ORIGINAL ARTICLE

Assessing trophic state of surface waters of Służewiecki Stream (Warsaw)

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Abstract

Phosphorus (P) is one of the key nutrient compounds for phytoplankton grow. In the conducted work, eutrophication indexes were used for the assessment of eutrophication level of water course (Służewiecki Stream) and the waters of nearby lakes (Bottom Berensewicz's Pond, Wyścigi Pond, Wilanowskie Lake). Calculating eutrophication indexes were based on the most important indicators which is crucial for eutrophication process: total phosphorus (TP), total nitrogen (TN), chlorophyll a (Chl(a)) and water transparency. The research revealed that the concentration of phosphorus and nitrogen in the analysed waters determined intensity of trophic processes. The average concentration of both indicators was high: 0.81 mg/l TP and 6.8 mg/l TN. During this research, two approaches were used: trophic state index (TSI) and trophic level index (TLI). TSI (TP) in Służewiecki Stream were, respectively: 83 and 6.5 whilst for standing waters (lake and ponds) 87 and 6.6. Both indexes indicated high trophic state and confirmed that eutrophication is a serious endangerment for analysed surface waters. Calculated indexes used in the assessment were sufficient and effective for sustainable water protection and management of water quality in Służewiecki Stream and in standing waters.

Introduction

The excess of nutrients (phosphorus and nitrogen) introduced to reservoirs and water courses in the result of anthropogenic activities combined with other factors like hydrological modifications, changes of temperature or insolation may cause eutrophication which is enlarged accumulation of organic matter from water plants and algae overgrowth. Those blooms may be unaesthetic and in some cases produce toxins and harmful odours. It may lead to occurrence of low level of dissolved oxygen which may result in a reduction of biodiversity of fish and other aquatic species. Determination of nutrient loads which may be assimilated by the water body may be difficult, because in the opposition of other specific substances, certain amount of nutrients is essential to maintain aquatic life. According to this, there is a need of controlling excessive inflow of nutrients and other parameters which may increase eutrophication. It is important to track the source of nutrients. Inland waters should be analysed to determine if there is an inflow of anthropogenic nutrient loads causing eutrophication, especially to examine possibility of algae bloom, decreases of dissolved oxygen and pH.

While the symptoms of eutrophication differ depending on typology of water body, the concept of developing tools to diagnose eutrophication and identifying nutrients is similar for every type of surface water body. Nutrients like phosphorus and nitrogen occur naturally in surface waters and are basic compounds having an impact on amount of biomass in water bodies. In natural conditions, their circulation is regulated in a cycle and their total amount in ecosystems does not change significantly. Intensification of human activity, especially wastewater management and agriculture, has significant impact on circulation cycle of nutrients in water environment (Wojtkowska and Dmochowski 2009). Higher

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nutrient loads in water ecosystems, which means increase in substrates in processes of creating biomass, lead to faster dynamics of these processes which is observed as higher productivity (algae blooms). This results in the existence of an anaerobic zone at the bottom of the reservoir and increase in putrefaction processes. For eutrophication, typical species are cyanobacteria, phytoplankton algae, green algae and diatoms (Neverova-Dziopak 2007).

Anthropogenic eutrophication causes many disadvantageous consequences for users of aquatic ecosystems, such as increase in costs of water purification, sanitary threat and transformation of lakes into swamps. Indicators of eutrophication are used to assess the risk of eutrophication of surface waters. The methods of their calculation are various, and their basics are based on assessing the factors which may be responsible for eutrophication or may be used for assessing its effects. They are often customized for particular area or even for single reservoirs.

Assessment the level of eutrophication is based mainly on determination water body productivity (Neverova-Dziopak 2007). There are three different types of water bodies according to their intensity of production processes: oligotrophic, mesotrophic and eutrophic. The methods of the assessment of trophic state may be based on particular parameters, which influence biological processes, relevant in the context of eutrophication, such as nutrients, concentration of chlorophyll a, but also temperature, insolation and dissolved oxygen, certain species of algae and fish (Neverova-Dziopak 2007). Besides of assessment of each of those parameters, basing on available limit values specified in the literature or legal standards, there are also methods based on particular parameters aggregated as indexes which includes certain relations between those parameters. To evaluate trophic state of surface waters, several parameters are used. The most important of them are levels of phosphorus, nitrate, chlorophyll a, dissolved oxygen and water transparency (El-Serehy et al. 2018). In fact, the assessment of water quality is very important, when it comes to balance the ecological and social-economic interests. There were many approaches to assess quality of rivers and lakes worldwide. In 1965 in the USA, Horton (1965) developed water quality index (WQI) which was widely used and accepted in Europe, Africa and Asia. Carlson (1977) developed numerical classification of lake trophic state—trophic state index (TSI), in Burns et al. (2005) modified Carlson's TSI into trophic level index (TLI).

To simultaneously assess trophic state, chemical and biological conditions of reservoirs, there is a need to find an index which includes those factors and allows to widely assess ongoing processes and their dynamics in waters. That index may be analysis of stable isotopes of elements which naturally occurs in water environment, mostly nitrogen and carbon. Comparison of amount of certain isotopes of particular element may indicate the intensity of the processes which depends on metabolism of water organisms (especially production) (Bartoszek et al. 2018). The $\delta^{13}C$ index shows the difference between ratio of carbon isotopes ^{13}C and ^{12}C in analysed example and ratio of those isotopes in reference sample which may be mineral oil with known (Bartoszek et al. 2018). This index is presented as per mille of difference between those ratios. This ratio is correlated with amount of nutrients in water and with other trophic indexes such as TSI, so it is possibility of usage of this index as a new index of trophic state in water quality analysis (Gu et al. 2011; Lehmann et al. 2004; Bartoszek et al. 2018; El-Serehy et al. 2018).

The aim of study was to do the research which may evaluate the trophic state of stream and reservoirs. The tests were conducted for surface waters localised in the area of agglomeration of city of Warsaw: Służewiecki Stream, Wilanowskie Lake, Bottom Berensewicz's Pond, Wyścigi Pond (Fig. 1). The assessment of water quality was carried basing of biological and physicochemical analysis.

Characteristics of analysed objects

Służewiecki Stream is not designed as single water body in the meaning of Water Framework Directive, and it is not included in National Monitoring Programme (WIOŚ 2017). It is included in water body "Wilanówka" (PLRW20002625929). Stream is a watercourse which is located all along in the area of City of Warsaw. The sources are located near the Chopin Airport (Okęcie district) and it mouths to Wilanowskie Lake within the sites of King John the third Park Museum. The length of stream is about 8 km. Around the stream, there are reservoirs fed with waters of stream:

- Two Ponds (Berensewicz's Upper and Bottom)—outside the riverbed
- Wyścigi Pond—directly in the riverbed
- Ponds at the area of Dolinka Służewiecka park—outside the riverbed (PRNG 2018).

According to Corine Land Cover 2018 land use of the streams's catchment area is mostly (53%) discontinuous urban, 24%—industrial, commercial or transport and 24%—other. 7% of catchment is managed as agricultural.

To obtain the aim of the study nine monitoring points were designated. All samples were taken between May and October 2018. Detailed information of each point is presented in Table 1. The location of monitoring point and basic information about studied area is presented in Fig. 1.
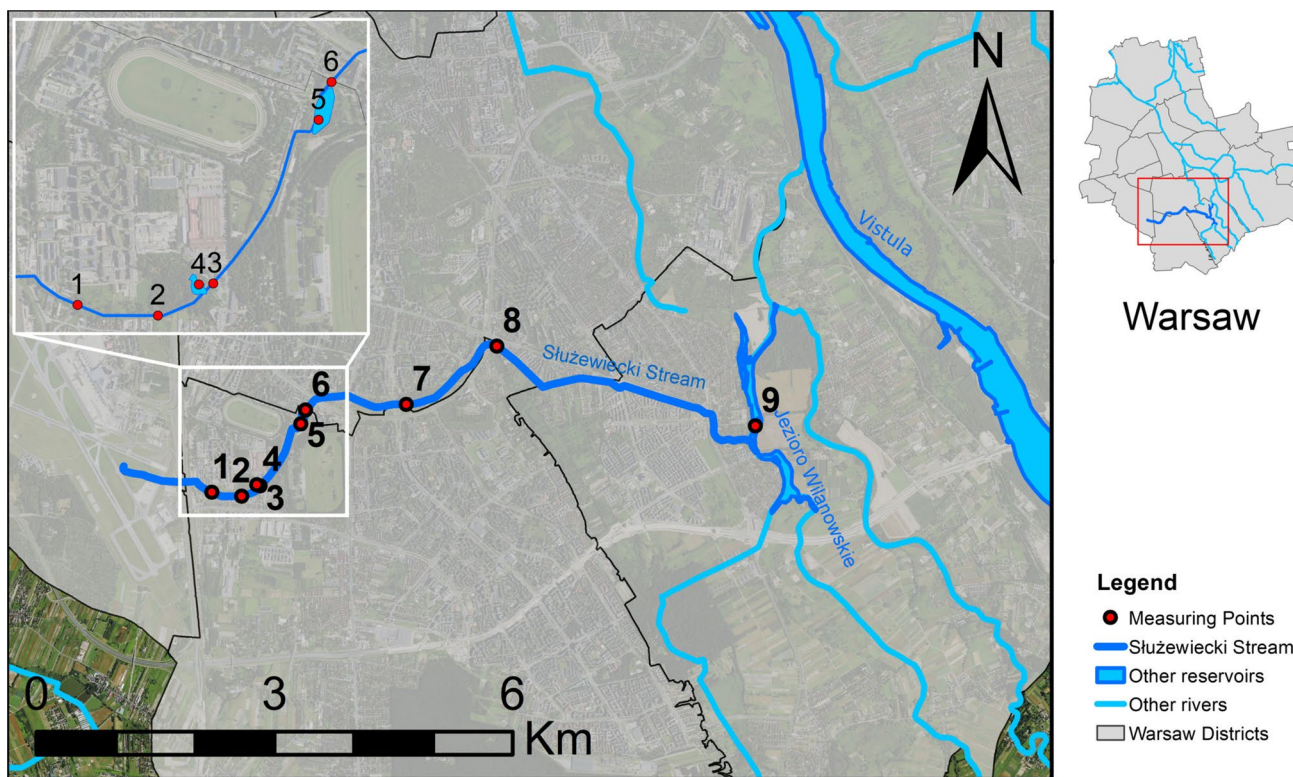
Fig. 1 Location of research area and measuring points

Table 1 Details of measuring points

ID	Point type	Point name	Annotations
1	Stream	Kłobucka–Brigde	
2	Stream	Wyczółki–Meadows	
3	Stream	Wyczółki–Bridge	Below the pond
4	Pond	Bottom Berensewicz's Pond	Outside the streambed
5	Pond	Wyścigi Pond	
6	Stream	Wyścigowa	Below the pond
7	Stream	Dolinka Służewiecka Park–Bridge	
8	Stream	Fosa–Bridge	
9	Lake	Wilanowskie Lake	Below the stream mouth

Methodology

To conduct the research nine measuring points were designated in which six was localised at the riverbed of stream two ponds and Wilanowskie Lake. Water samples were taken four times: in May, July, August and October 2018. The physicochemical and biological parameters in collected samples were determined, which allowed to assess the level of eutrophication in stream, ponds and lake. In measurements included: total phosphorus (TP), orthophosphates, total nitrogen (TN), nitrates (V), nitrates (III), ammonia nitrogen, chlorophyll a and transparency (Secchi's method with compatibility of EU standards). Prepared maps use data from polish River Basin Management Plans database (KZGW 2017) and national boundaries of administrative units (GUGiK 2021).

Each sample was taken once in amount of 2 l. Chemical analysis has been made the same day as sampling. The following methods of chemical analysis were used: TN concentration: using Kjeldahl's method, $N-NO_3$ concentration: spectrophotometric nitrates determination using sodium salicylate (expressed as N-form), $N-NO_3$ concentration: colorimetric nitrites detection using sulfanilic acid and α-naphthylamine (expressed as N-form), $N-NH_3$ concentration: Colorimetric ammonium detection using Nessler

reagent (expressed as N-form), TP concentration: spectrophotometric phosphorus determination using ammonium molybdate and tin (II) chloride after mineralization, P-PO$_4$ concentration: spectrophotometric phosphorus determination using ammonium molybdate and tin (II) chloride (expressed as P-form), pH—electrometric method using an electrode, electrical conductivity using conductometer, general alkalinity—by titration against indicators (methyl orange and phenolphthalein); calcium concentration: by titration complexometric using sodium edetate, magnesium concentration: by titration complexometric method with the use of disodium edetate, chloride concentration: by Mohr's argentometric method, concentration of sulphates: by spectrophotometric method with the use of barium chloride, Secci's Depth: using Secchi disc, Chlorophyll a concentration in planktonic algae: using monochromatic spectrophotometric method with correction for phaeopigments a (PN-C-05560-01:1986), δ^{13}POC content in suspension: after filtering a given volume of water through a glass fibre filter, dried at 50 °C and subjected to HCl vapours in a desiccator to remove carbonates. The filter with the sample was analysed with a DELTA Plus apparatus paired with a Flask 1112 apparatus for elemental analysis, TSI indicator: using Carlson's equitation (Carlson 1977), TLI indicator: using equitation given by Burns et al. (1999).

Results and discussion

To assess eutrophication level and obtain data for further TSI and TLI analysis, we performed chemical analysis of 16 parameters, including trophic-related and other physicochemical indicators. The analysis showed that both waters of Służewiecki Stream and analysed reservoirs showed high concentrations of nutrients. In waters from the stream, the amounts of TN were in the range of 2–14 mg N/l and TP between 0.04 and 2.24 mg P/l. The chlorophyll amount was in the range 1.1–62.7 μg/l. Comparison of those values with concentrations of orthophosphates and nitrogen forms indicates that nitrogen in analysed objects is mainly in organic form. Table 2 shows the detailed values of each measurement. Highest amounts of nutrients were observed in summer–autumn measurements and highest Chl(a) was observed in late-spring measurements which indicates impact of eutrophication and algae bloom on nutrient loads in stream and ponds. Służewiecki Stream flows through small agricultural (mostly allotments), however, its catchment is located mainly in urban area. According to conducted research, it is not recipient of any municipal wastewater (WIOŚ 2017, 2018) which means that main part of nutrient loads remains unidentified. It is unlikely that atmospheric deposition is responsible for such high concentration values, so illegal sewage or recharge from sediments may be the source of nutrient loads. Recharge from highly eutrophicated ponds located in area (both inside and outside streambed) may be source of nutrients in Służewiecki Stream. Values of δ^{13}POC which might be good indicator of trophic state (Lehmann et al. 2004) were between − 34.1‰ and − 23.46 ‰, however, in this study, we did not find any correlation between δ^{13}POC and other parameters.

Auxiliary parameters were analysed to provide indicative information about non-trophic-related state of stream and lake and ponds water. Performed analysis indicates high values of conductivity (for which good ecological value—GES for this type of water bodies are set at 795 μS/cm), concentration of magnesium (GES = 11.3 mg/l) and concentration of chloride ion (GES = 176 mg/l). All values of these parameters in each point and measurement are presented in Table 3. High values of this parameters may be indicated by industrial pollution or rainwater discharges from urban area. The most significant industrial activity in catchment is National Airport. However, analysis of the loads from airport sewages was not part of this study so it is not possible to confirm airport influence on the quality of stream and transported loads.

TSI Index in stream and reservoirs

Basing on obtained concentrations of phosphorus chlorophyll a and Secchi's depth TSI was calculated. The most important index taking into account surface water trophic state TSI(Chl) based on chlorophyll a concentration as the determinant of biomass of algae was between 31–72 (Table 4) depending on measuring point and date of sampling. The lowest values were in summer (July) the highest—in autumn (September). For the stream average value of TSI (Chl) was 53, for Bottom Berensewicz's Pond—52, for Wyścigi Pond—50 and for Wilanowskie Lake 56. Those values of TSI (Chl) indicate trophic state as eutrophic, with the anoxic conditions and possibility of macrophytes growth.

Very important for trophic state evaluation is TSI (TP) index which was very high with values between 57–140 with the average 83 in Służewiecki Stream, 87 in Bottom Berensewicz's Pond, 89 in Wyścigi Pond and 89 in Wilanowskie Lake (Table 4). All analysed objects where TSI (TP) is much higher than TSI (Chl) which may indicate that there are limitations for the algae growth like low nitrogen concentrations, low insolation or toxic substances. Obtained results indicated that availability of nitrogen may be bottleneck—the excesses of nitrogen was lower comparing to reference limit values than in case of total phosphates. TSI (SD) which is based on transparency (Secchi's depth) was between 50 and 66 (Table 4) which value is similar to values of index based on chlorophyll a.

Table 2 Obtained results of trophic-related parameters

Date	ID	TP mg P/l	P-PO$_4^{3-}$ mg P/l	TN mg N/l	N-NO$_3$ mg N/l	N-NO$_2$ mg N/l	N-NH$_3$ mg N/l	Secchi m	Chl (a) μg/l	δ^{13}POC ‰
05.2018	1	0.1	0.08	11.2	9	0.007	0.57	1	7.9	− 26.52
05.2018	2	0.07	0.06	6	6	0.008	0.39	–	–	− 29.1
05.2018	3	0.08	0.08	4	5	0.007	0.29	1.5	2	− 27.93
05.2018	4	0.17	0.16	4	5	0.007	0.48	0.5	62.7	− 33.85
05.2018	5	0.11	0.1	6	6	0	0.45	0.75	8.1	− 31.69
05.2018	6	0.16	0.15	6	7	0.005	0.23	1	23.9	− 34.1
05.2018	7	0.15	0.1	12	16	0	0.22	1	44	− 31.73
05.2018	8	0.07	0.05	2	2	0	0.38	1	39.7	− 31.91
05.2018	9	0.85	0.85	4	1	0.285	3.7	0.5	35.8	− 30.18
07.2018	1	0.44	0.4	8.4	6	0.252	1.15	1	1.1	− 26.06
07.2018	2	0.6	0.34	8.4	7	0.232	1.18	–	1.2	− 26.22
07.2018	3	0.04	0.03	8.4	7	0.2	0.76	0.5	1.7	− 26.54
07.2018	4	0.21	0.21	2.8	1	0	0.42	0.5	3.3	–
07.2018	5	0.36	0.36	5.6	1	0	0.55	0.75	5.2	− 29.38
07.2018	6	0.12	0.06	5.6	1	0.72	0.66	1	–	− 28.65
07.2018	7	0.04	0.03	2.8	1	0.079	0.71	1	13.3	− 29
07.2018	8	0.08	0.03	2.8	1	0	0.57	1	8	− 26.35
07.2018	9	0.27	0.27	2.8	1	0	0.56	0.5	12.4	− 30.08
09.2018	1	0.48	0.19	8.4	0.7	0.058	0.19	1	1.4	− 24.89
09.2018	2	-	0.18	2.8	0.5	0.04	0.24	–	9.6	− 24.63
09.2018	3	1.04	0.29	2.8	0.6	0.01	0.21	0.5	2.8	− 25.3
09.2018	4	0.36	0.28	2.8	0.2	0.003	0.38	0.5	5.6	− 29.48
09.2018	5	1.16	0.35	5.6	0.4	0	0.36	0.75	6.5	− 30.09
09.2018	6	2.24	0.03	14	0.6	0.02	0.37	1	53.3	− 30.85
09.2018	7	0.72	0.09	2.8	0.6	0.012	0.38	1	42.5	− 31.62
09.2018	8	0.28	0.01	5.6	0.1	0.028	0.26	1	43.3	− 29.6
09.2018	9	0.76	0.18	14	0.2	0.004	0.31	0.5	2.9	− 30.22
10.2018	1	0.34	0.34	14	0.7	0.041	0.52	1	–	− 24.59
10.2018	2	0.44	0.24	8.4	0.5	0.024	0.26	–	–	− 24.7
10.2018	3	0.44	0.1	8.4	0.5	0.022	0.58	0.5	16.4	− 25.34
10.2018	4	1	0.17	-	0.3	0.027	0.19	0.5	5.4	− 28.82
10.2018	5	0.35	0.35	11.2	0.7	0.031	0.06	0.75	13.1	− 28.04
10.2018	6	0.24	0.02	5.6	0.5	0.029	0.41	1	8	− 28.56
10.2018	7	0.15	0.15	2.8	0.5	0.05	0.03	1	11.1	− 23.46
10.2018	8	0.32	0.24	5.6	0.6	0.039	0.04	1	25	− 27.16
10.2018	9	0.4	0.16	11.2	0.5	0.009	0.12	0.5	23.8	− 27

Obtained results indicated that Służewiecki Stream and nearby reservoirs are significantly eutrophicated and the concentration of total phosphorus was a dominant factor. Reason of that state may be various, however, in general, the most important sources in surface waters in this area are municipal wastewater inflow and surface runoff, including agricultural land use (Wojtkowska and Bojanowski 2018). Nevertheless, the Służewiecki Stream is not recipient of any municipal wastewater and intensity of agriculture in this area is negligible, so the source of nutrients in stream remains unknown.

It should be noted that TSI was developed for assessment of trophic state in lakes, which are reservoirs of large area and slow water flow. However, bearing in mind that it is based on parameters which are possible to test in flowing waters as well as in standing waters and obtained results were comparable it is possible to indicate that utilization of TSI to evaluate trophic state of surface waters of Służewiecki Stream and nearby reservoirs was reasonable.

Table 3 Obtained results of auxiliary parameters

Date	ID	pH –	Cond µS/cm	Alkal mg CaCO₃/l	Ca mg Ca/l	Mg mg Mg/l	Cl⁻ mg Cl/l	SO₄²⁻ mg SO₄²⁻/l
05.2018	1	7.61	1140	350	124.25	68.04	175	48
05.2018	2	7.76	1137	350	116.23	19.44	170	44
05.2018	3	7.71	913	250	66.53	24.3	155	58
05.2018	4	7.67	1010	330	92.18	31.59	177	22
05.2018	5	7.69	1064	325	85.77	44.71	187	28
05.2018	6	7.71	901	200	68.94	26.73	165	40
05.2018	7	7.64	920	195	68.14	29.16	163	60
05.2018	8	7.64	989	200	64.13	31.59	205	50
05.2018	9	7.49	801	245	56.11	55.89	100	80
07.2018	1	8.04	1290	375	120.24	48.6	208	58
07.2018	2	8.1	1305	360	102.6	41.31	211	70
07.2018	3	7.9	1148	340	102.6	26.73	213	75
07.2018	4	7.53	650	250	76.15	43.74	83	105
07.2018	5	7.2	1152	275	120.24	51.03	173	0
07.2018	6	8.01	614	190	40.08	24.3	128	55
07.2018	7	7.77	633	250	72.14	26.73	128	63
07.2018	8	7.65	836	200	64.13	36.45	168	58
07.2018	9	7.45	740	225	104.21	36.45	78	85
09.2018	1	7.66	1721	430	196.39	55.89	250	90
09.2018	2	8.05	1405	475	72.14	38.88	230	55
09.2018	3	8	1343	475	80.16	48.6	230	73
09.2018	4	7.23	856	300	76.15	53.46	125	90
09.2018	5	7.28	553	325	48.1	29.16	95	11
09.2018	6	8	855	275	32.06	43.74	150	83
09.2018	7	7.95	851	350	92.18	82.62	140	83
09.2018	8	7.68	843	250	40.08	24.3	160	88
09.2018	9	7.24	850	325	44.09	43.74	125	58
10.2018	1	7.82	1358	390	76.95	54.43	190	75
10.2018	2	8.01	1278	400	16.03	102.06	185	95
10.2018	3	8.18	1094	300	24.05	68.04	165	65
10.2018	4	7.58	736	195	44.09	46.17	107	98
10.2018	5	7.79	612	180	32.06	38.88	110	7
10.2018	6	7.76	779	190	32.06	54.43	135	65
10.2018	7	7.81	778	200	20.04	55.89	135	75
10.2018	8	8.1	803	175	25.65	51.03	140	58
10.2018	9	7.85	706	250	33.67	65.12	102	100

Calculation of TLI for analysed subjects

The range of values of TLI was between 5 and 8 (Table 5), and the highest values were observed in September and October. Average values of TLI were 6.4 in Służewiecki Stream, 6.5 in Bottom Berensewicz's Pond, 6.5 in Wyścigi Pond and 6.7 in Wilanowskie Lake. These results indicate that those subjects are in hypertrophic state (range 6.0–7.0). Trophic state in analysed reservoirs was determined mostly by phosphorus and nitrogen concentrations which were higher than reference limit values. High concentration of chlorophyll a and low transparency.

There were many studies aiming on establishing the acceptable criteria and classification levels of lakes basing on trophic state, nutrients, total phosphorus and other physical factors (transparency, dissolved oxygen) and biological (algae pigments) (OECD 1982; Vollenweider 1989; Galvez-Cloutier and Sánchez 2007; Zębek 2010; Ferreira et al. 2011). Conducted research allowed to identify quality significant quality parameters of waters of Służewiecki Stream and nearby reservoirs which have influence on trophic state and ecological state of this waters. Water quality in stream is bad. Main indicator of that state is concentration of total phosphorus and high concentration of TN. Calculated values

Table 4 Obtained TSI values

ID	05.2018			07.2018			09.2018			10.2018		
	TSI TP	TSI SD	TSI Chl	TSI TP	TSI SD	TSI Chl	TSI TP	TSI SD	TSI Chl	TSI TP	TSI SD	TSI Chl
1	70.6	60	–	91.9	60	31.6	93.2	60	33.9	57.3	60	–
2	65.4	–	–	96.4	–	32.4	138	–	52.8	91.9	–	–
3	65.4	65.8	37.4	57.3	50	35.8	104.3	50	40.8	91.9	50	58.1
4	78.2	50	71.2	80.6	50	42.3	89	50	47.5	103.8	50	47.1
5	71.9	55.9	51.1	89	55.9	46.7	105.9	55.9	48.9	87.3	55.9	55.9
6	77.3	60	61.7	73.2	60	–	115.4	60	69.6	83.2	60	51.1
7	76.4	60	67.7	57.3	60	56	99	60	67.4	73.2	60	54.2
8	65.4	60	66.7	67.3	60	50.9	85.4	60	67.6	87.3	60	62.2
9	83.8	50	65.7	67.3	50	55.3	99.8	50	41	90.5	50	61.7

Table 5 Obtained TLI values

ID	05.2018	07.2018	09.2018	10.2018
1	6.2	6	6.1	6.4
2	6.7	6.3	–	8.1
3	5.2	5.6	6.4	6.9
4	6.8	5.9	6.2	7.1
5	6.1	6.3	6.7	6.8
6	6.4	6.5	7.8	6.2
7	6.8	5.6	6.8	5.9
8	5.9	5.6	6.7	6.6
9	6.7	6	6.8	7.1

of aggregated indexes of trophic state: TSI and TLI indicate eutrophic state of waters in Służewiecki Stream, Bottom Berensewicz's Pond, Wyścigi Pond and Wilanowskie Lake. It also indicates that it is rational to use those indexes to evaluate trophic state of flowing waters as well as standing waters. It should be noted that TLI index which is based on average values of each parameters is more restrictive than TSI which is based on one parameter (chlorophyll a, TP, SD). The reason may be reference scale proposed by its authors. TSI (TP) indicates high intensity of eutrophication, therefore TP may be the reason of that state in analysed subjects.

Conclusions

- The Służewiecki Stream is not a recipient of municipal wastewater, and agriculture in the catchment area is not intensive, and therefore, the cause of high concentrations of substances responsible for eutrophication is unknown. The cause may lie in illegal discharges of substances into the rainwater sewage system (despite the fact that the area is well canalized), recharge from bottom sediments or atmospheric deposition, including surface runoff from urbanized areas. Hypothesis on non-municipal origin of those pollutions is supported by high content of calcium, chlorides, sulphates the high alkalinity of stream's waters.

- Values of TSI and TLI indexes indicate high eutrophic state of analysed objects. The main factor responsible of that state is high TP concentrations.

- Evaluation of trophic state of waters utilizing TSI and TLI is suitable for the needs of water management. (Parparov et al. 2010) as it confirms the conclusion from common indicator. However, we do not found significant correlation between the values of trophic indicators (TN, TP, TLI, TSI) and $\delta^{13}POC$.

- Actions aimed at restoring good quality of water in the Służewiecki Stream and nearby reservoirs would require the long-term identification of factors and pressures that could affect the condition of these waters, and then undertaking measures at limiting their impact on the Służewiecki Stream catchment area.

- Preventing an eutrophication should consist limitation of pressures related to nutrients to surface waters by utilizing the best available techniques and suitable legal procedures. Removing the effects of eutrophication results with the necessity of re-cultivation of reservoir and usually is time consuming and expensive.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethics approval The authors approved ethical responsibilities of journal.

Consent for publication The authors consent to the publication.

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