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# SELF-PURIFICATION CAPACITY OF SURFACE WATERS UNDER CONSIDERABLE ANTHROPOPRESSION

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**Keywords**: Self-purification, biodegradation rate coefficient, assimilative capacity, biodegradable pollutants.

**Abstract:** The analysis of water self-purification process includes headstreams of rivers in the Upper Silesian agglomeration: the Bierawka, the Kłodnica, Bielszowicki creek and the Szotkówka. These are rivers characterized by small natural flows and a significant anthropogenic pollutant load. Results of our own research on the self-purification rate were used. The attention was focused on biodegradable substances. The biodegradation rate coefficient $k_1$ and water assimilative capacity were determined. Within the same rivers, their particular parts differ in types of a riverbed and swift currents alternate with slow flows. In the case of Bielszowicki creek and the Szotkówka River impoundments were observed, which results in different self-purification conditions. In all investigated parts the rate of organic substance removal, characterized by $k_1$ coefficients, was usually much higher than the literature values for comparable rivers, which usually are below 2.0, rarely exceeding 3.0. The creek impoundments occurring in the watercourse beds do not always have a positive impact on the water quality. The role of the creek impoundments in the river self-purification process and their impact on water ecosystems require separate investigations.

## INTRODUCTION

Determining the permissible level of human impact on the water environment, which does not result in exceeding the pollution level tolerated by water ecosystems or the level settled arbitrarily, must be preceded by determining the water permissible pollutant load, i.e. the water processing capacity. On this basis the admissible anthropogenic pollutant load can be determined. This is particularly important in catchments of significant anthropopression, slight natural flows and therefore sensitive to pollutants.

These include catchments of the Upper Silesian Agglomeration, where in the period of 1991–1999 the possibilities of applying methods based on the use of water self-purification capacity to support investment activity were investigated and analyzed [3, 14, 17–19]. Moreover, a research on the development of a method for water quality management in anthropogenic catchments with controlled volume of the introduced pollutant loads was carried out [4–6]. One of the main objectives was to assess the effectiveness of the self-purification process understood as the effect of dilution and removal of contaminants from water environment as a result of various processes, the explicit identification and description of which is sometimes very difficult. The research activity is continued within the project “Friendly Kłodnica River”, being carried out since 2004.

Practically, in order to assess the effects of all integral processes, it is often enough to use appropriate coefficients and indices. The aim of this study is to present selected measurement results obtained within the above-mentioned research activity.

## RESEARCH METHODOLOGY

To assess the self-purification capacity of the analyzed rivers some commonly used coefficients were applied, which very well describe the final effect of this process. These are:

- biochemical oxygen demand rate coefficient – $k_{1(r)T}$ coefficient for water temperature at the measurement time and $k_{1(r)20}$ coefficient, corrected for standard temperature of +20°C;
- water processing capacity *PC*;
- water self-purification degree *SD*.

*Biochemical oxygen demand rate coefficients* – oxygen demand rate in the process of biochemical decomposition of organic substances in laboratory conditions proceeds according to the first order reaction [2, 11], which can be described by the following general formula (1):

$$-\frac{dL_t}{dt} = K_1 L_t \qquad [\mathrm{g/m^3 \cdot d^{-1}}] \tag{1}$$

where:

$L$ = BOD at the beginning of the process [g $O_2/m^3$];
$L_t$ = BOD after time $t$ [g $O_2/m^3$];
$t$ = time [d];
$K_1$ = biochemical oxygen demand rate coefficient for a natural logarithm ($K_1 = 2.3\ k_1$, where $k_1$ is a biochemical oxygen demand rate for a decimal logarithm) [$d^{-1}$].

After integration the following is obtained:

$$L_t = L \cdot 10^{-k_1 t} \tag{2}$$

In natural conditions, in the case of flowing waters, where changes of the oxygen consumption in the process of biochemical decomposition of organic substances are considered in time, in which the organic substance covers a particular river stretch between cross-sections: upper (A) and lower (B), the equation (2) can be presented in the following way:

$$L_B = L_A \cdot 10^{-k_1 \cdot t} \tag{3}$$

From the equation (3) the following can be concluded:

$$k_{1(r)} = \frac{1}{t} \log \frac{L_A}{L'_B} \tag{4}$$

or

$$k_{1(r)} = -\frac{1}{t} \log \frac{L'_B}{L_A} \tag{4a}$$

where:

$k_{1(r)}$ = biochemical oxygen demand rate coefficient in the river, under natural conditions;
$t$ = water flow time on the stretch between cross-section A and B [d];
$L_A$ = BOD at the beginning of the stretch, at A cross-section [g $O_2/m^3$];
$L'_B$ = BOD at the end of the stretch, at B cross-section, having considered the correction resulting from decreasing BOD due to dilution with natural flow waters. The cor-

rection is calculated according to the following formula:

$$L'_B = L_B : (Q_A : Q_B) \quad [\mathrm{g\ O_2/m^3}],$$

where:
$Q_A$ = water flow at the beginning of the stretch at A cross-section [$m^3/s$],
$Q_B$ = water flow at the end of the stretch at B cross section [$m^3/s$].

Analyses of BOD in the river were carried out at different temperatures and their values were referred to the temperature of +20°C in order to unify the values of coefficients obtained from measurements at actual temperatures. The following Theriault's equation was used [11]:

$$k_{1(r)T} = k_{1(r)20} \cdot \alpha^{(T-20)} \tag{5}$$

therefore

$$k_{1(r)20} = k_{1(r)T} \cdot \left[\alpha^{(T-20)}\right]^{-1} \tag{5a}$$

where:
$\alpha$ = thermal coefficient dependant on several factors (such as: course of the self-purification process, wastewater treatment degree, climate conditions) and assuming various values. In this study the value of 1.047 according to Theriault was assumed [11].

*Water processing capacity* – degradable pollutant load, reduced in a particular time at the analyzed river stretch due to self-purification processes. The water processing capacity was determined using the following equation:

$$PC = \frac{(Ł_A - Ł_B) \cdot 3600}{1000 \cdot t} \quad [\mathrm{kg\ O_2/h}] \tag{6}$$

where:
$PC$ = BOD load per hour, reduced on the stretch A – B [kg $O_2$/h];
$Ł_A$ = BOD load per second, at the beginning of the stretch, at A cross-section [g $O_2$/s];
$Ł_B$ = BOD at the end of the stretch, at B cross-section [g $O_2$/s];
$t$ = flow time on the stretch [h].

Determining the water processing capacity allows for quick definition of the pollutant load which can be discharged to the water without causing its excessive pollution.

*Water self-purification degree* – effect of the actual reduction and apparent pollution reduction resulting from dilution. It illustrates changes in the pollutant concentration along the watershed; for the water user it is the most communicative instrument for measuring the quality changes. It was determined as follows:

$$SD = \frac{L_A - L_B}{L_A} \cdot 100\% \quad [\%] \tag{7}$$

where:
$L_A$ = BOD measured at the beginning of the stretch, cross-section A [g $O_2/m^3$];
$L_B$ = BOD measured at the end of the stretch, cross-section B [g $O_2/m^3$].

## OBTAINED RESULTS AND DISCUSSION

Values of the analyzed self-purification parameters were calculated. Based on the results of research carried out by the Institute for Ecology of Industrial Areas (IETU) in the period of 1992–2005 on the Bierawka, the Szotkówka and the Kłodnica rivers as well as Bielszowicki creek, with the leading participation of the author. The obtained results were presented in Table 1.

Table 1. Water self-purification parameters (BOD) in upper stretches of the Bierawka, the Szotkówka, the Kłodnica Rivers and Bielszowicki creek

| River, stretch length (number of measurements) | $k_{1(r)T}$ | | $k_{1(r)20}$ | | Water processing capacity $PC$ [kg $O_2$/h] | | Water self-purification degree $SD$ [%] |
|---|---|---|---|---|---|---|---|
| | Range | Mean | Range | Mean | Range | Mean | Range |
| the Bierawka 1996 | | | | | | | |
| Below Orzesze 1.0 km (3) | 1.26–1.94 | 1.6 | 1.1–3.9 | 2.2 | 0.44–1.19 | 0.9 | 10.5–13.1 |
| Orzesze – Bełk 4.7 km (5) | 0.61–4.71 | 2.5 | 1.1–7.0 | 4.1 | 0.15–1.07 | 0.7 | 57.6–90.5 |
| Bełk – Czerwionka 4.5 km (4) | 0.15–3.72 | 1.6 | 0.2–6.7 | 2.7 | 0.10–3.13 | 1.0 | 21.7–89.7 |
| Bielszowicki creek (Kłodnica tributary) 1992–1993 | | | | | | | |
| Above Mośniak creek impoundment 1.0 km (2) | 5.11–6.99 | 6.1 | 7.0–12.9 | 9.9 | 0.43–0.85 | 0.6 | 64.7–72.1 |
| Mośniak creek impoundment 0.6 km (5) | 1.24–3.35 | 2.7 | 1.3–4.4 | 3.2 | 0.29–0.79 | 0.5 | 8.9–27.3 |
| Above Bielszowice creek impoundment 1.0 km (1) | 3.04 | – | 4.2 | – | 14.2 | – | 39.3 |
| Bielszowice creek impoundment 0.8 km (3) | 1.21–2.21 | 1.7 | 1.7–2.9 | 2.2 | 1.4–10.6 | 5.6 | 20.1–50.0 |
| Below Bielszowice creek impoundment 0.6 km (2) | 5.09–9.03 | 7.1 | 6.7–12.5 | 9.6 | 18.82–26.4 | 22.6 | 41.0–62.1 |
| Bielszowicki creek (Kłodnica tributary) 2005–2006 | | | | | | | |
| Mouth stretch 1.3 km (2) | 2.0–3.37 | 2.68 | 2.21–4.24 | 3.23 | 0.55–5.29 | 2.92 | 30–64 |
| the Kłodnica 1991 | | | | | | | |
| Above Katowice 5.4 km (1) | 0.29 | – | 0.7 | – | 0.34 | – | 19.1 |
| Katowice – Panewniki 3.8 km (1) | 2.24 | – | 5.5 | – | 6.12 | – | 80.5 |
| Above the Jamna mouth 4.1 km (1) | 0.39 | – | 0.9 | – | 3.06 | – | 15.3 |
| the Kłodnica 2005–2006 | | | | | | | |
| Katowice – Panewniki 0.8 km (6) | 0.54-15.29 | 7.87 | 1.0–18.37 | 9.48 | 0.02–0.42 | 0.19 | 19–74 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Above the Jamna mouth 3.81 km (6) | 0.25–11.56 | 3.95 | 0.26–12.4 | 4.79 | 0.12–17.77 | 4.64 | 17–93 |
| Below Halemba Treatment Plant 1.6 km (4) | 0.48–8.32 | 2.92 | 0.69–9.37 | 3.3 | 1.05–27.94 | 12.22 | 6–62 |
| the Szotkówka 1994 | | | | | | | |
| Above the Mszanka mouth 2.6 km (2) | 0.65–1.09 | 0.9 | 0.7–1.3 | 1.0 | 0.16–1.19 | 0.7 | 36.5–39.7 |
| Below the Ruptawka mouth 6.5 km (2) | 0.67–0.77 | 0.7 | 0.8–0.9 | 0.9 | 2.33–7.03 | 4.7 | 36.6–41.4 |

Values of $k_1$ depend on several factors and may vary significantly, from 0.01 to 3.0 and more, depending on the type of receiver and pollutant characteristics. Research carried out on the Odra River in the navigation period – from spring to autumn – showed that at the initial BOD of 15 mg $O_2$/dm$^3$, $k_{1(r)20}$ coefficient (referred to the temperature of +20°C) did not exceed the value of 0.2 [11]. In the research conducted on the Vistula River from autumn 1968 till the end of summer 1969 on the stretch between the Przemsza and the Skawa Rivers [12, 13] the average values of this coefficient varied from 0.13 (summer and high water levels) and 0.54–1.90 (autumn, normal flows). IETU's own measurements, which the presented study is based on, indicate that under specific hydrochemical conditions of watersheds (low water flows, varied flow rate, poor wastewater treatment level) the coefficient $k_1$ under actual conditions ($k_{1(r)T}$) may reach values up to 15.3 as, for example, in the case of the Kłodnica River in 2005 (Tab. 1).

### *The Bierawka*

There is a regulated riverbed throughout the whole river. The bottom and banks are almost entirely natural, with exuberant waterside vegetation [14]. Swift currents and small cascades are quite common. The research covered 3 stretches of the river of the total length of 5.6 km: Orzesze region (about 1 km), between Orzesze and Bełk (approximately 3 km) and between Bełk and Czerwionka (about 4.5 km). In the first, upper stretch, within the town boundaries (about 1 km) $k_{1(r)T}$ and $k_{1(r)20}$ coefficients (Tab. 1) maintained at the level of 1.3–1.9 (mean 1.6) and 1.1–3.9 (mean 2.2), respectively. These are relatively high values, if compared to the literature data, typical for rivers of a lower wastewater burden [11–13]. This resulted from good aeration and mixing of waters due to the unevenness bottom. Decrease of BOD, measured with PC self-purification degree of 10–13%, was connected with organic matter decomposition occurring in diluted or colloidal form rather than with sedimentation. The processing capacity in this river stretch, due to not very significant flows, was not high and varied from 0.4–1.2 kg $O_2$/h (approximately 0.9 kg $O_2$/h). In the lower stretch, between Orzesze and Bełk, despite remarkably higher average values of coefficients $k_{1(r)T}$ and $k_{1(r)20}$, amounting to 2.5 and 4.0, respectively, and greater flows, the processing capacity of the river went down and amounted approximately to 0.7 kg $O_2$/h. However, the average drop of BOD – water self-purification process PC – was high and reached almost 74% with its maximum at about 91%. On the next stretch, between Bełk and Czerwionka, the BOD reduction rate decreased significantly and was comparable to the values typical of the upper stretch.

No seasonal differences were observed on any of the investigated Bierawka stretches in the self-purification rate, reflected in $k_{1(r)T}$ coefficients, which seems to confirm the literature data on the adaptation capacity of plankton biomass microbes to slow, seasonal water temperature changes within the range of 5–30°C [9].

### *Bielszowicki creek*

Since the measurement campaign carried out in 1992–1993, the self-purification conditions of the creek water have changed significantly. The most characteristic feature of the creek was creek impoundments. Some of them decreased or were liquidated. The major part of the riverbed was straightened and longitudinal declines were leveled. Waste rock was used for regulation purposes. Natural conditions favorable for self-purification were remarkably impoverished.

However, in order to illustrate the self-purification capacity of the flowing waters in anthropogenic catchments and to identify the negative consequences of the inconsiderate watercourse control, particularly those containing wastewater, it was also decided to present the data obtained in the above-mentioned campaign. In the period of 1992–1993, apart from slow flow stretches also swift currents and creek impoundments were also observed in the creek bed, which resulted from mining damages [18]. During the measurements, some of the creek impoundments were slight and marked only with widening the bed with luxuriant vegetation (Mośniak creek impoundment); others covered the area of several hectares. Among the largest ones was the creek impoundment located near Bielszowice Coal Mine, covering an area of 4.8 ha, with fertile water and waterside vegetation, the annual balance of which showed water loss – outflows from the creek impoundment were lower than inflows.

Water self-purification was estimated at 5 stretches of a total length of 4 km (Tab. 1). The first stretch, above which almost completely untreated domestic sewage was discharged, showed high values of $k_1$ coefficient. The average value of $k_{1(r)T}$ was 6.1 and $k_{1(r)20}$ – 9.9. Due to low water flows the creek processing capacity was not high enough and reached the value of 0.6 kg $O_2$/h. This was the stretch of the bed similar to a natural one, with luxuriant waterside vegetation, where favorable conditions for sedimentation of suspensions and adsorption were observed. Water velocity was merely 0.23 m/s. The self-purification degree, i.e. the decrease of BOD varied from 64.7–72.1% (with the average of 68.4%). On the other stretch the self-purification parameters went down remarkably. The average values of $k_{1(r)T}$ and $k_{1(r)20}$ coefficients decreased to 2.7 and 3.2 respectively, and the processing capacity decreased to 0.5 kg $O_2$/h. On the next two stretches the situation was much better. The average values of both coefficients $k_1$ increased up to 3.0 and 4.2 respectively and their processing capacity to 14.2 kg $O_2$/h. On the final stretch, behind Bielszowicki creek impoundment the average values of $k_1$ coefficients were up to 7.1 ($k_{1(r)T}$) and 9.6 ($k_{1(r)20}$), and the processing capacity – up to 22.6 kg $O_2$/h. In the case of $k_{1(r)T}$ and $k_{1(r)20}$ coefficients the values were high. The creek self-purification degree (SD) throughout the flow changed in a similar way: in the upper stretch it was high and ranged from 67.4–72.1%, whilst on the next stretch it decreased and did not exceed 27.3% (the average value – 19.4%); on the farther ones – it was gradually going up reaching the values of 41.0–62.1% (average value 51.6%) on the final stretch.

The deterioration of the analyzed self-purification conditions within the creek impoundments was observed. Quite unexpected was the impact of the largest creek impoundments – Bielszowice, which covered 0.8 km of the creek, in which the effectiveness of water self-purification processes was the lowest. The average value of $k_{1(r)T}$ was merely 1.7, whereas the value of $k_{1(r)20}$ – 2.2. Based on the literature data [9–11] and results obtained from IETU's own research activity carried out on other creek impoundments one might have expected quite opposite effects – higher values of $k_1$. It can be supposed that the observed situation was the result of processes occurring in bottom sediments. The creek impoundment was 3–5 m deep in its central part and some rotting, anaerobic processes may have prevailed in the bottom sediments, not so efficient as the aerobic ones. During the measurements frequent outflows of bottom sediments forming a layer were already observed near the inflow part, accompanied by gas bubbles. The accompanying "immediate (chemical) oxygen consumption" hampered the aerobic biochemical decomposition. Moreover, the banks of the creek impoundment were buried with a waste rock, which moved the bottom sediment, increasing the oxygen consumption and hampering the growth of microorganisms. All these factors may have deteriorated the self-purification effect in the creek impoundment.

The research carried out in 2005–2006 on the mouth stretch showed a remarkable decrease of the self-purification capacity – $k_1$ coefficients were twice as low as in the period of 1992–1993.

### *The Kłodnica*

The self-purification of the river was investigated in 1991 and 2005–2006. The analysis covered the upper spring part of the river at three stretches of a total length of 10.8 km (in 1991), and 6.21 km (in 2005–2006). There were different aims of these analyses; therefore the stretches overlap only partially (Tab. 1). On the first stretch the riverbed is natural, on the other two it is regulated with the native material. In many places the banks of the river are covered with vegetation [17]. On all the stretches both swift currents and slow flow sections can be observed, without water damming and creek impoundments.

In 1991 three stretches were analyzed – two within Katowice city limits (2.7 km and 3.8 km long) and one within Ruda Śląska (4.1 km long). The best conditions were noted on the central stretch – $k_{1(r)T}$ and $k_{1(r)20}$ coefficients were 2.24 and 5.5 respectively. They were quite high in comparison to the literature values [12, 13]; on the two other stretches they were, however, much lower – $k_{1(r)T}$: about 0.3–0.4 and $k_{1(r)20}$ 0.7–0.9. Quite opposite was the processing capacity – due to small flows it was very low on the first stretch (0.34 kg $O_2$/h), whereas on the central one it was 20 times higher (6 kg $O_2$/h) and in the downstream – 10 times higher (more than 3 kg $O_2$/h). The greatest drop of BOD was observed in the central stretch – 80%. In other stretches it did not exceed 20%.

In 2005–2006 the research covered one stretch within Katowice city limits (0.8 km long) and two stretches in Ruda Śląska (3.8 km and 1.6 km long). A high self-purification capacity was noted. The values of $k_{1(r)T}$ ranged from 0.25–15.3. The range of values increased downstream. The highest values were observed in Katowice with relatively low amplitude: 11.94–15.3. In the central stretch the fluctuation range was significantly higher and amounted to 0.25–11.56, whereas in the lower stretch it was 1.52–8.32. These are very high values, both as far as the values and the range of the occurrence within the same stretch are concerned and they should be checked during a longer period. Generally, they are much higher than the literature values. Despite a high degradation rate, due to insignificant flows in the upper stretch the processing capacity *PC*, i.e. volume of the reduced contaminant loads in time is not high and does not exceed several grams per hour. In the lower stretches, where flows are much higher, ZP is up to 17.8 kg/h above the Jamna mouth and almost up to 28 kg/h below the Halemba Treatment Plant.

### *The Szotkówka*

The self-purification of the Szotkówka River was analyzed on two separate stretches above the Mszanka mouth, of the total length of 2.6 km and in the lower stretch, below Ruptawka mouth (6.4 km long). The stretches represent different hydrological conditions. In the upper stretch, where the flows are lower, slow flow and small creek impoundments appear. In the lower stretch the flow is rather calm without noticeable slowdowns.

The calculated values of $k_1$ coefficients in the lower stretch were higher than in the upper one. Coefficients $k_{1(r)T}$ and $k_{1(r)20}$ (average values, Table 1) decreased down the river from 0.9 to 0.7 and from 1.0 to 0.9 respectively. However, due to much higher flow, the average processing capacity of the river in the lower stretch was almost seven times higher – it increased from 0.7 kg $O_2$/h to over 4.7 kg $O_2$/h. The self-purification degree for the whole river was 36.5–41.4%, showing slightly higher values in the lower stretch.

The assessment of the Szotkówka River's self-purification capacity would be incomplete if the impact of Jastrzębie creek impoundment, located between the Mszanka and Ruptawka mouths were not taken into consideration. The creek impoundment was formed in the river valley but it is separated from the riverbed with a slightly flooded bank for most of the year and only when the water level is high enough the creek impoundment reaches the river, the effect of which is a positive impact of the creek impoundment on the quality of the river waters. However, some negative impact can also be observed. Below the creek impoundment there are two smaller ones and the impact of this creek impoundment complex on the Szotkówka River self-purification process would require a more detailed study.

## CONCLUSIONS

Based on the carried out analysis of the water self-purification process in the upper stretches of the Upper Silesian agglomeration rivers, i.e. the Bierawka, the Kłodnica, the Szotkówka and Bielszowicki creek, the following conclusions can be drawn:

- in each of the investigated watercourses the water self-purification conditions are good due to the natural or semi-natural type of the riverbeds, which facilitates mixing of waters and aeration;
- the best conditions were observed in the Bierawka River, Bielszowicki creek and upper stretch of the Kłodnica River;
- on all the investigated stretches, the organic matter removal rate, described by $k_1$ coefficients, was generally much higher than the literature values, which generally varied from < 2.0 rarely exceeding 3.0. A good example is Bielszowicki creek and the upper stretch of the Kłodnica River, one of the most heavily contaminated watercourses in the agglomeration ($k_{1(r)T}$ exceeding 15). On the stretches where the $k_{1(r)T}$ coefficient is so high untreated municipal wastewater (or not treated entirely) is discharged. Quite frequent slowdowns in the flow cause

the conditions in the riverbed to be similar to the artificial conditions observed in treatment plants;

- a higher self-purification capacity was recorded in free flow stretches;
- at flow slowdowns and creek impoundment formed as a result of ground subsidence due to mining damages, the self-purification capacity was lower. The creek impoundments are typical examples of anthropogenic changes of catchments in the Upper Silesian agglomeration;
- the role of creek impoundments in the river self-purification process and the impact on river ecosystems requires separate investigations;
- clear relationships between $k_{1(r)}$ and water temperature were not observed on any of the analyzed stretches. The increase of this coefficient with the increase of temperature, observed in laboratory conditions, was not confirmed in the field. This may point to a high adaptation capacity of the microorganisms taking part in the aerobic decomposition of organic matter.

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## ZDOLNOŚĆ DO SAMOOCZYSZCZANIA SIĘ WÓD PŁYNĄCYCH W ZLEWNIACH O ZNACZNYM STOPNIU ANTROPOGENICZNEGO PRZEKSZTAŁCENIA

Przeprowadzona ocena samooczyszczania się wód dotyczy górnych odcinków rzek aglomeracji górnośląskiej: Bierawki, Kłodnicy, potoku Bielszowickiego i Szotkówki. Są to rzeki o małych przepływach naturalnych, znacznie obciążone zanieczyszczeniami antropogenicznymi Wykorzystano wyniki własnych badań szybkości przebiegu procesu samooczyszczania się. Skupiono się na zanieczyszczeniach rozkładalnych biochemicznie. Wyznaczono współczynniki szybkości biochemicznego rozkładu $k_1$ i zdolność przetwórczą wód. W obrębie tych samych rzek, poszczególne odcinki różnią się charakterem koryta, występują na przemian bystrza i odcinki o spowolnionym przepływie. Na potoku Bielszowickim i Szotkówce istnieją rozlewiska. Efektem tego są odmienne warunki samooczyszczania się wód. Na wszystkich badanych odcinkach szybkość procesu usuwania substancji organicznych, opisywana współczynnikami $k_1$, najczęściej była dużo większa od literaturowych, wahających się w granicach poniżej 2,0 rzadko przekraczając wartości 3,0. Rozlewiska występujące w korytach cieków nie zawsze wpływały korzystnie na jakość ich wód. Rola takich rozlewisk w procesie samooczyszczania się rzek oraz wpływ na ekosystemy wodne wymaga odrębnych badań.