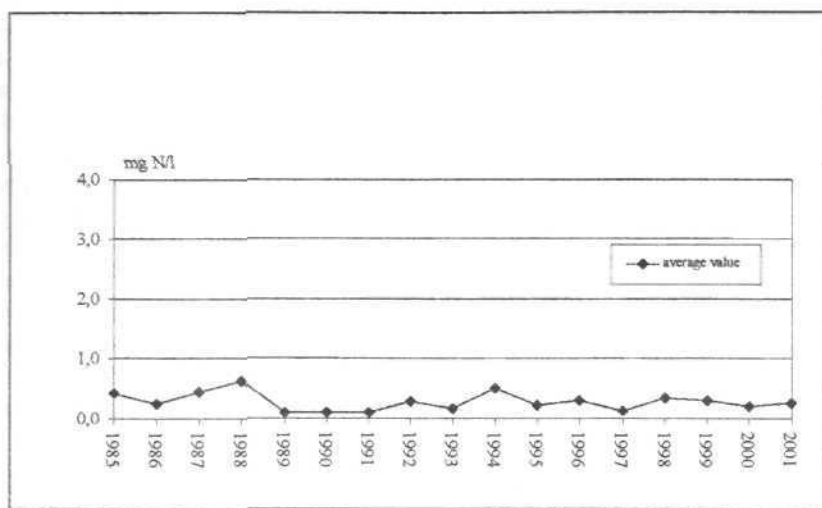


Fig. 6. Nitrates content in the waters of Pomeranian Bay in years 1985-2001[1]

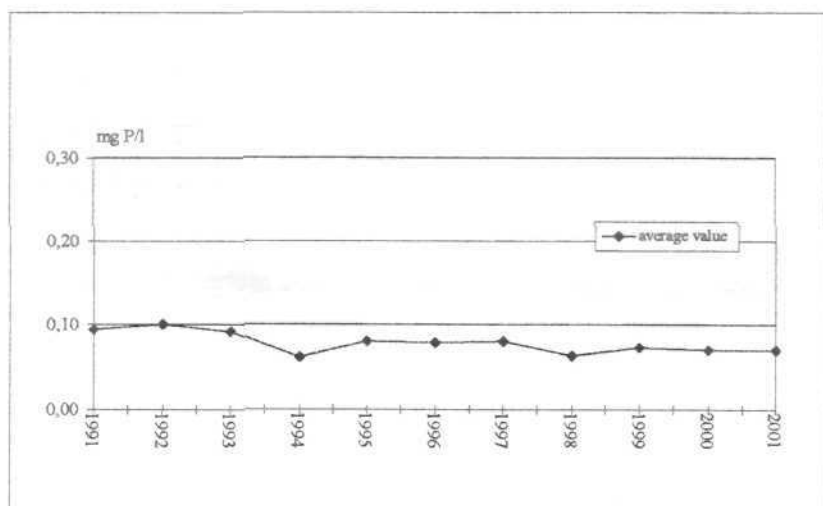


Fig. 7. Total phosphorus content in the waters of Pomeranian Bay in years 1991-2001[1]

With the phytoplankton growth is correlated the transparency of the waters as well as pH of the water. During the blooming the waters transparency has been considerably reduced, and the reaction has increased (up to 9.5 pH). The lowest transparency, at the level of 0.30 m, was noticed during the very intense blooming in July 1999 (chlorophyll content – 231  $\text{mg}/\text{m}^3$ ).

Phenol compounds content is very low since many years in the waters of Pomeranian Bay. Their average concentrations have achieved the values lower or equal to 0.002 mg/l (limit of analytical detection).

According to the few years' examinations (1994-2000) it has been stated, that concentration of arsenic and heavy metals (cadmium, chromium, copper, mercury, nickel, lead, zinc) in the waters of Bay have shown the low levels.

Sanitary condition of watering places in Pomeranian Bay is good. All localities situated alongside the seashore of the West-Pomeranian Province have now the permission to organise the watering places (decision of the State Provincial Sanitary Inspector in Szczecin). Since 1997 (start-up of the new municipal wastes treatment plant in Trzebiatów) it is allowed for use the beach in Mrzeżyno, to the East from Rega River. It was the only place on the Szczecin seashore where the quality of the waters did not allow swimming.

Quality of the coastal waters of Pomeranian Bay is closely connected with the quality of the waters of Odra River. Main reason of the present state of the quality of waters of Bay, Szczecin Lagoon and Odra River (region of Szczecin) is the non-regulated waste management of the city of Szczecin. About 100 000 m<sup>3</sup>/d of the untreated or insufficiently treated wastes are disposed each day to Odra River from the territory of the City.

Because of the scale of the project and the investment costs (construction of one or more waste treatment plants, construction of sewage systems) it should not be expected any considerable improvement of the quality of the waters of Odra River on the territory of Szczecin, and therefore also of the coastal waters of Pomeranian Bay, during the nearest years.

## ASSESSMENT OF THE EUTHROPICATION DEGREE OF THE WATERS OF SZCZECIN LAGOON AND POMERANIAN BAY

Table 1

### Szczecin Lagoon and Pomeranian Bay.[1]

Index	Unit	Estimated boundary value	Average value	Remarks
<b>Szczecin Lagoon</b>				
Total phosphorus	mg P/dm <sup>3</sup>	> 0,3	0,18-0,31*	inconsiderably exceeded in 1991
Total nitrogen	mg N/dm <sup>3</sup>	> 7	1,39-2,52*	without exceeding
Nitrates	mg N/dm <sup>3</sup>	> 3,39	0,52-1,76**	without exceeding
Chlorophyll	mg/m <sup>3</sup>	> 50	31,8-73,8**	exceeded in 1990
Transparency	m	< 4	0,82-1,14**	exceeded during intense blooming
<b>Pomeranian Bay</b>				
Total phosphorus	mg P/dm <sup>3</sup>	> 0,3	0,062-0,1*	without exceeding
Total nitrogen	mg N/dm <sup>3</sup>	> 7	0,68-1,03*	without exceeding
Nitrates	mg N/dm <sup>3</sup>	> 3,39	0,11-0,63**	without exceeding
Chlorophyll	mg/m <sup>3</sup>	> 50	9,6-23,6**	without exceeding
Transparency	m	< 4	1,3-2,62**	exceeded during intense blooming

Table 2

## Pomeranian Bay as the coastal seawaters [1]

Index	Unit	Estimated boundary value	Average value	Remarks
<i>Pomeranian Bay</i>				
Total phosphorus	mg P/dm <sup>3</sup>	> 0,1	0,062-0,1*	without exceeding
Total nitrogen	mg N/dm <sup>3</sup>	> 4	0,68-1,03*	without exceeding
Nitrates	mg N/dm <sup>3</sup>	> 1,8	0,11-0,63**	without exceeding
Chlorophyll	mg/m <sup>3</sup>	> 10	9,6-23,6**	exceeded in 1987, 1988 and 1997
Transparency	m	< 2	1,3-2,62**	exceeded during intense blooming

\* results of years 1991-2001

\*\* results of years 1985-2001

According to the draft Ordinance of the Minister of Environment regarding the criteria of determination of the waters susceptible to the pollution with nitrogen compounds of the agricultural origin, the waters of Szczecin Lagoon and Pomeranian Bay (coastal) are the eutrophic waters. During the intense phytoplankton blooming the (estimated) boundary values are exceeded as regards the contents of chlorophyll and the transparency of waters. Inconsiderably exceeded is also the boundary value for the total phosphorus in the waters of Szczecin Lagoon.

## CONCLUSIONS

1. Quality of the coastal waters of Pomeranian Bay is determined by the influence of the eutrophicated waters of Szczecin Lagoon, and the quality of Lagoon is under the strong influence of the pollutions brought by Odra River. The waters condition is also affected by the deposit of pollutions in the bottom sediments.
2. It is observed during the last years the visible tendency of reduction of the trophy of Szczecin Lagoon, which should be maintained. To that purpose, it is necessary to make further investments connected with the arrangement of the waste management in the basin of Odra River.
3. Places for dumping areas should be covered by the monitoring, and the deposits dumped there should undergo quality examinations. It would be also purposeful to start with the regular examinations of the bottom sediments of Szczecin Lagoon.

## REFERENCES

- Inspekcja Ochrony Środowiska, Wojewódzki Inspektorat Ochrony Środowiska w Szczecinie, Raport o stanie środowiska w województwie zachodniopomorskim w latach 1997-1998-1999-2000-2001 [1]
- Kowalewska, H. 1995. Kształtowanie się fizycznych cech oraz struktury wód Zatoki Pomorskiej (Development of physical properties and water structure in the Pomeranian Bay). Zesz. Nauk. Uniw. Szczecińskiego, 171, 65-86. [2]



- Robakiewicz, W. (red.) 1993. Warunki hydrodynamiczne Zalewu Szczecińskiego i cieśnin łączących Zalew z Zatoką Pomorską (Hydrodynamic conditions in the Szczecin Lagoon and in the connecting straits to the Pomeranian Bay). Hydrotechnika, 16. 1-278. [3]
- Tadajewski, A. 1977. Zanieczyszczenia wód dopływowych Zatoki Pomorskiej (Pollutants in water inflowing into the Pomeranian Bay). Master. Sesji Naukowej: Bałtyk i jego wody dopływowe, Szczecin, 2 grudnia 1997, STN-PWN, Poznań, s. 7-12 [4]

## JAKOŚĆ WÓD ZALEWU SZCZECIŃSKIEGO I ZATOKI POMORSKIEJ

### Streszczenie

Zalew Szczeciński charakteryzuje się dużą zmiennością składu chemicznego, co związane jest z wymianą między jego wodami, a wodami Zatoki Pomorskiej. Jakość wód Zalewu Szczecińskiego kształtuje się głównie pod wpływem wód rzecznych, które wnoszą zanieczyszczenia komunalne, przemysłowe oraz pochodzące z spływu powierzchniowego.

W ujściowym odcinku Ordy odprowadzane są ścieki ze Szczecina, oraz Zakładów Chemicznych „Police” (z Policami).

Zalew jest silnie zeutrofizowanym zbiornikiem wodnym. Nadal występują silne przetlenienia warstwy powierzchniowej, związane z bardzo wysokim poziomem produkcji pierwotnej. Zakwity fitoplanktonu trwają praktycznie przez cały okres badawczy – od kwietnia do listopada łącznie. Powodują one wzrost odczynu wody i obniżenie granicy, do której dociera w wodzie światło słoneczne.

Płytkie wody Zalewu podlegają silnym procesom mieszania i są na ogół dość dobrze natlenione. Jednak na przestrzeni lat w przydennych warstwach toru wodnego obserwowano deficyty tlenowe.