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Assessment of the Ecological Status of "Dalgachka" River in its Section within the Protected Site "Ovcharovo", (NE Bulgaria)

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Abstract. Hydrobiological monitoring and assessment of the ecological status of Dalgachka River and an ecological potential assessment based on abiotic metrics of Ovcharovo dam, was performed in the region of Protected Site "Ovcharovo" in 2017 and 2018. The ecological status assessment was based on the macroinvertebrate community as a bio-indicator and the measurement of the supportive physicochemical and hydrological parameters of the water (according Water frame directive and Bulgarian legislation). The water basins fall into Ecoregion 12 - Pontic province and Black Sea River Basin. To date no recorded indices/parameters or sample collection from Dalgachka River and dam Ovcharovo were obtained, despite such data are required for the purposes of the ecological status/potential assessment. In the present study we assessed for the first time the ecological status of the river section which passes through Protected Site "Ovcharovo" - BG0002093 and provide supportive physico-chemical parameters of the superficial waters in Ovcharovo dam. The river/dam ecosystem is of moderate ecological status, because of high concentration of nitrates and BOD_5 in the dam and phosphorus, phosphates and BOD_5 in the river section. The ecological status assessment conducted in the spring of 2017 at sample site 1 showed moderate status and at sample site 2 the ecological status was assessed as good, according to Biotic index. Additionally, we established a georeferenced database which can be used as a reference base for the further research on the protected site, but can also serve the purposes of the ecological decision making for the area.

Key words: ecological status assessment, macrozoobenthos, river dam system, protected area, water physicocemistry, water dependent Natura 2000 site.

Introduction

The Biological quality elements (BQE), which are used for ecological status (ES) assessment of rivers in Bulgaria are defined by the National water legislation. These are: phytoplankton, phytobenthos and macrophytes, macroinvertebrates and fish (Ordinance N4/2013). The following anthropologically induced hydromorphological changes have been identified to have a negative impact on river ecosystems: river flow regulation, sediment retention, water abstraction and others. The high concentration of nutrients and organic contamination from diffuse or local sources of pollution, riparian vegetation modification (for example from agricultural activity), biological pressures from alien species and others may put pressures on the fresh water basins (Pardo et al., 2012; RBMP of Black Sea Basin Directorate, appendix 4.1.1.s, 2016).

Macrozoobenthic fauna and ichthyofauna are among the most sensitive BQE to hydro-morphological alterations (Marzina et al., 2012) such as: quantity and dynamics of the water flow, fluctuations of the water level, cutting longitudinal river continuum with different damming facilities, artificial riverbed corrections, dikes and damaged connection between the main water course and adjacent wetlands, reduced biodiversity of micro- and meso-habitats (RBMP of Black Sea Basin Directorate, appendix 4.1.1.s, 2016). The most relevant BQE for assessment of organic pollution is the macrozoobenthos, (RBMP of Black Sea Basin Directorate, appendix 4.1.1.s, 2016), due to the fact that these organisms are numerous, but highly sensitive (Patang et al., 2018).

Macrozoobenthos is a well studied BQE, introduced by the Water Framework Directive 2000/60/EU (WFD) for the purposes of the ES assessment. Benthic communities proved to be an efficient indicator of water quality and ecosystem integrity, since they are weak migrators and respond to habitat and long-term ecosystem changes (Li et al., 2019). Many methodologies connected to ES, which are based on invertebrate ratio and biodiversity were introduced as national standards in countries like Germany, Chech Republic, Serbia, Bulgaria and others (Uzunov et al., 2013).

Factors, like the absence of fish fauna, the greater sensitivity of macroinvertebrate metrics to general degradation of the river and the high sensitivity of the BQE "macroinvertebrates" to all kind of anthropogenic impacts (RBMP; Marzina et al., 2012), determine this biological indicator as the most appropriate for the analysis of the ES of Dalgachka river. The National Environmental Monitoring System (NEMS) of Bulgaria had no monitoring points on Dalgachka river, nor on the Ovcharovo dam (RBMP of Black Sea Basin Directorate, appendix 4.1.1.a 2016). Other scientific data concerning the ecology of that river or the lentic ecosystem are lacking to date. The present research was the first one, which gathers data on that river-dam ecosystem.

Dalgachka river and Ovcharovo dam are part of one surface water system with code BG2KA800R033. Currently, 5 monitoring points for hydrobiological and physicochemical monitoring of that water body are available from the National Environmental Monitoring System (NEMS). None of these points provide data or takes into consideration the ecological conditions and ES/EP of the sections of both water bodies included in PS "Ovcharovo" – BG0002093 (RBMP of Black Sea Basin Directorate, 2016, Section 4, appendix 4.1.2).

The upper course of the river – 5.5 km long river stretch, to sample site 2 (Ss2) (including the dam built there) is in the range of Natura 2000 protected site (PS) BG0002093 "Ovcharovo" (natura2000.moew.government.bg). The PS was classified as SCI, under the jurisdiction of HD, because in the area, one of the identified habitats is listed in Appendix I of Directive 92/43/EEC – wet meadows on the northern slopes of Preslavska Mountain, around the tributaries of Kamchia river. As a SPA, Ovcharovo PS is important for protection of water dependent birds like the Corncrake (*Crex crex*) – listed in Appendix I of migrating birds from BD (natura2000.moew.government.bg).

The presence of suitable habitats, like wet meadows (Commandment RD-844/17.11.2008) and the fact that the site aims the protection of *C. crex*, should have required the inclusion of the surface waters of the PS Ovcharovo in the register for water protection in accordance to al. 6 of WFD. The PS should have been stated as "water-dependent Natura 2000 site" (European Commission, Links between the WFD (WFD 2000/60/EC) and Nature Directives, December 2011) - all surface waters within the PS should be subject of protection by WFD and the National water legislation. That would mean, that besides the aims of the Bird directive and the Habitat directive, the aims of WFD should have been reached, and GES for all surface waters within the margins of the site should have been achieved in 2015 (Directive 2000/60/EC). According to WFD CIS Guidance document (2003), water bodies such as BG2KA800R033, which enter into the Natura 2000 network in Bulgaria, should be divided into subsections, because of some additional requirements to the territory. That subdivision will help for the better management of the water units. For the proper assessment of the river/dam system status, data on the condition of the water body are needed. The data are also important to consider the ES in attempt to avoid further degradation of the water ecosystems.

The present survey was the first one, which provides hydro-biological data on river-dam ecosystem "Dalgachka river/ Ovcharovo dam". The main goal of the study was to assess the ES of the river forming the PS BG0002093 "Ovcharovo" and to gather data on the supportive physico-chemical parameters concerning the ecological potential (EP) of the dam, because of the identification of the PS as SCI and SPA.

Material and Methods

Study area. The investigated section of Dalgachka river and Ovcharovo dam is located in Targovishte district (N-E Bulgaria). The river and the dam are part of the Kamchia river watershed and are indicated as water body with code BG2KA800R033 named Kamchia river, III – section, river Dalgachka from the spring to the Kralevska river. (RBMP of Black Sea Basin Directorate, appendix 1.2.5, 2016). Our studies were provided in the lands of the villages Ovcharovo and Pevets.

According to the Bulgarian typology of the surface waters, Dalgachka river refers to semi-mountain river type R4, and the dam refers to small and medium semi-mountain lake types L12 - both in the Pontic province (RBMP of Black Sea Basin Directorate, appendix 1.2, 2016). The river gathers its water sources from the slopes of Preslavska mountain and flows into Ovcharovo dam, which was constructed in 1977 for the purposes of irrigation (see Permission № 200218/15.02.2005). Ten kilometers downstream, the waters are discharged into the Kralevska river.

Benthological samples were taken twice – on 14.05.2017 and 31.10.2018. The probes were obtained in different years and seasons in order to register variation in the hydrology regimes and the subsequent difference in the population of benthic organisms.

We selected the sample site at the dam (Ssd) located near the wall, because from that part of the reservoir (near the water tower), the water is discharged down the stream. The two sample sites (Ss) in the river are located in the sections along the river bed around which different types of agricultural activities were performed (Fig. 1, Tab. 1). Sample sites above the "Ovcharovo'' dam were not considered, due to the lack of major agricultural or other human activity in that region of the PS. The territory above the dam is occupied by forest ecosystem and a survey of that river stretch will not provide information concerning the anthropogenic influence to the aquatic ecosystem.

Sample collection and processing. Water samples for physicochemical analysis were collected from the surface water of the dam, and Ss 1 and Ss 2 (Table 1), according to BNS EN ISO 5667-6:2016. The conductivity (Cond.) and temperatures (T) were measured *in situ* by portable conductometer WTW 196 LF (WTW Gmbh, Weilheim, Germany). According to Ordinance N4 (2013), obligatory parameters for ecological status assessment such as pH, dissolved oxygen (DO), total phosphorus (TP mg l^{-1}), phosphate as phosphorus (PO_4-P mg l^{-1}), nitrite nitrogen (NO_2-N mg l^{-1}), nitrate nitrogen (NO_3-N mg l^{-1}), ammonium nitrogen (NH_4-N mg l^{-1}) and Biological demand of oxygen for 5 days

(BOD_5 mg l^{-1}) have to be monitored. For our study, all these parameters were measured using HI 83200 Multiparameter Bench Photometer for Laboratories (Hanna Instruments, Woonsocket, Rhode Island, USA). Storage of water samples for BOD_5 was performed according to BNS EN 1899-2, 2004 (20 ± 2° C).

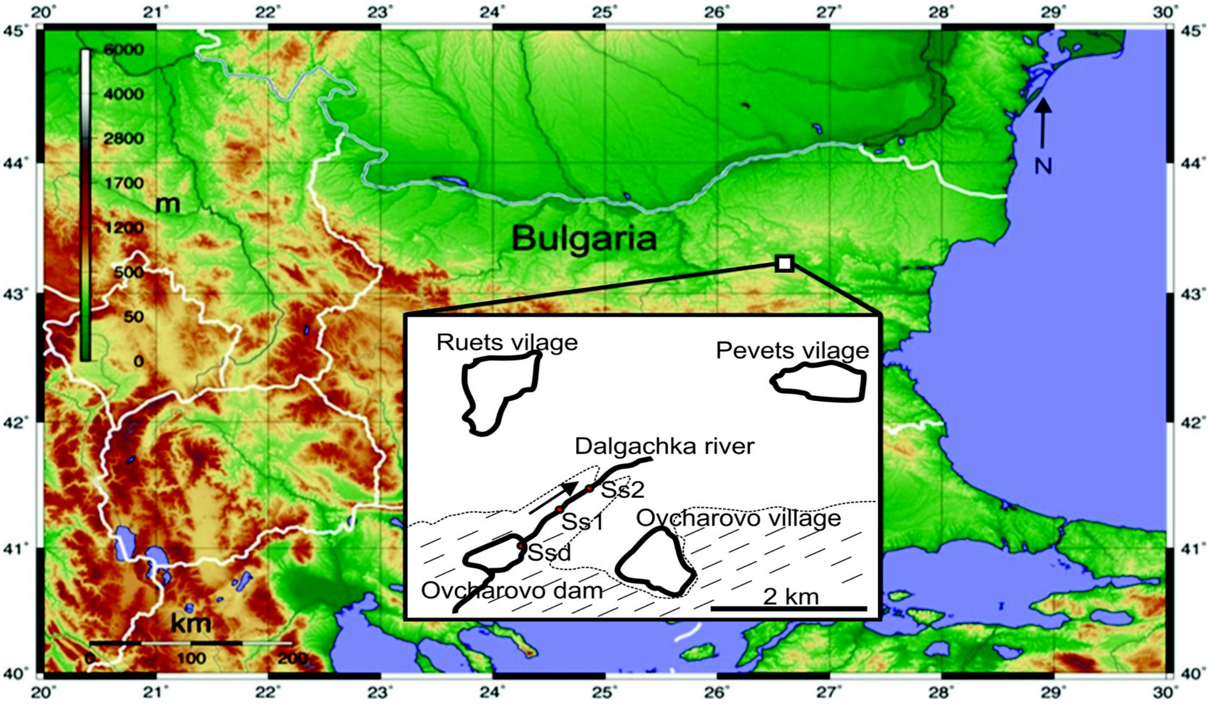

Fig. 1. Schematic map of the locations of the sampling sites; Ssd, position of the sample site at the dam "Ovcharovo"; Ss1, position of the sample site 1 at Dalgachka river; Ss2. position of the sample site 2 at Dalgachka river; the arrow indicates the direction of the water flow of the river; the margins of the PS BG0002093 "Ovcharovo" are indicated in striped code.

Table 1. Sample sites and basic information. Legend: Ssd – Sample site at the dam; Ss 1 – sample site 1 in the river; Ss 2- sample site 2 in the river.

	Water body type	Latitude N	Longitude E	Altitude (m a.s.l)	Distance to the dam
Ssd	L 12	43°11.212′	26°37.234′	300 m	-
Open lined channel	-	43°11.326′	26°37.784′	275 m	15 m After
Ss 1	R 4	43°11.513′	26°38.144′	259 m	700 m After
Ss 2	R 4	43°11.730′	26°38.474′	251 m	1300 m After

Two semi-quantitative composite macroinvertebrate samples were collected in 2017 and 2018 with a hand-net (500 μm mesh size) for about 5 minutes, according to Cheshmedjiev et al. (2011). Sample collection of invertebrates from the autumn of 2018 was performed during a period of low water levels. The water masses, released from the dam, were insufficient to form a stable surface runoff. The collection of organisms from Ss1 was impossible, because of the lack of superficial runoff in that particular riverbed section. The invertebrates were sorted in the laboratory and identified to family and order level for ecological status determination of the studied sites by two metrics – Total Taxon Number (TTN) and adapted version of Irish Biotic Index (BI) (Cheshmedjiev & Varadinova, 2013).

Quantity and dynamics of water outflow. The quantity of the water outflow from Ovcharovo dam was measured in open lined channel immediately after the dam wall (Table 1). We selected that point, because river sections with morphologically homogenous river bed create uniform water current with relatively permanent water velocity (V). That velocity remains unchanged on the full width of the channel and that makes it suitable to determine the flow rate (Gore, 2007). Maximum velocity (V max.) and average velocity (V av.) was measured with flowmeter FP 201, serial № 92389, Nibco – NSF – PW (Global Water Instrumentation Inc., - a Xylem brand, Gold River, California, USA) and the flow rate (Q) was determined by calculations based on the measurements and the width and depth of the water column.

Assessment of the ecological status/potential of the studied sites. EP assessment of the dam was based only on the one time annual measurement on physicochemical parameters of the surface water, which is enough to asses only the quality of the single samples (Ordinance N4/2013), while for ES assessment of the river, the bottom invertebrate fauna indices (according to national legislation) were used, considering BI as relevant. We used the type specific scale with the ranges provided for semi-mountain rivers of type R4 and for small and medium semi-mountain lake types L12 in Ponthic provinces provided by the Ordinance N4 (2013). It prescribes three ranges, based on abiotic metrics and five ranges (Ordinance N4/2013), based on the biological indicator visualized by the same color coding (see Table 2).

Results

Dalgachka river is a representative of R4 river type with a narrow river bed and mainly rocky bottom substrate. At Ss1 and Ss2 the river bed is formed by macrolithal (stones with diameter 40-20 cm), mesolithal (stones with diameter 20-6 cm), microlithal (gravel 6-2 cm), akal (fine to medium-sized gravel 0.2-2 cm) fractions and psammopelal (sand and mud). The ratio of distribution of the substrate at Ss1 is 40% psammopelal, to 20% akal, to 30% microlithal, to 10% mesolithal. The ratio at Ss2 is 50% mesolithal, to 25% microlithal, to 10% akal, 10% macrolithal, to 5% psammopelal.

The hydrological measurements of the outflow from the dam registered spring maximum and autumn minimum. The low runoff in 2018 (Table 3), the low velocity and the infiltration capacity of the river bed led to an absence of surface water at Ss1, but at Ss2 water appeared again (due to groundwater source, or because of reduced infiltration capacity of the river bed).

The data, regarding the physicochemical conditions of the surface water from the Ovcharovo dam in the spring of 2017 and the autumn of 2018 demonstrates different concentration levels, corresponding to different EP for the oxygen regime in respect to DO and BOD_5 and for TP, $P\text{-}PO_4$ and $N\text{-}NO_2$. For both years, the values for $N\text{-}NO_3$ were not in the range to ''achieve'' good ecological potential (Table 3).

The results from the measured physico-chemistry of the water at the studied river sections indicated that the majority of the elements pointed out for good ecological status. Data considering Ss1 were gathered solely from 2017. MoES was registered only for TP and $P\text{-}PO_4$. According to our measurements, at every sample collection on Ss2 was found one abiotic parameter with levels corresponding to moderate status (Table 3).

A comparison between Ss1 and Ss2 for the spring in 2017 was possible. The comparison indicated different concentrations levels for TP, corresponding with different ES (Table 3).

Taxonomic composition of the macrozoobenthos was performed to allow ES assessment. A total of 19 taxonomic groups were found at the studied sites. Ss2 had greater diversity and density of benthic organisms, compared to Ss1. These results provided the values for BI, which characterize Ss1 with MoES and Ss2 with GES in 2017, while in the autumn of 2018 was possible to assessed solely Ss 2 with MoES, because the river was dry at Ss1 (Table 4). The results from Ss2 in 2018 showed equality between the used indices TTN and BI - both indicated MoES of river Dalgachka.

Table 2. Color coding, according to National water legislation.

High ecological status/Maximum ecological potential (HES/MEP)	Good ecological status/potential (GES/GEP)	Moderate ecological status/potential (MoES/MoEP)	Poor ecological status/potential (PES/PEP)	Bad ecological status/potential (BES/BEP)

Table 3. Hydrological and physicochemical parameters. Legend: Q (m^3 s^{-1}); V av. (m s^{-1}); V max.; DO (mg l^{-1}); Cond. (µs cm^{-1}); N-NH_4 (mg l^{-1}); N-NO_3 (mg l^{-1}); N-NO_2 (mg l^{-1}); P-PO_4 -(mg l^{-1}); TP (mg l^{-1}); BOD_5 (mg l^{-1}).

	SsD	SsD	Ss1	Ss1	Ss2	Ss2
Season Year	Spring 2017	Autumn 2018	Spring 2017	Autumn 2018	Spring 2017	Autumn 2018
Q	-	-	0.046	-	0.046	0.004
V av.	-	-	0.34	-	0.57	0.25
V max.	-	-	0.5	-	0.6	0.3
DO	7.5	10.67	6.9	-	7.65	9.17
pH	8.4	8.38	8.4	-	8.2	7.92
Cond.	222	260	280	-	273	580
N-NH_4	0.02	0.01	0.16	-	0.12	0.05
N-NO_3	0.9	1.5	1	-	1	0.75
N-NO_2	0.01	0.02	0.01	-	0	0.01
P-PO_4	0.03	0	0.097	-	0.048	0.03
TP	0.03	0	0.1	-	0.05	0.03
BOD_5	3.25	1	2	-	2.35	3.7

Table 4. Taxonomic groups of macrozoobenthos. Legend: TNI – total number of individuals per square meter; TTN – total taxon number; BI – biotic index; (A) - Sensible macroinvertebrate taxon; (B) - Less sensible macroinvertebrate taxon; (C) - Relatively tolerant macroinvertebrate taxon; (D) - Tolerant macroinvertebrate taxon.

	Ss1 – 2017	**Ss1 – 2018**	**Ss2 – 2017**	**Ss2 – 2018**
Ephemoptera order				
Heptagonidae fam. (A)	60	-	115	8
Ephemeridae fam.				-
Ephemera sp.(B)	36	-	8	
Baetidae (C)	52	-	186	30
Odonata order				
Aeshnidae fam. (B)	-	-	7	-

Athericidae fam. (B)	6	-	20	-
Tricladida order				
Dugesidae fam.				
Dugesia gonocephala (B)	7	-	9	-
Plecoptera order				
Nemouridae fam. (B)	-	-	-	3
Trichoptera order				
Psychomyiidae fam. (C)	-	-	3	-
Hydropsyhidae fam.(C)	13	-	19	2
Philopotamidae fam.(C)	-	-	2	-
Rhyacophilidae fam. (C)	-	-	7	-
Limnephilidae (C)	15	-	9	1
Gammaridae fam.				
Gammarus sp.(C)	262	-	554	431
Empididae fam.(C)	8	-	-	-
Coleoptera				
Elmintidae fam. (C)	92	-	124	3
Tricladida order(C)	3	-	31	-
Tipulidae fam. (C)	-	-	-	1
Simulidae fam. (C)	-	-	-	1
Chironomidae fam. (D)	-	-	10	22
Rheotanytarsus sp.(B)	5	-	-	-
Oligochaeta subclass(D)	-	-	112	-
TNI	559	-	1216	502
TTN	12	-	16	10
BI	3	-	3-4	2-3

Discussion

Our research revealed that the physicochemical parameters in 2017 and 2018 for the Ovcharovo dam accomplished the goal of WFD and ''achieved'' values at the range of GEP for all the abiotic parameters (excluding N-NO_3 for both years and BOD_5 in 2017). The observed high concentrations of N-NO_3, corresponding to MoEP, in the epilimnium of Ovcharovo dam, are likely due to agriculture activities, such as excessive use of fertilizers, but could also be caused by enhanced soil erosion and surface runoff (Damyanova & Varadinova, 2018).

The measurements of the supportive physicochemical parameters of the river showed rather heterogeneous results for the various abiotic factors. The values of the parameter TP for example, was in the range of GES in 2017 and in 2018 only at Ss2, but the results at Ss1 for 2017 correspond to MoES and were 0.1 mg l^{-1}. GES and MoES values don't fit to the definition of unpolluted waters, according to Wetzel (2003), because mean concentration of total dissolved phosphorus in unpolluted waters should be about 0.025 mg l^{-1}. Every result with values below 0.025 mg l^{-1} for TP in that river type (R4), corresponds to HES, according to our legislation. The measured values of TP can easily be reached after a heavy rainfall, at initial stages of snowmelt or from agricultural runoff (Wetzel, 2003), considering the fact that a large proportion of TP is delivered to surface waters via runoff in dissolved or particulate forms (Fraterrigo, 2008). The territories located to the left of the river bed (around Ss1) were occupied by annual crops, which demand more intensive tillage, than the surroundings of Ss2, which are occupied by perennial raspberry plantation. Greater rate of soil disturbance in agricultural riparian area within 100 meters of open water is the part of the watershed which is the most sensitive to increase of phosphorus loads (Sorrano et al., 1996). Therefore, the differences in the concentration levels of TP at both sample sites could be due to hydromorphological variations of the bottom substrate, caused by agricultural pressure as a factor increasing erosion processes and as a factor of diffuse source of pollution.

BOD_5 has values in the range of MoES only during the low water period in the autumn of 2018. That result could be attributed to natural decomposition processes or can be a good indicator for organic pollution (Damyanova & Varadinova, 2018). The other six measured physicochemical parameters are with values characterizing the river sections with GES and HES.

Based on the BQE "macrozoobenthos" two comparisons were made. The river section from dam Ovcharovo to the boundary of the PS in 2017, according to BI varies from MoES at Ss1 to GES at Ss2 and according to TTN from GES at Ss1 to HES at Ss2 (Table 4). The ES at Ss2 demonstrate a drop of the value for BI from 3-4 (GES) to 3 (MoES) from 2017 to 2018 and for TTN from HES to MoES (Table 4). The decline of the ES at Ss2 can be attributed to the changing hydrological conditions such as e.g. the flow rate (Table 3), which influence the community structure of bottom dwelling invertebrate fauna (Li, et al., 2019). Better management of the dam can contribute for maintaining GES at the river section downstream from Ovcharovo dam through all seasons, by promoting a more constant flow rate.

In 2017, Ss1 indicated poorer ES compared to Ss2. These results correspond with the different community structure of the benthic invertebrate fauna at the two sample sites. The source for that difference could be the dominance of finer substrate as psammopelal and lower flow velocity at Ss1, because these hydro-morphological factors affect both directly, and indirectly the macrozoobenthic community (Li, et al., 2019). The greater portion of finer sediment in the bottom substrate at Ss1 was probably caused by enhanced surface runoff induced from agricultural activities. Local point sources of pollution were not present, which means that allochthonous input may be occurring at Ss1.

The present preliminary study indicates on pressure in the PS at all sample sites, due to agricultural activities near the water bodies and inappropriate flow rate management of Ovcharovo dam. These factors could lead to degradation of the aquatic ecosystem to MoES regarding both measured abiotic and hydrologic parameters, as well as biotic indicators. Our results can serve as a basis and reference for eventual future monitoring, which would identify the potential pressures and threats that may impact the site and cause further environmental degradation of that complex aquatic ecosystem. The information published in this research article may be used from Black Sea Region Basin Directorate (BSBD) in the preparation of new River Basin Management Plan, in order to accomplish more detailed and objective information concerning the ES of the water body BG2KA800R033.

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