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HYDROMORPHOLOGICAL RIVER ASSESSMENT OF DEGRADED LAND IN THE REGION OF OPEN CAST MINES

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River and floodplains form one of the most valuable elements of the surrounding landscape. Over the centuries, anthropogenic impacts have led to numerous transformations of river ecosystem. Following this study, river beds noted the need for corrective action and renaturalisation. Therefore, there was a need to assess the current state of watercourses. This assessment is designed to identify transformed and degraded sections on which appropriate corrective action should be taken. Such studies were conducted in the area of quarries PGE KWB Turow. The studies included an assessment of hydromorphological state of the following rivers:The Lusatian Neisse to the mouth of the Miedzianka and Miedzianka river.

Keywords: river, hydromorphology, river bed

1. INTRODUCTION

Hydromorphological valoralisation of rivers is becoming more and more important in terms of anthropogenic transformations. This assessment allows to designate watercourses which are the most transformed and closest ones to the potential natural state of rivers. The Water Framework Directive (WFD) also focuses on the issue. It requires Member State countries to determine the extent of water environment transformation and to apply corrective action/measures aiming at the achievement of a good ecological status. WFD recommends normative definitions from a high to moderate ecological state based on hydromorphological elements of quality. A high state of rivers is the one which is not disturbed by anthropogenic activities. Fulfilling the condition favors free migration of aquatic organisms. Rivers which reach state below moderate, due to hydromorphological elements, shall be classified as bad quality water [Directive 2000, 60/EC].

Hydromorphological assessment of rivers in accordance with the requirements of the WFD should cover assessment of the following parameters: hydrological regime, river continuity and morphological conditions. To meet the requirements of the WFD Department of Regional Research Institute of Meteorology and Water Management Wroclaw Branch has developed a methodology for assessing hydromorhological state. What is more, it conducted a pilot assessment of the state of the Lusatian Neisse River and some of its tributaries in 2007-2009. The studies included three zones namely the river bed, the riparian zone and the stream valley.

In this paper, hydromorhological assessment for rivers in the area of 'Turów' Brown Coal Mine will be presented. To put it more precisely, it will concentrate on the Lusatian Neisse River from the 'tri-border point' to the mouth of the Miedzianka and Miedzianka River from the border to the mouth.

2. CHARACTERISTICS OF RESEARCH FACILITY

The Lusatian Neisse River is the left tributary of the Odra river. Its total length is 246.09 km out of which about 50 km is in the Czech Republic and the remaining watercourse constitutes the Polish-German border, including less than 79 km in Lower Silesian Province. The total area of the Lusatian Neisse Basin is 4 403 km^2 whereas within the border of The Lower Silesian Province is approximately 640 km^2. The Lusatian Neisse Basin is on the borders of three countries: the Polish Republic, the Federal Republic of Germany and the Czech Republic. The area of the river basin, in terms of land use, is forest and agricultural one. Approximately 45% of river basin is covered by forests and more than 40% comprises arable land. Brown coal mining and related to it the process of turning the raw material into electrical energy are one of the most developed branches of industry in the Lusatian Neisse Basin.

The Lusatian Neisse River has its origin in the Czech Republic in the south-western slopes of the Izerskie Mountains. It flows in at a height of 780 meters above the sea level near the town of Budrichovo and flows between the Biedrzychowski and Harcowski Mountain Ridge. Till the Polish- Czech border, it flows through The Liberecka Basin and collects waters flowing down from the slopes of the Łużyckie and Izerskie Mountains. It passes over Hradek to Poland at an altitude of 230 meters above sea level, where in the so called 'tri-border point', three country borders meet, namely the Polish, Czech and German one. Starting from the 'tri-border point', the Lusatian Neisse River becomes a boder river between Poland and German. In the area of Zittau, the river enters Zittau-Zgorzelec Depression, tectonic depression consisiting of two basins: The Turoszów i Zgorzelec Basin. Turoszów Basin is filled with Teritiary deposits with thick brown coal seams (Fig. 1).

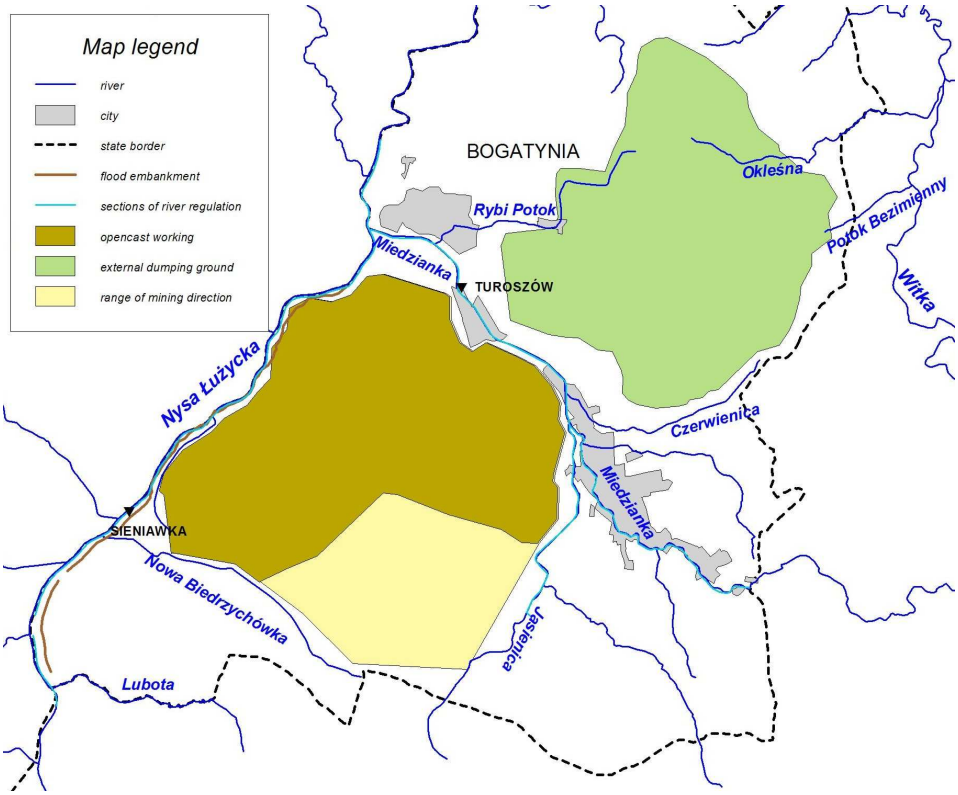

Figure 1. The localization of the research facility

The Miedzianka River (Oleška), which flows into the Neisse River at 186,80 km, is a watercourse whose length is 22,02 km and the river basin area counts A= 82,7 km^2. It takes its origin in the Czech Republic in the Izerskie Mountains between peaks: Kopřivnik and Strzovývrch. Both flowing into Turoszów Basin and running through Bogatynia, it collects left-bank waters of Gaśnica stream (Ślad) which flows from the Czech Republic. In the upper river course of the Miedzianka River,noth of Bogatynia, the left-bank side of the Czerwienica River flows and drains the southern part of the external dump. The Zatonka River (Ochota) with The Rybi Stream flows from the region of the Turów power plant. Furthermore, they dewater the north-west part ofexternal waste heap. The Miedzianka River, in the passage from Bogatynia to the mouth, flows in a partially concreted river bed (protecting strip mining from the infiltration of the river's water), deep pit, which should contain flood water runoff with the probability p=0,5% [Wilk 2003]. The largest water body, in the area of Miedzinaka river basin, is Zatonie water reservoir. It is the source of drinking water for Bogatynia and other nearby towns. Exploatation of brown coal in Turów Mine caused partial change of river course of the Miedzinaka

river bed and the size of its river basin. Forest areas are situated not only in the highest areas of the river basin but in area of an external, rehabilitated dump as well (Fig. 1).

3. RESEARCH METHODOLOGY

Institute of Meteorology and Water Management, Wroclaw Branch, developed methodology of the hydromorphological assessment of watercourses which takes into consideration both physical and hydrological characteristics of a watercourse. The basis of the applied methodology was a fieldwork research covering hydromorphological inventory and assessment of individual parameters. The developed methodology included an assessment of individual hydromorphological parameters in three zones, namely: river bed, riparian zone, river valley. The evaluation of individual zones was based on developed protocols which were basis for carrying out the valorization of the assessment of hydromorphological state. The list of hydromorphological attributes, assessed in the applied methodology and adopted to Polish conditions, was created on the basis of a review of the applied methods in the countries of Member States, recommendations of the WFD and CEN standards.

The developed methodology assumes that the river bed is the lowest part of the river valley and it reaches its scraps. Six attributes were chosen in the zone namely: geometry of the river bed, hydrological regime, river continuity, riverbed substrate, structures of the slope, vegetation. The riparian zone forms part of an inundation terrace which includes riparian belt to 20 meters from the top of a scrap. It is an area stretching along the river which is covered in trees, shrubs, grasses and perennials to various extent. Three zones were assessed in the riparian zone, namely: the geometry of riparian zone, vegetation and the use of the riparian zone. The zone of the valley covers inundation terrace which depends on the topographic features can develop into a riverside plain. Three attributes were assessed within its range, i.e. the shape of the valley, use, anthropogenic transformations.

In the framework of works, after gathering all information from the inventory carried out in the field and taking into consideration background map and aerial images, an evaluation form was compiled. Then it allowed to crate five classes for assessment of hydrological state: class I-green colour > 90 points – high state, class II – blue colour - 1989 to 1975 points – good state, class III – yellow colour- 74 – 60 points – moderate state, class IV – orange colour - 59 - 45 points – poor state, class V – red colour - <44 points - bad state.

4. RESEARCH RESULTS

The Lusatian Neisse river has been divided into twelve one kilometer sections from the 'tri-border point' to the mouth of the Miedzianki river. For so designed sections in accordance with the agreed methodology, field mapping .was conducted. Next, the gathered information has been quantified (Table 1). What is more, hydromorphological valorization of an examined river section was carried out.

Table 1 A list of hydrological assessment results of the Neisse River

	river bed						riparian zone			valley		assessment	class
km	geometry of the river bed	regime	river continuity	river bed substrate	slope structure	vegetation	geometry of the riparian zone	vegetation	riparian zone management	valley management	antropogenic transformation		
185	4	3	2	9	8	9	3	8	4	3	3	56	IV
186	4	3	2	9	8	9	3	7	4	3	3	55	IV
187	4	3	3	9	8	9	3	7	4	3	3	56	IV
188	4	3	3	9	8	8	2	4	4	2	3	50	IV
189	4	3	3	9	8	9	2	3	4	2	3	50	IV
190	4	3	3	9	8	9	2	3	4	2	3	50	IV
191	4	3	3	9	8	9	2	3	4	3	3	51	IV
192	4	3	3	9	8	9	2	3	4	3	3	51	IV
193	4	3	2	9	8	9	2	4	4	3	4	52	IV
194	4	5	2	9	7	9	2	4	3	4	4	53	IV
195	4	3	3	9	7	9	2	7	4	3	4	55	IV
196	4	3	3	7	4	9	2	3	4	2	4	45	IV

The analysis of results obtained for each zone indicates that the Lusatian Neisse river, on the evaluated river course in the zone of river bed area, gained an average rating for 35 points (max. assessment 70 points). The lowest value obtained the river course on the 196th kilometer that is 30 points whereas the highest score that is 36 points on the river course of 187, 189, 190, 191, 192, 194th kilometer. Among the six assessed attributes in the zone of river bed, vegetation of the watercourse was assessed as the poorest (average 9 points / max 25 points) while the highest score was given to the structure of the slope (average 7 points/ max 10 points). In the riparian zone, river gained an average score of 11 points (max score 20 points). Among the three evaluated attributes in

the riparian zone, the lowest score was given to vegetation (average 4,1 points/ max 10 points) whereas the highest was given to use the riparian zone (average 3,9 points/max 5 points). However, the Lusatian Neisse river, in the valley zone, got an average value of 6 points at the maximum value of 15 points. The parameter which was ranked as the lowest was the use of the valley (average 3 points/ max 10 points) while the highest one were the anthropogenic transformations (average 3,4 points/ max 5 points) [Andykiewicz-Piragas, Błachuta 2009].

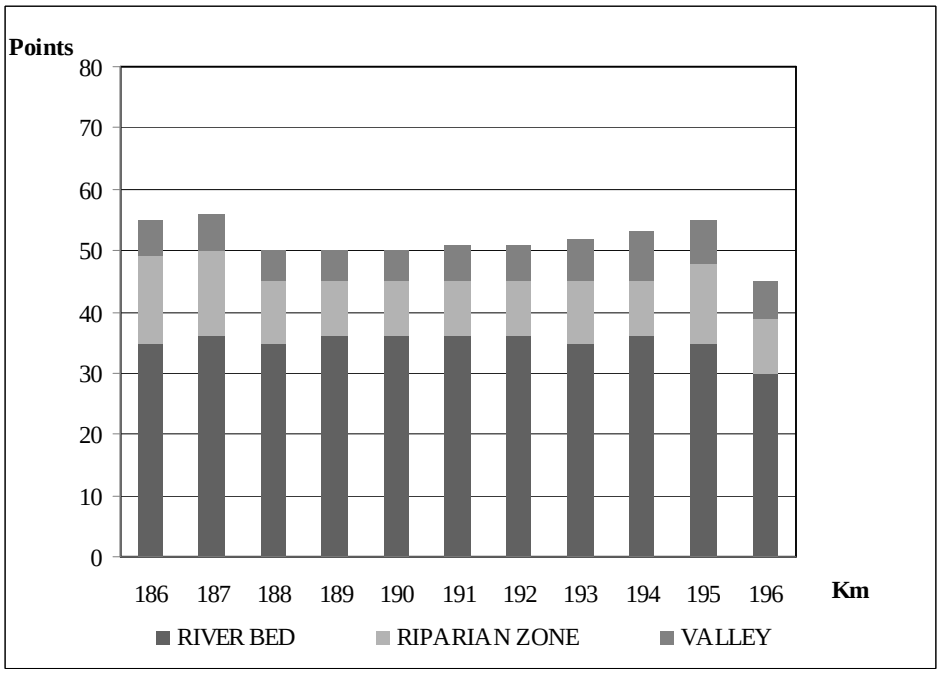

Figure 2. Changeability of hydrological quality assessment in individual zones of the Lusatian Neisse River from 186th km to 196th km

In the case of the discussed river course of the Lusatian Neisse river, 6 parameters out of 11 obtained more than a half of possible points to get within use of valley and scarp structure which got the value exceeding 74 %. The lowest score was obtained by two parameters namely use of valley (27%) and vegetation of the river bed (36%). The river gained an average total score of 51.3 points which indicates that it can be classified as a river belonging to class IV. It means that the river is in a poor state and a variety of action should be taken in order to improve its morphological state to the year 2015.

The Miedzianka river was divided into 10 one-kilometer river courses. The river mapping was carried out in accordance with the accepted protocol. On the basis of field mapping valoralisation of collected data was made in line with approved assessment form. Then, the results of valoraliastion for individual

attributes and zones were summarized in Table 2 and their variability in Figure 3.

The analysis of the results obtained for individual zone indicates that the Miedzianka river in the river bed zone gained an average assessment of 35 points (max assessment 70 points). The lowest value was attributed to the river course in 8th kilometer which was 27 points whereas the highest one was noted in 3rd kilometer and 1st one. Among six assessed attributes in the zone of river bed, the river continuity was rated as the lowest one (average 1,9 points/max 25 points) while vegetation of the river bed was noted as the highest one (average 13 points/ max 25 poits).

Table 2 A list of hydrological assessment results of the Miedzianka River

km	river bed						riparian zone			valley		assessment	class
	geometry of the river bed	regime	river continuity	river bed substrate	slope structure	vegetation	geometry of the riparian zone	vegetation	riparian zone management	valley management	antropogenic transformation		
1	6	5	2	9	8	12	2	8	3	8	1	64	III
2	4	3	2	8	8	9	2	10	4	3	1	54	IV
3	6	3	3	8	10	13	2	9	3	3	2	62	IV
4	4	1	2	8	8	11	2	9	2	2	2	51	IV
5	6	1	3	8	8	11	2	9	4	3	2	57	IV
6	6	1	1	7	2	14	1	2	1	2	1	38	V
7	6	1	1	7	2	14	1	2	1	2	1	38	V
8	4	1	1	7	2	12	1	2	1	2	1	34	V
9	6	1	2	7	2	15	1	2	1	2	1	40	V
10	6	3	2	8	2	16	1	2	2	3	1	46	IV

In the riparian river zone, the river scored 9,1 points (max assessment: 20 points). Among the three attributes in the evaluated riparian zone, geometry got the lowest score (average 1,4 points/ max 5 points) whereas vegetation the highest one (average 5,5 points / max 5 points). However, the Miedzianka river in the valley zone noted an average value of 4,6 points at the maximum value of 15 points. Both the anthropogenic transformations (average 1,3 points/ max 5 points) and the use of the valley (average 3 points/ max 10 points) did not exceed 30 % of the maximum value [Adynkiewicz-Piragas, Błachuta 2009].

In the case of discussed watercourse, none of the parameters exceeded 55 % of the points possible to score. Only three parameters (geometry of the river

bed, riverbed substrate and vegetation of river bed) exceeded values of 50 %. These results implicate that in case of the river, many elements must be improved by taking action of renaturalisation so that the watercourse will have gained a good hydromorphological assessment by 2015. The river received an average total score of 48,3 points which classifies the river to class IV (poor hydromorphological state).

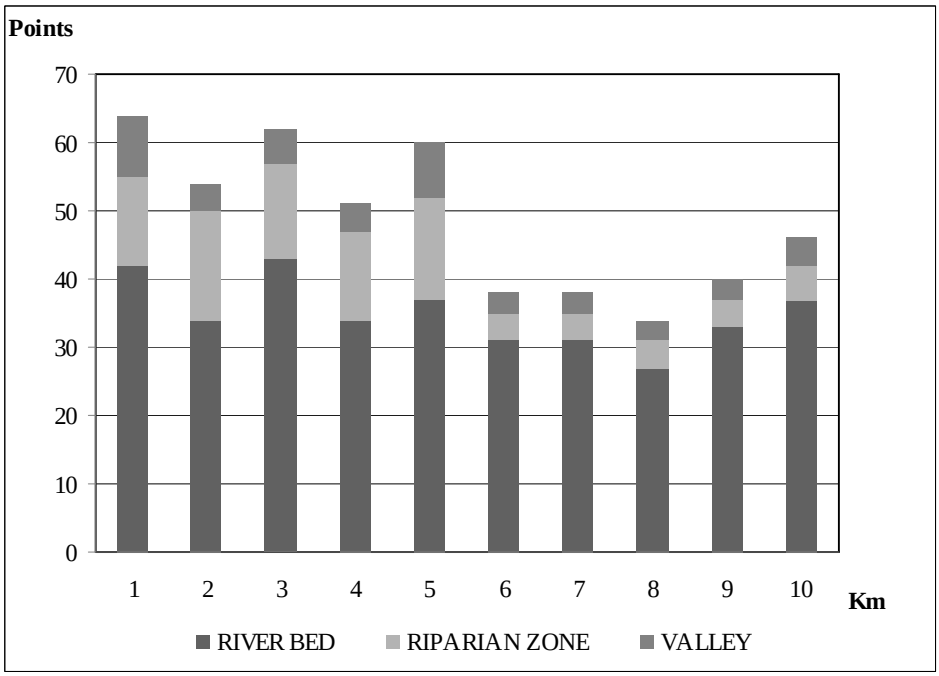

Figure 3. Changeability of hydrological quality assessment in individual zones of the Miedzianka River from 0^{th} km to 10^{th} km

5. INTERPRETATION OF RESEARCH RESULTS

The results of visualisation of hydromorphological assessment of both of assessed rivers are illustrated in Figure 4. As it has already been mentioned, the Lusatian Neisse river scored the total average evaluation of 51,3 points which categorizes the river to class IV. What is more, all river courses received low number of points. Thus, they are in poor condition. Such a low assessment of watercourse derives both from the nature of the watercourse as well as the specific localization of the discussed river course. It is a border river between Poland and Germany. Therefore, it is a sort of water course which is regulated in a way which prevents the river from 'moving' (e.g. through the creation of meanders among riparian forests which would be the characteristic of the water course if it had not been regulated by man in the past). Additionally, the

discussed river course is adjacent to the brown coal open mine at Turoszów and the way extending through the entire length of the discussed river course. It also forces taking up action such as: building an anti-filtration screen in the valley of the river course or flood embankments along the right bank of the Lusatian Neisse river located in a very short distance from the river course.

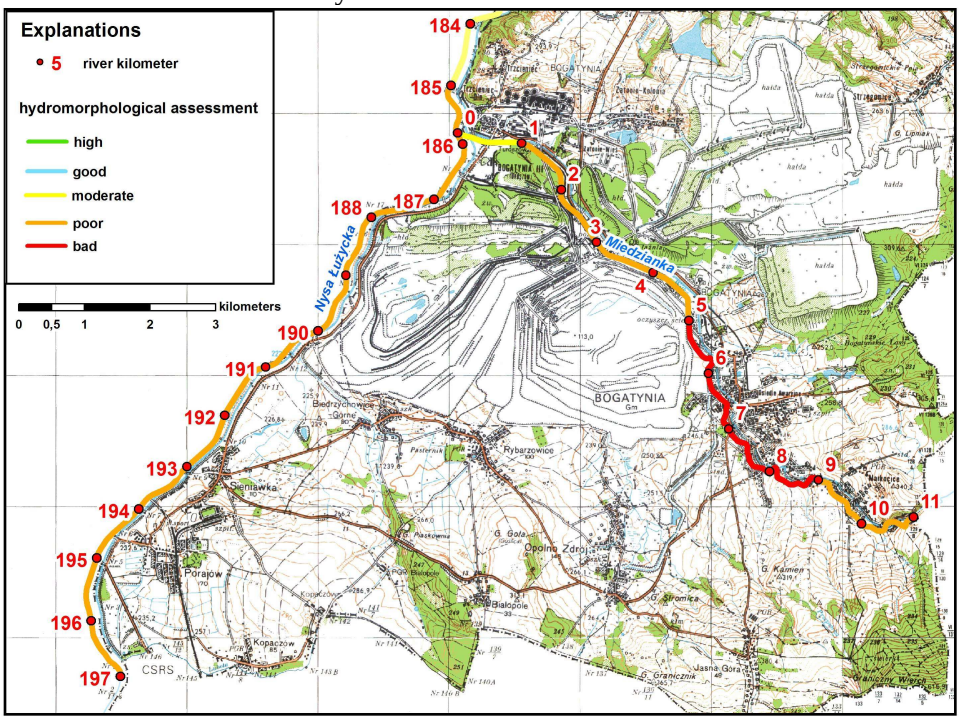

Figure 4. Visualization of the outcomes of hydrological assessment of the Lusatian Neisse River and Miedzinaka River

The Miedzianka river received an average total score namely 48,3 points which classifies the river to class IV. This means that the river is in a poor state and all possible measures should be taken in order to improve its hydromorphological state by 2015. The highest number of points was given to the river course in the 1st kilometer in the mouth. It is a class III which consequently can be categorized as a moderate state. Other river courses from 2nd km to 5th km and 10th km were labeled as class IV- poor state as well as four river courses from 6th km to 9th km where the river flows through he region of Bogatynia. The changes of classes of the researched river course are given in Figure 4. Such a low assessment is due to the fact that the river course is subject to significant anthropogenic impact. What is more, the whole river course is at urban-rural area on Polish territory or areas afflicted by mine activity which implies a low assessment of the river course. It is essential that in a river bed zone, the river bed was previously concreted and it has improved as a result

of a deposition of a sandy and rocky material from the upper watercourse. Therefore, it is possible to develop aquatic, waterside and bank side vegetation at the bottom of the watercourse. A much worse situation was observed in the case of the other two zones.The fact that the Miedzianka river is closed in retraining walls and lacks of riparian zone (houses, gardens, pavements or streets are near the watercourse) has a direct impact on its poor assessment in the urban-rural area of Bogatynia and Markosice.

6. CONCLUSIONS

The fragements of the Neisse river and Miedzianka river located in the so-called 'turoszowski bag' are watercourses which are under the influence of strong anthropopersion resulting from the impact of surface mining. Both of the assessed rivers did not exceed the ceiling of 50% taking into consideration the total sum of 105 points possible to obtain in the hydromorphological assessment (The Neisse river obtained 49 % and the Miedzianka river got 46%). They received a poor average score. The location of the Miedzianka river implies that the pressure of anthropogenic changes is greater than on the Neisse river. As already mentioned in the description of the area, the watercourse's river bed was changed. Now it is mostly concreted in order to prevent water infiltration form the river to the well's network dewatering the Turów pit. Additionally, almost the whole river course of Polish territory is located in the urban-rural area. After carrying out the assessment of hydromorphological assessment including site inspection, it may be concluded that the researched river courses are poor in terms of landscape. [Adynkiewicz-Piragas, Lejcuś 2010]. The watercourses are strongly modified by human activity. What is more, they are continuously subject to a strong anthropogenic pressure. Therefore, they scored a poor evaluation [Adynkiweicz-Piragas, Błachuta 2009]. Thus, it is necessary to take corrective action in order to improve the hydromorphological state by the year 2015.

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OCENA STANU HYDROMORFOLOGICZNEGO RZEK TERENÓW ZDEGRADOWANYCH W REJONIE KOPALŃ ODKRYWKOWYCH

S t r e s z c z e n i e

Rzeki wraz z obszarami zalewowymi tworzą jeden z najcenniejszych elementów otaczającego nas krajobrazu. Na przestrzeni wieków antropogeniczne oddziaływania doprowadziły do licznych przekształceń ekosystemu rzecznego. W wyniku przeprowadzonych badań koryt rzecznych zauważono konieczność przeprowadzenia działań naprawczych i renatryzacyjnych. Zaistniała zatem potrzeba oceny aktualnego stanu cieków. Ocena ta ma na celu wskazanie odcinków przekształconych i zdegradowanych, na których należy podjąć odpowiednie działania naprawcze. Takie badania przeprowadzono w rejonie kopalni odkrywkowej PGE KWB Turów, które obejmowały ocenę stanu hydromorfolicznego następujących rzek: Nysa Łużycka do ujścia Miedzianki i Miedziankę.