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NATURAL AND ANTHROPOGENICAL THREATS OF LAKES OF POLISH COASTAL ZONE

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NATURALNE I ANTROPOGENICZNE ZAGROŻENIA JEZIOR POLSKIEJ STREFY BRZEGOWEJ

Strefa brzegowa południowego Bałtyku to miejsce gdzie zazębia się oddziaływanie z jednej strony wód morskich a z drugiej wód lądowych. Oddziaływanie to szczególnie dobrze widoczne jest w jeziorach przybrzeżnych. Na warunki makroskalowe nakładają się lokalne warunki hydrologiczne oraz dla poszczególnych jezior specyficzne cechy morfometryczne ich niecek i hydrologiczne zlewni, co powoduje zmianę stosunków wodnych poszczególnych obiektów hydrograficznych. Na te wszystkie warunki naturalne nakłada się od ponad ośmiu wieków działalność człowieka. W efekcie mamy do czynienia z licznymi zagrożeniami naturalnymi i antropogenicznymi wpływającymi już nie tylko na pojawiające się zmiany w strukturze jeziora, lecz wręcz zagrażające jego istnieniu.

Summary

The aim of this study is to determine natural and anthropogenic threats and their effects concerning the lakes situated within the coastal zone of the southern Baltic. The shore zone is a place of contact of the sea waters and the inland waters. This results in the formation of special water relationships and special circulation water. Macroscale conditions overlap local hydrological conditions and morphometric features of basins and hydrological features of catchments specific to particular lakes. All the natural conditions have been affected by human activity for over eight centuries. As a result, numerous natural and anthropogenic threats occur and cause not only periodic changes in the structure of lakes but such that even endanger their existence.

INTRODUCTION

The coastal zone, defined as a belt of land of undefined breadth (up to several kilometers) which stretches between the shoreline and the first larger changes of the topographic features [15], encompasses numerous hydrographic objects that constitute places of transitory accumulation of river waters on their way to the sea as well as places of salt waters intrusions [6]. A special role in economy, tourism and recreation is played by all reservoirs of stagnant waters, which are water ecosystems not found in other areas of the world, and which are also natural places of retention [19]. Unfortunately, the location and usability of the majority of reservoirs expose them to numerous threats that result from natural forces as well as anthropogenic activity, especially visible from the second half of the 20^{th} century.

An example of a place exposed to numerous threats is the Polish coastal zone of the Baltic Sea. The Baltic, as a half-closed sea, is a very sensitive marine area. Water exchange is extremely slow here, which substantially increases its susceptibility to degradation and makes poisonous substances that get here remain in circulation for a long time. As a result, numerous influences of the sea on the reservoirs of the coastal zone can have a very negative effect [10]. This is significant, as despite the absence of tides, there are descriptions of empirically observed periodic intrusions of sea waters into coastal lakes [1, 16, 17, 20]. This is due to the hydraulic connection of individual lakes with the open sea and is similar in effect to the ones observed in the zone of open seas [8, 9, 13]. This causes the formation of a totally new water quality – something between fresh and salty water. Consequently, there are several problems, which should be taken into consideration when adopting various strategies of the use of the geographic environment [7]. This is important as the influence can affect the way particular areas are used. It has become especially urgent to highlight them in view of the forecast of rising sea levels related to the global climate changes [14, 18, 21].

The coasts of the southern Baltic have been under human pressure for almost 800 years. They are places of valuable deposits of organic matter (peatlands) and of agricultural use. An increase in industrial and transportation activity (shipping industry, transshipment harbors) as well as tourism and recreation has been observed here too. These areas are thus heavily transformed. The transformations often lead to threats. On the other hand, however, they sometimes condition further existence of those areas (the Vistula Delta).

The aim of this study is to determine natural and anthropogenic threats and their effects concerning the lakes situated within the coastal zone of the southern Baltic.

AREA INVESTIGATION

The study area was the Polish coastal zone of the southern Baltic, which is characterized by complex water relationships that result from the mutual influence of the sea water body and land zone. The study objects included 19 coastal lakes (Fig. 1). In the case of a lack of available materials from some lakes, during an analysis of a particular element, e.g. resistance to degradation, this number was reduced to 16.

The lakes situated in the coastal zone in majority belong to the group of coastal lakes, except for Lake Dąbie and Druzno, which are delta lakes, and Lake Żarnowieckie, which is a channel lake. On the other hand, such lakes as Dołgie Wielkie, Dołgie Małe and Pusty Staw are reservoirs without a visible surface outflow. Consequently, the analyzed lakes are highly diverse in terms of morphometric as well as hydrological features (Tab. 1). The area of the reservoirs ranges from 6.3 ha for Lake Dołgie Małe to 7140 ha in the case of Lake Łebsko. Mean depth ranges from 0.6 m for Lake Pusty Staw to 8.4 m for Lake Żarnowieckie, while maximum depth ranges from 1.7 m for Lake Liwia Łuża and Dołgie Małe to 19.4 m for Lake Żarnowieckie. A catchments area of particular lakes is from 0.2 km^2 for Lake Dołgie Małe to 75 500 km^2 for Lake Dąbie. Inflows form the catchments range from 0.4 m^3/s for Lake Kopań to 296 m^3/s for Lake Dąbie. A water exchange index in the reservoirs ranges from 0.6 for Lake Żarnowieckie to 450 for Lake Dąbie. 14 out of

19 analyzed lakes have a direct connection with the sea. The length ranges from 300 m for Lake Bukowo and Kopań to almost 15 km for Lake Druzno. In the case of Lake Kopań and Jamno the connection can be periodically blocked with sandy material.

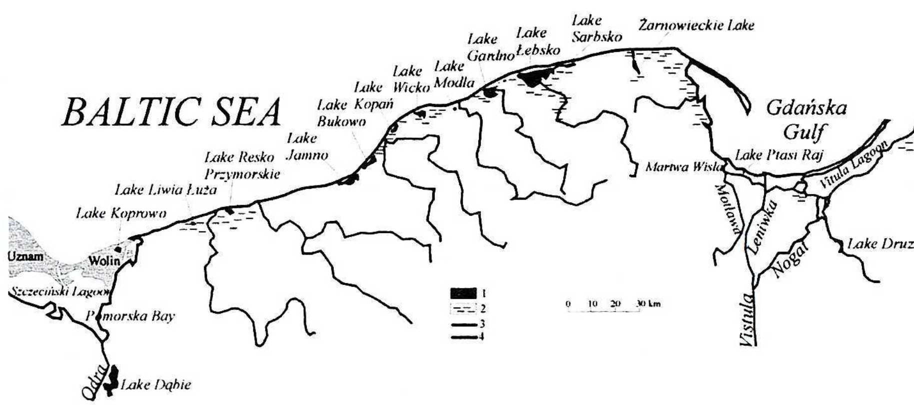

Fig. 1. Coastal lakes in Polish shore zone
1 – lakes, 2 – wetlands, 3 – rivers, 4 – coastal border

METHODS

The basic research works consisted in a preliminary survey of source materials concerning water quality (purity classes) of chosen lake reservoirs obtained from WIOŚ (Regional Inspectorate for Environmental Protection) in Gdańsk, Szczecin and Koszalin. They also included the determination of natural and anthropogenic threats with the use of materials from state institutions, including the Municipal Council in Gdańsk and Regional Office in Szczecin and Gdańsk. Due to the fact that WIOŚ performs measurements of water quality in lakes every 5 years, the author decided to divide lake water into 3 purity classes, on the basis of about 30 physical, chemical and bacteriological coefficients, according to the data obtained from the period when the division was in effect. For some lakes and their catchments (Łebsko, Gardno, Jamno, Żarnowieckie, Sarbsko, Kopań, Wicko, Bukowo, Modła, Dołgie Wielkie, Dołgie Małe, Druzno, Ptasi Raj, Karaś, Pusty Staw) the author performed chemical analyses of water concerning the determination of basic physical and chemical indices in 2002–2005. The samples were taken from the surface and near-bottom layers. All the types of waters were subjected to laboratory analysis that covered the determination of chlorides, sulphates, sodium, calcium, magnesium, potassium and bicarbonates concentrations. Chemical analyses were performed in the hydrochemical laboratory of the Department of Hydrology, University of Gdańsk, in compliance with Polish norms.

Three (lake Modła) to eight (lake Łebsko) measurement sites were situated in each lake, as well as on main tributaries, canals, outflows to the sea if there were such and on the Baltic Sea – between 3 to 10 sites. The study used mainly the results of chloride concentrations, which were expected to determine the influence of the Baltic Sea on water quality of particular lakes. The chlorides concentration analyses were performed by Mohr – Knudsen methods.

Flows were measured using Acoustic Doppler's Current Profiles model Teledyne RD Instruments StreamPro ADCP and Teledyne RD Instruments Workhorse Rio Grande 1200 ZedHed ADCP.

Table 1. Hydrological and morphometric features of chosen lakes

Lake	Area [ha]	Maximum depth [m]	Mean depth [m]	Area of catchments [km²]	Tributary from catchments [m³/s]	Coefficient of exchange	Connection with the sea
Łebsko	7140.0	6.3	1.6	1594	16.9	4.4	Łeba
Gardno	2468.1	2.6	1.3	964.4	9.11	9.3	Łupawa
Jamno	2239.6	3.9	1.4	510.6	4.32	4.4	Jamneński Channel
Bukowo	1747.4	2.8	1.8	102.8	0.88	0.9	Szczuczy Channel
Wicko	1058.9	6.1	2.7	107.7	1.02	8.0	Głownica
Kopań	789.7	3.9	1.9	38.5	0.4	0.7	Channel
Modła	41.0	2.0	0.5	26.9	n.d.	n.d.	Potynia
Dołgie Wielkie	156.4	2.9	1.4	3.2	n.d.	n.d.	No
Dołgie Małe	6.3	1.7	0.7	0.2	n.d.	n.d.	No
Sarbsko	651.7	3.2	1.2	213.3	2.09	8.1	Chełst
Żarnowieckie	1431.6	19.4	8.4	259.8	2.9	0.6	Piaśnica
Pusty Staw	7.5	3.0	0.6	0.7	n.d.	n.d.	No
Druzno	1446.0	3.0	1.2	1084	6.9	12.5	Elbląg
Karaś	9.5	n.d.	n.d.	0.9	n.d.	n.d.	No
Liwia Łuża	210.8	1.7	0.9	175.5	1.24	20.0	Liwka
Resko Przymorskie	577.1	2.5	1.3	315.2	2.36	9.6	Ditch
Dąbie	5600.0	4.2	3.0	75500	296	55.0	Nurt Iński
Ptasi Raj	61.5	2.4	1.2	5.5	n.d.	n.d.	No
Koprowo	486.8	3.1	1.6	51.1	n.d.	n.d.	Kamieński Lagoon

n.d. – no data

NATURAL THREATS

The characteristic feature of most of the lakes situated in the coastal zone is a large area with a small mean and maximum depth. This feature, accompanied by highly varied values of water exchange during a year and diverse use of direct catchments, poses a large threat and susceptibility to degradation of particular reservoirs that could consequently lead to their disappearance. On the basis of calculations performed in compliance with the System of Quality Evaluation of Lakes [11] it was established that for the 16 analyzed lakes as many as 7 are outside classification and 8 belong to class III (Tab. 2). Only Lake Żarnowieckie was classified as class II, which is no surprise as this reservoir is genetically a channel lake, and as such is very resistant to degradation thanks to the morphometry of its basin.

Table 2. Susceptibility of coastal lakes to degradation

Lake	The value of coefficient/Score							The result of score /category
	1	2	3	4	5	6	7	
Sarbsko	1.2/IV	0.52/IV	0.0/IV	0.81/IV	700/III	23.1/III	< 60% forests, soils/II	3.43 = apart from category
Łebsko	1.6/IV	2.12/II	0.0/IV	0.61/IV	450/III	13.7/III	< 60% forests, soils/II	3.14 = III
Gardno	1.3/IV	1.35/III	0.0/IV	0.80/IV	1000/III	29.8/III	< 60% forests, soils/II	3.29 = apart from category
Jamno	1.4/IV	1.11/III	0.0/IV	0.71/IV	450/III	16.9/III	< 60% forests, soils/II	3.29 = apart from category
Koprowo	1.6/IV	0.8/III	0.0/IV	0.62/IV	11.5/I	7.18/II	< 60% forests, soils/II	2.86 = III
Bukowo	1.8/IV	1.38/III	0.0/IV	0.55/IV	90/II	3.8/II	< 60% forests, soils/II	3.0 = III
Wicko	2.7/IV	1.34/III	0.0/IV	0.37/IV	800/III	4.2/II	< 60% forests, soils/II	3.14 = III
Kopań	1.9/IV	1.2/III	0.0/IV	0.54/IV	70/II	3.1/II	< 60% forests, soils/II	3.29 = apart from category
Dołgie Wielkie	1.4/IV	0.32/IV	0.0/IV	0.73/IV	0/I	2.2/II	> 60% forests/I	2.86 = III
Dołgie Małe	0.7/IV	0.04/IV	0.0/IV	1.4/IV	0/I	5.8/II	> 60% forests/I	2.86 = III
Żarnowieckie	8.4/II	6.48/I	26.2/II	0.15/II	60/II	2.3/II	< 60% forests, soils/II	1.86 = II
Druzno	1.2/IV	0.7/IV	0.0/IV	0.8/IV	1100/IV	48.4/IV	< 60% forests, soils/II	3.7 = apart from category
Liwia Łuża	0.9/IV	0.31/IV	0.0/IV	1.06/IV	2000/IV	89.6/IV	< 60% forests, soils/II	3.71=apart from category
Resko Przymorskie	1.3/IV	0.66/IV	0.0/IV	0.75/IV	960/III	41.7/II	< 60% forests, soils/II	3.29 = apart from category
Dąbie	3.0/III	4.44/I	0.0/IV	0.33/IV	5500/IV	449.7/IV	< 60% forests, soils/II	3.14 = III
Ptasi Raj	1.2/IV	0.06/IV	0.0/IV	0.81/IV	0/I	7.2/II	< 60% forests, soils/II	3.0 = III

1 – mean depth [m]; 2 – volume of lake / area of lake [thousand m^3/m^2]; 3 – stratification of water [%]; 4 – area of gout active / volume of epilimnion [m^2/m^3]; 5 – exchange of water in year [%]; 6 – Schindler coefficient (area of catchments + area of lake/ volume of lake) [m^2/m^3]; 7 – prepare farm implements in direct of catchments

Periodic intrusions of salty waters during the period of autumn-winter storms and during low water stages in lakes in summer. Constitute another element that can lead to a change in water quality in individual lakes. Another possibility is a constant impact of the sea which causes an increased salinity of lake waters and is related to quasi-estuary phenomena (remains of water after intrusions that stagnate for a longer time, wind damming, inflow of salty waters with ground waters, etc.). On the basis of minimum, maximum and mean values of the whole research period (Fig. 2) for particular lakes, several lake types can be distinguished.

In the case of Lake Ptasi Raj much higher values of about 3000–4000 mg/dm^3 are recorded. In the waters of Lake Bukowo and Łebsko, even the minimum values of chlorides do not fall below 250 mg/dm^3, while mean values are about 900 mg/dm^3 for Lake Bukowo and 1200 mg/dm^3 for Lake Łebsko. Also the mean values for such lakes as Druzno, Jamno, Gardno or Kopań do not fall below 100 mg/dm^3.

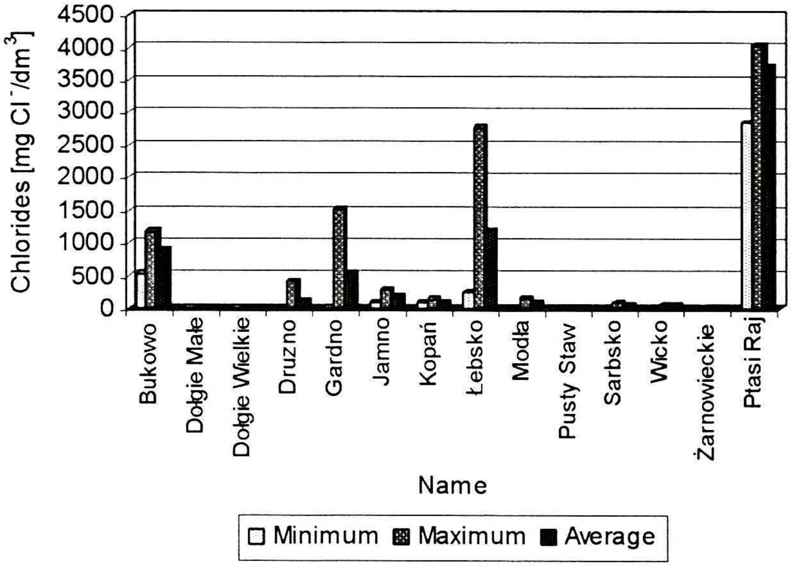

Fig. 2. Minimum, maximum and mean chloride values in chosen lakes of the coastal zone of the southern Baltic

The maximum values for lakes Modła and Sarbsko range between 100–160 mg/dm^3. Only in the case of lakes Dołgie Wielkie, Dołgie Małe, Pusty Staw, Żarnowieckie or Wicko, high chloride values above 100 mg/dm^3 are not observed, though the concentrations in Wicko are 36–60 mg/dm^3. In several reservoirs a constant influence of the Baltic Sea can be observed, for others only a periodic increase during intrusions of salty waters, and in the remaining cases there is no visible evidence of intrusions, though in the spatial distribution the impact of the sea is observed in the form of the tendency of chlorides increasing towards the sea shoreline or an outflow to the sea, if any (Fig. 3).

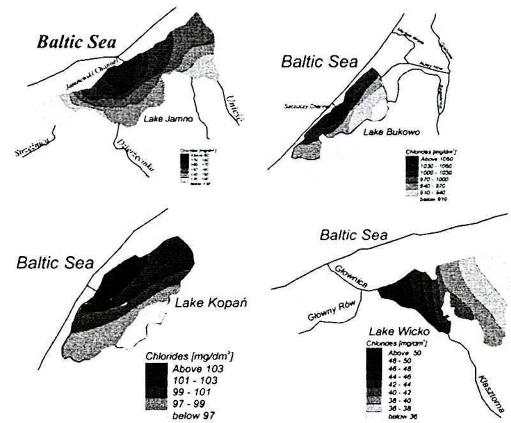

Fig. 3. The spatial chlorides schedule in chosen coastal lakes

This tendency is observed in all the analyzed lakes. The tributary of salty water to lakes is holds across river and channels the making up only one connection of reservoirs from the sea. In this place can appear the turned direction of flow from the sea to lake. The example of such situation is flow measurement on channel on 10.11.2006 when the flow was 54 m^3/s (Fig. 4).

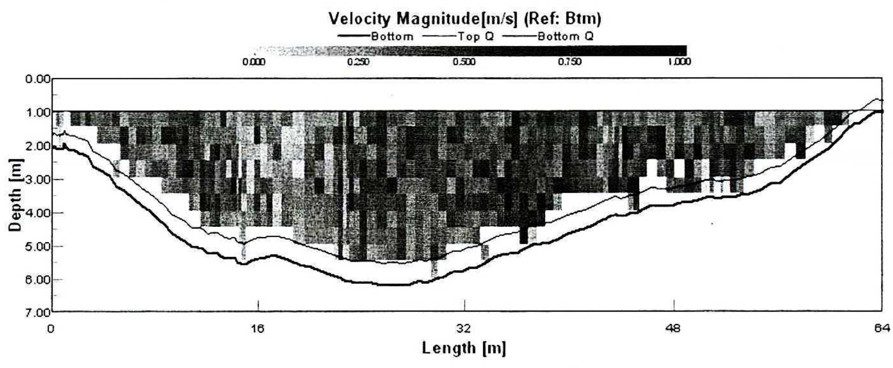

Fig. 4. Schedule of speed of water in trough channel Łeba on 10.11.2006

The waters of the coastal inland reservoirs are periodically used to irrigate polders. Due to the occurrence of intrusions, salty waters penetrate to polders. This is obviously unfavorable for the development of agriculture. In other local conditions this phenomenon enables unique halophilous vegetation to exist, e.g. in the Słowiński National Park (Lake Łebsko and Gardno).

Floods are another possible cause of pollution of lake waters, especially if they are adjacent to urbanized areas. In the Pomeranian and West-Pomeranian regions there are usually two types of floods: precipitation and storm. For example, the dangerous floods on channel Łeba and Lake Łebsko were observed in summers 1396, 1441 and 1467. In effect the town of Łeba was warned out. In summer 1497 the flood caused the shift of the river Łeba mouth of about 2 km eastwards. In turn, the flood in summer 1558 forced Łeba dwellers to escape. Today we observe floods but now they are not on such scale as in the past. Others examples of floods are observed on catchments in lake Ptasi Raj. In storm time the dam separating water Lake Ptasi Raj and the Wisła Śmiała River is enclosed by water. In this time there is a free exchange of waters between Lake Ptasi Raj and the Wisła Śmiała River.

ANTHROPOGENIC THREATS

The coastland zone of the southern Baltic and the Vistula Delta are characterized by high moisture content due to the topographic features on the one hand, and on the other hand, due to the location in relation to the land and sea. A part of the plateau inundated by inland and sea waters is situated in depression and constitutes the bottoms of lagoons and lakes in original and natural form. Due to the low situation of these areas, natural drainage and use is difficult and sometimes impossible. Hence, the plateau situated around numerous coastal lakes under study has been polderised. Landscape is directly related to the polder water-melioration network, where man is the main element determining the vitality of the landscape [2]. Polders perform the function of irrigating the area from the outside during droughts or draining (pumping out) during periods of water excess. This causes an exchange of the gravitational water circulation for a forced one. A short characterization of polders that exist around coastal lakes is presented below.

A. Polders on the eastern shore of Lake Dąbie
   A polder irrigating-draining system with an irrigation pumping station and embankment sluices. The polder system consists of 5 polders of total area of about 3000 ha. The total capacity of the pumping station is about 4.8 m^3/s [2].
B. Polders near Lake Koprowo
C. Polders near Lake Liwia Łuża and Resko Przymorskie
   Polders of total area of 6.9 thousand ha comprise two polder systems and one polder cluster.
D. Polders of the Słowińskie Coastland
   There are 37 polders that occur in clusters and systems of the total area of 13400 ha. The polders of interest to the author are:
   - a cluster of 5 polders in the River Unieść Valley and near-lake zone of Lake Jamno of 930 ha of area. They are protected against flood by embankments and 5 pumping stations of total capacity of 1.02 m^3/s [2],
   - a system of 4 polders in the River Grabowa Valley and near-lake zone of Lake Bukowo of 2090 ha of area,
   - a single draining polder of the River Głownica Valley of 1600 ha of area and capacity of 1.6 m^3/s, situated at the outflow from Lake Wicko,
   - a system of 3 polders on a near-lake plateau of Lake Modła of 750 ha of area and 2.0 m^3/s of capacity,
   - a polder system and a cluster of 7 polders on a near-lake plateau of Lake Gardno (Fig. 5) of 1630 ha of area and total capacity of 4.45 m^3/s. They are grouped

on the southern, western and eastern sides of the lake. The polders are separated by rivers flowing into the lake,

– a polder system and a cluster of 14 polders on a near-lake plateau of Lake Łebsko of 5900 ha of area and pump capacity of about 9.7 m^3/s [2].

The hydrological connection of these polders with Lake Żarnowieckie consists in taking lake waters to irrigate these areas. The quantity of water possible to be taken from the lake is estimated at 1.7 m^3/s.

F. Polders around Lake Druzno

20 polders provide the capacity of outflow of about 3.33 $m^3/s/km^2$ and inflow of about 6.36 $m^3/s/km^2$ [3].

E. Polders in the drainage basin of the River Piaśnica and Karwianka.

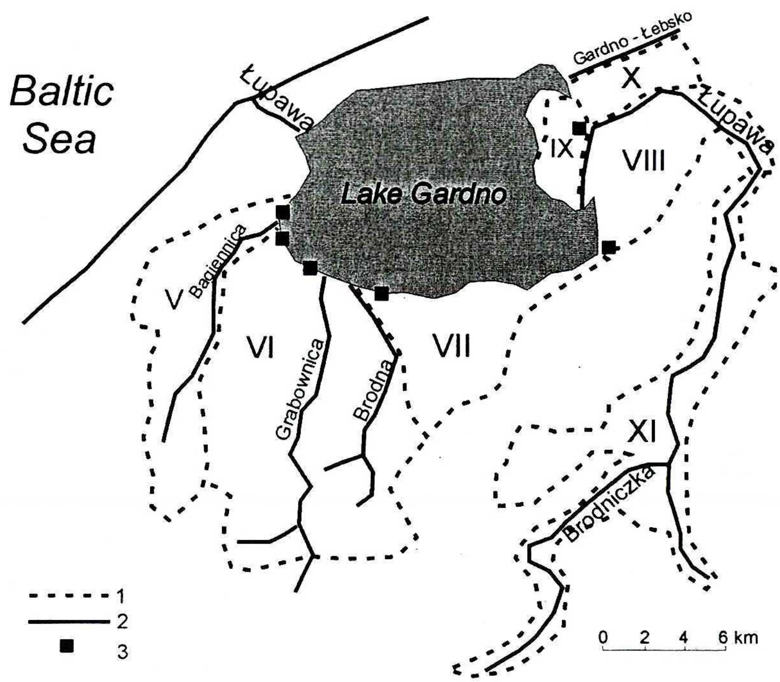

Fig. 5. Polder system of Lake Gardno
1 – border of polders, 2 – rivers, 3 – pumping station of polders

On area polders predominates the net of meliorative channels and ditches, dry from time to time. Many lakes were degraded by industry and economy for example Lake Zaspa in Gdańsk or Lake Żarnowieckie.

Tourism is nowadays a very important source of income for seaside regions, yet the expansion of tourist-recreation movement causes directly the degradation of the environment in the shore zone, including the quality of coastal lakes. There are several reasons: from increased water demand, to sewage disposal and to municipal waste.

Agriculture (Fig. 6) is another example of the degradation of lakes, and seems to be the most dangerous one. As a result of an excessive use of crop protection chemicals and mineral fertilizers as well as waste coming from breading livestock, e.g. storing stable and liquid manure, large quantities of pollutants are introduced to lakes. One of the basic spread pollution sources is also pollution resulting from intense potato farming (fertilization – 650 NKP kg/ha). Overland flow from arable fields contaminates underground waters and gets to rivers that flow into lakes, and directly into lake basins.

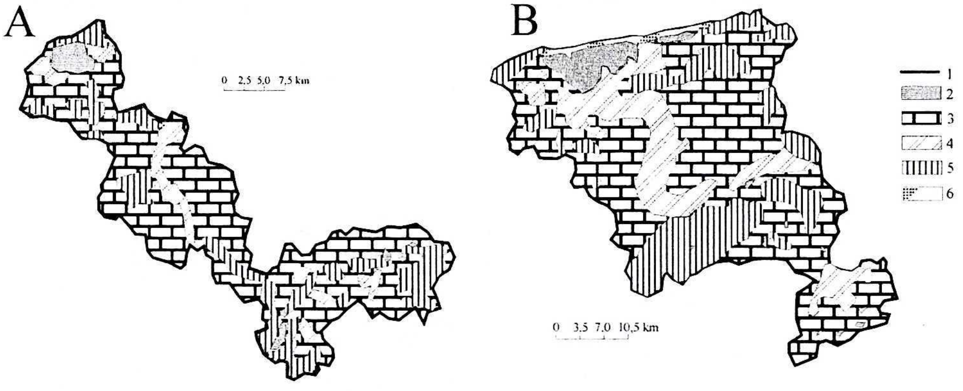

Fig. 6. Land use within the area of the catchments of Lake Gardno (A) and Łebsko (B)
1 – border of catchments, 2 – waters, 3 – ploughs, 4 – green uses, 5 – forests, 6 – waste lands

A local problem, especially in tourist resorts which sewage system lack are septic tanks. Since the discharge of sewage is costly, there is a widespread practice of economizing by damaging the tightness of the walls or bottoms of the septic tanks. The leaking sewage gets to the ground and with underground waters migrates to rivers and lakes [12]. Quite a fast development of agriculture, often at the expense of decrease in forest areas, has contributed to the increase in spread of pollution resulting from the use of artificial fertilizers (nitrogen and phosphorus compounds) and crop protection chemicals, which leads mainly to polluting waters with biogenes. Pollution of this type is most clearly visible in the case of lakes, which due to a big supply of biogenes, start overgrowing intensively (growth of biomass), due to which the oxygen balance of reservoirs is changed and ultimately the lakes disappear. For instance, in Lake Łebsko the value of pollution load is over 300 kg O_2/d expressed as BZT_5 and over 70 kg P/d. For Lake Jamno the supplied load is 41 kg O_2/d expressed as BZT_5, 55 kg N/d and over 1.5 kg P/d. Lake Bukowo receives 10.5 kg O_2/d expressed as BZT_5, 23 kg N/d and about 3 kg P/d from the mechanical-biological sewage treatment plant in Dąbki.

Critical, in terms of the outflow of spread of pollution to lakes in the area of the coastal zone, are the catchments of the littoral rivers: the Łeba and Łupawa. The rivers carry large quantities of dangerous loads, especially from industrial plants. The majority of the sewage is treated but still it carries a high percentage of discharged pollution. Coastal water bodies of the open sea are the last but one recipient on the way of pollution flow into the Baltic. These water bodies are potential recipients of local pollution flowing from their direct catchments [5].

The main point sources of pollution for particular lakes are connected with towns and settlements situated along rivers, which then flow into or are at the outflow from a reservoir. An example of such pollution for Lake Łebsko is the towns of Łeba and Lębork, and for Lake Gardno the village of Rowy together with the industry located there and village sewage.

If point pollution is analyzed on a local scale, i.e. in the direct catchments of the lakes, no large concentration can be observed. For example, in the catchments of Lake Sarbsko there is only one point source of pollution – village sewage treatment plant Sarbsk, which discharges domestic and farming sewage. On the other hand, in the catchments of Lake Łebsko there are four pollution sources: Szczypkowice distillery, Szczypkowice housing estate, Główczyce housing estate and the Production Plant in Krakulice. For Lake Gardno: "Trojak" office in Rowy, village sewage treatment plant in Smołdzino, village sewage treatment plant in Objazd and a holiday centre "Skalnik" in Dębina [4].

An analysis of purity classes according to Regional Inspectorate for Environmental Protection of particular lakes reveals a domination of waters outside classification (Jamno, Wicko, Modła, Druzno, Karaś, Liwia Łuża, Dąbie, Ptasi Raj, Koprowo) and of class III (Łebsko, Gardno, Bukowo, Kopań, Dołgie Wielkie, Dołgie Małe, Sarbsko, Resko Przymorskie) (Fig. 7). Only Lake Żarnowieckie represents class II.

These values indicate an intensified eutrophication and considerable pollution, which result not only from the location in the coastal zone and on the line of transit of rivers that carry pollution from the catchments but also result from a very strong influence of morphometric features of basins and hydrological features of catchments. The classification of a large group of lakes to class III or below is related to high values obtained mainly for organic substances that are chemically decomposed, to general suspension, chlorides, sulphates, sodium, potassium, magnesium, coli titre or compounds of nitrogen and phosphorus as well as BZT_5.

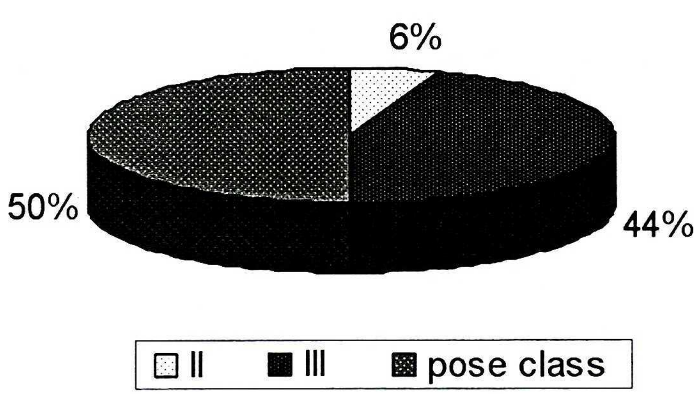

Fig. 7. Percentage distribution of lakes in purity classes according to Regional Inspectorate for Environmental Protection

Table 3. Cleanness classes of waters of coastal lakes

S.n.	Name	Purity classes
1	Łebsko	III
2	Gardno	III
3	Jamno	pose class
4	Bukowo	III
5	Wicko	pose class
6	Kopań	III
7	Modła	pose class
8	Dołgie Wielkie	III
9	Dołgie Małe	III
10	Sarbsko	III
11	Żarnowieckie	II
12	Druzno	pose class
13	Karaś	pose class
14	Liwia Łuża	pose class
15	Resko Przymorskie	III
16	Dąbie	pose class
17	Ptasi Raj	pose class
18	Koprowo	pose class

CONCLUSION

The coastal zone of the southern Baltic is a place of contact of the influence of sea waters and the influence of inland waters. This results in the formation of special water relationships. Macroscale conditions overlap local hydrological conditions and morphometric features of basins and hydrological features of catchments specific to particular lakes. All the natural conditions have been affected by human activity for over eight centuries. As a result, numerous natural and anthropogenic threats occur and cause not only periodic changes in the structure of lakes but such that even endanger their existence. The largest threat is now posed by the inflow of polluted water in the form of municipal sewage, containing large quantities of nitrogen and phosphorus compounds, which lead to the intensification of eutrophication. Agriculture also causes an increase in this phenomenon by overland flow of artificial fertilizers and crop protection chemicals. The above elements are accompanied by a low natural resistance to degradation. Lakes of the coastal zone, with few exceptions, are unable to resist an intensified process of the disappearance of their basins, which results from an excess of energy and matter. They are shallow and vast lakes with no vertical stratification observed even during summer stagnation. Intrusion processes, which cause an increase in the salinity of lake waters, can also significantly change water relationships of particular lakes, which in turn can make human activity more difficult and sometimes even impossible.

The coastal zone encompasses highly interesting and valuable areas of natural, economic and technical values, where lakes play an important role in determining the space and potential of the coastal zone. Thus, reasonable and effective forms of action must be adopted so that the reservoirs in this area could last as long as possible.

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