Joint Danube Survey 2

Full report on General Physico-Chemical Quality Elements (Thermal, Oxygenation, Salinity and Acidification Conditions)

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1 Introduction

This chapter refers to the on board measurements results for selected general physico-chemical quality elements analysed during JDS2, namely thermal, oxygenation, salinity and acidification conditions .

1.1 Relevancy of general physico-chemical elements in the Water Framework Directive

The EU Water Framework Directive (WFD) requires surface water classification by means of the assessment of ecological status and chemical status, imposing to achieve good ecological status in all water bodies by 2015 (Council Directive 2000/60/EC of 23 October 2000 establishing a framework for Community action in the field of water policy, 2000). In Annex V, Section 1.1.1 (Rivers), WFD lists three groups of quality elements to be used in this assessment, among which the third group refers to the "**chemical and physico-chemical elements supporting the biological elements**". Within this group, under the "General" category, the following quality elements are listed: thermal conditions, oxygenation conditions, salinity, acidification status and nutrient conditions."

2 Methods

2.1 Sampling and storage

Water samples designated to on-board measurements were collected directly from the river using the motor-boat used for the collection of biological samples. No storage was necessary for analysing the general physico-chemical parameters, since the determination took place immediately after the sampling. Samples from the longitudinal surveys on major tributaries were sampled by national experts from the riparian countries for a given tributary. In-situ measurements were done also by national experts and the results were recorded in the sampling protocols for each sampling location.

2.2 Determination

Table 1 presents the overall summary of the general chemical quality elements that were determined on board of the Argus laboratory ship. The Standard Operational Procedures (SOPs) based on international standardised methods were used for in-situ measurements, using portable multiple-probe WTW instrument (temperature, dissolved oxygen, pH and conductivity) and digital titration system for alkalinity.

2.3 Analytical Quality Control

Calibration of the instruments was done according to the WTW Instruction Manual as frequent as it was asked in the specific SOP and by the instrument-set-up. All calibrations were recorded in the instruments' log.

Table 1: General physico-chemical quality elements measured in field and on-board

Sample type	Sampling profile	Quality element	Unit	Determination	Analytical method - principle
Water	Middle	Temperature	°C	In-situ measurement	WTW Temperature-probe
Water	Middle	Dissolved oxygen	mg/l and %	In-situ measurement	ISO 5814/1990 – WTW; DO-probe

Water	Middle	pH	-	In-situ measurement	ISO 10523:1994 – WTW; pH-probe
Water	Middle	Conductivity @ 20 °C	µS/cm	In-situ measurement	ISO 7888/1985 - WTW Conductivity-probe
Water	Middle	Alkalinity	mmol/l	On-board analysis	ISO 9963-1:1994 - titrimetric

3 Results and discussion

In order to have a better view of the spatial distribution of values, the interpretation of the results will be made according to a previous splitting of the Danube Basin into three major sections (Joint Danube Survey, Technical Report of the ICPDR, 2002)

- *Upper Danube: from river km 2600 to river km 1880 (sampling stations JDS1 – JDS15).*
- *Middle Danube: from river km 1869 to river km 1077 (sampling stations JDS16 – JDS58).*
- *Lower Danube: from river km 1077 to river km 0 (sampling stations JDS59 to JDS0).*

Variation ranges and statistical data (where appropriate) for the general physico-chemical quality elements (temperature, conductivity, pH, alkalinity and dissolved oxygen) are presented in Table 2.

Table 2: Variation ranges and statistical data for the *general physico-chemical quality elements* – Danube River and tributaries

Quality element	Unit	Danube River			Tributaries		Longitudinal surveys on major tributaries	
		Minimum value	Maximum value	Mean value	Minimum value	Maximum value	Minimum value	Maximum value
Temperature	^{0}C	17.4	24.9	21.1	11.0	26.6	-	-
Conductivity	µS/cm	346	577	387	280	1073	136	1073
pH	-	7.32	8.10	7.76	7.26	8.27	7.20	8.59
Alkalinity	mmol/l	2.3	4.4	2.7	1.4	7.6	0.8	7.4
Dissolved Oxygen (concentration)	mg/l	3.49	10.1	8.18	1.67	11.02	0.36	10.4
Dissolved Oxygen (saturation)	%	39.3	114.9	93.96	17.4	127.9	3.5	112.7

3.1 Temperature

Water temperature variation along the Danube River and in tributaries is presented in Figure 1.The minimum value recorded at river km 2600 (*Upstream Iller*) was specific for the site location - altitude of 480m a.s.l.[1] in the upper course region (according to the Typology of the Danube River and JDS2 Factsheets Draft). The maximum value was measured at river km 1707 (*Szob*) within the maximum spatial profile comprised between km 1766 and km 1707 (with water temperature over 23.0 ^{0}C). For the rest of the Danube River, a slight decreasing line, from middle to lower course, was noticed. As far as concerns the water temperature in mouth of the selected tributaries, variation was similar with the Danube itself, higher values (over 25^{0}C) being recorded in the *Hron* and *Ipoly* tributaries. The minimum temperature value was measured in the *Arges* tributary and it was, most likely, due to the early sampling time.

3.1 Conductivity

Conductivity showed a relative constancy along the Danube River course during JDS2 with several distinctive profiles – see Figure 2. Thus, in the upper region comprised between river km 2600 (*Upstream Iller*) and km 2278 (*Niederalteich*) conductivity values over 400µS/cm decreased to

[1] a.s.l. – above sea level

363µS/cm at river km 2204 (*Jochenstein*) due to the low conductivity value of the *Inn* tributary (280 µS/cm). This influence is generally due to the mean annual discharges from these sites: 640 m^3/s at sampling site from river km 2278 and 745 m^3/s at station *Passau Ingling* on the *Inn* (JDS2 Factsheets Draft). In the lower course of the Danube, only the *Olt* tributary, with 705µS/cm, had a slight influence on the downstream sampling site: 371µS/cm at river km 606 (*upstream Olt*) and 577µS/cm at river km 602 (*downstream Olt*). As regards the conductivity values from mouth of the tributaries, except for the *Inn* and *Drava* with lower values than the Danube profile, the salt content from the others was generally higher, but no significant influence on the Danube itself was noticed.

The longitudinal surveys on the major tributaries showed an increasing trend from the upper part down to the confluence with the Danube River for *Velika Morava*, *Iskar*, *Olt*, *Russenski Lom* and slight decreasing for *Tisa*, *Sava* and *Prut* tributaries – Figure 3.

Figure 1: Variation in *water temperature* values for the Danube River and selected tributaries during JDS2

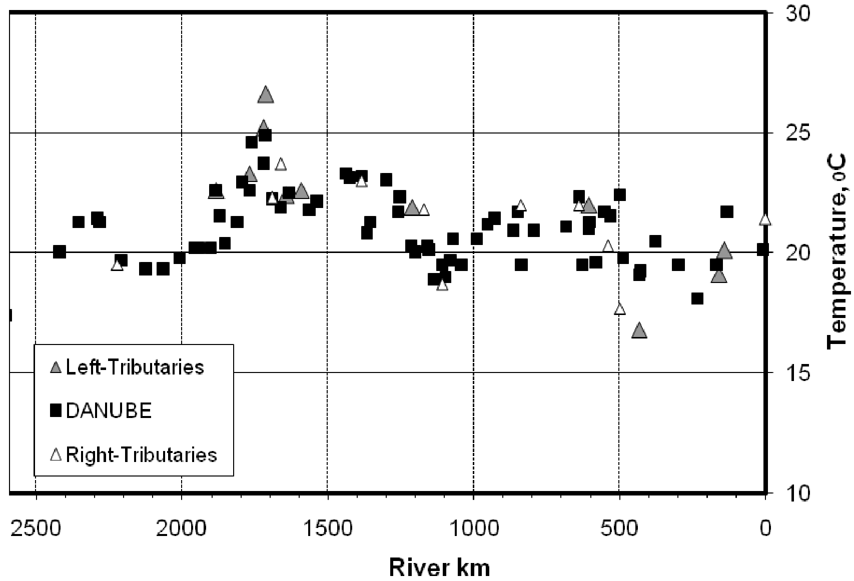


Figure 2: Variation in *conductivity* for the Danube River and selected tributaries during JDS2

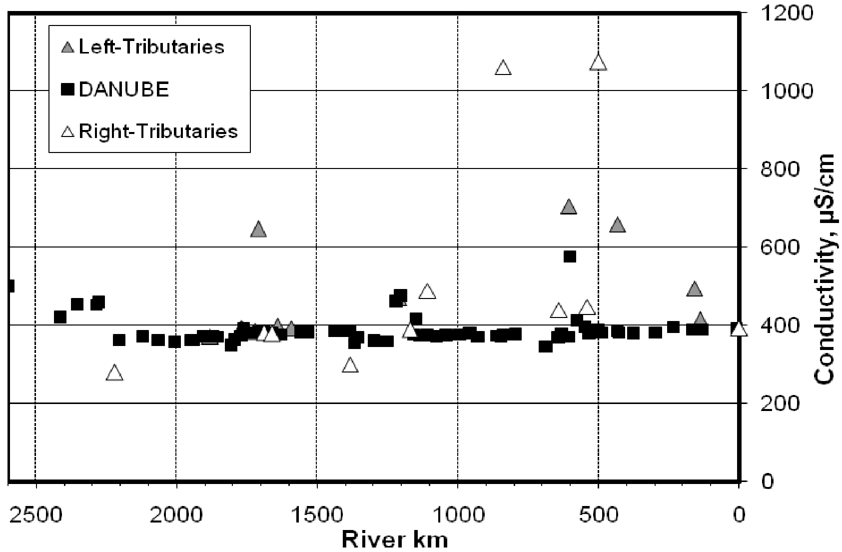
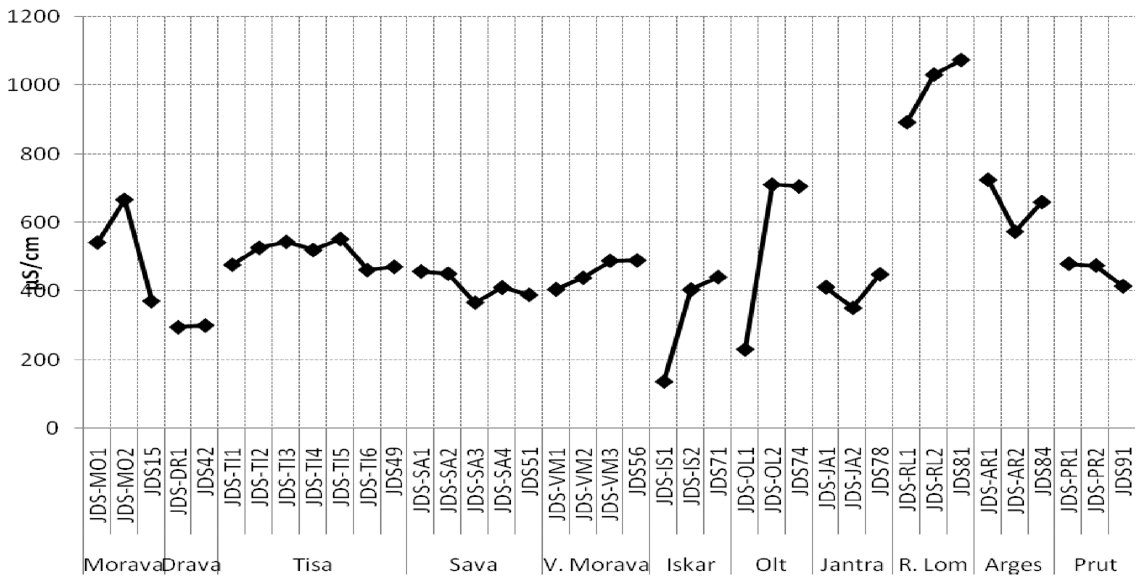


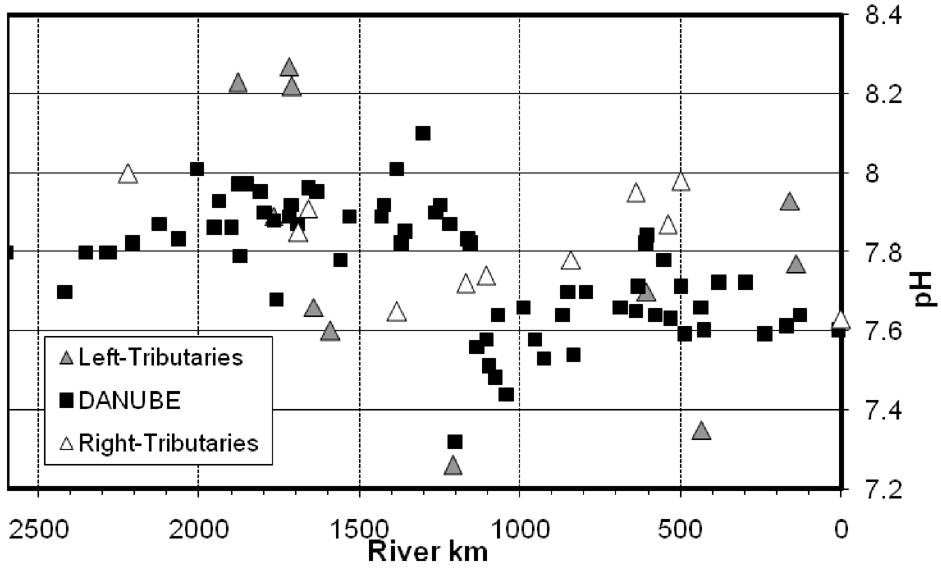
Figure 3: Variation in *conductivity* in water samples for the longitudinal surveys on major tributaries



3.2 pH

pH variation in the Danube River and its tributaries is shown in Figure 4. In the upper section of the Danube course, a slight increasing profile is visible from river km 2415 (*Kelheim*) to river km 2008 (*Oberloiben*), with pH values from 7.70 to 8.01 respectively. In the middle Danube, most of the pH values were over 7.70, except for the ones measured in the *Rackeve-Soroksar Danube arm*: 7.66 at start (river km 1642) and 7.60 at the end of the arm respectively (river km 1586). In the middle reach - at river km 1300 (*Ilok/Backa Palanka*) - the maximum pH value for the Danube River was measured (8.10), followed by a significant decreasing profile, with pH values below 7.6. The minimum value - 7.32 at river km 1200 (*Downstream Tisa*) - was mainly due to the *Tisa* River influence, on which the minimum pH value in tributaries was measured (7.26).

Figure 4: Variation in *pH* values for the Danube River and selected tributaries during JDS2



The general pH variation profile along the Danube River can be well correlated with the biochemical processes in the water, the primary production and respiration along with bacterial decomposition of algal detritus. Given the JDS2 usual sampling time (during daylight) primary production exceeded organic decomposition leading to increasing pH values and dissolved oxygen content, mainly visible in the middle reach of the Danube between river km 1605 (*Adony/Lórév*) – and km 1200 (*Downstream Tisa*). In addition, correlation of pH with dissolved oxygen saturation was made. From Figure 5a) it can be seen that the pH is well correlated with dissolved oxygen saturation values along the entire Danube River ($R=0.7036$, $N=78$, $P<0.0001$). If the above mentioned middle stretch is selected (river km 1605 – 1200), a highly better correlation is found ($R=0.90145$, $N=15$, $P<0.0001$) – see Figure 5b) which confirms the previous indications according to which this area, with slow flowing and relatively shallow reaches, may be sensitive to eutrophication process (Roof Report, 2004).

Lower pH values were measured along the lower course of the Danube, especially in the *Iron Gates* area. Even though parameters indicating the extent of organic pollution (chemical and bio-chemical oxygen demand) were not analyzed in the water samples, the decrease of both pH and oxygen content in the lower course of the Danube could be explained either by the presence of oxygen consuming pollutants or by the strong influence of the quasi-stagnant water regime in the *Iron Gates* stretch.

As regards the pH in mouth of the tributaries, values over 8.2 were measured in the *Morava*, *Hron* and *Ipoly* (8.23, 8.27 and 8.22 respectively), values which are well correlated with over-saturation in dissolved oxygen (see Figure 9), reflecting primary production occurrence. Relatively lower pH values were measured at the mouth of the *Tisa* and *Arges* tributaries (7.26 and 7.35 respectively) but only the *Tisa*'s influence on the downstream site was visible.

Along the major tributaries, pH values generally decreased from the upper sections down to the confluence with the Danube River, except for the *Morava* tributary, on which increasing pH values were measured. The pH profile was well correlated with the dissolved oxygen pattern, reflecting biochemical activity – see Figure 6.

Figure 5a) and b): Correlation between pH and DO saturation along the Danube River (a) and along the middle stretch of the Danube (river km 1605 – 1200)

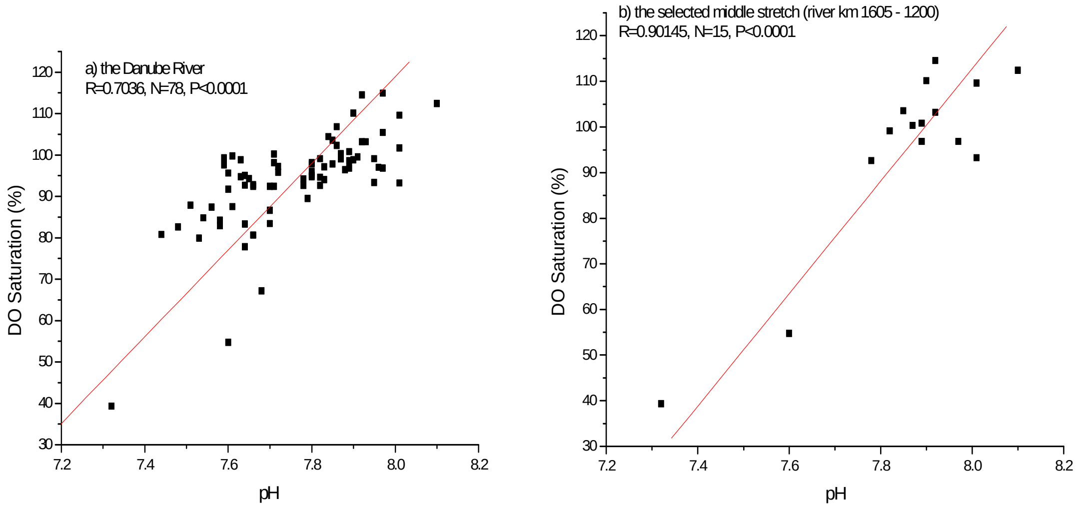
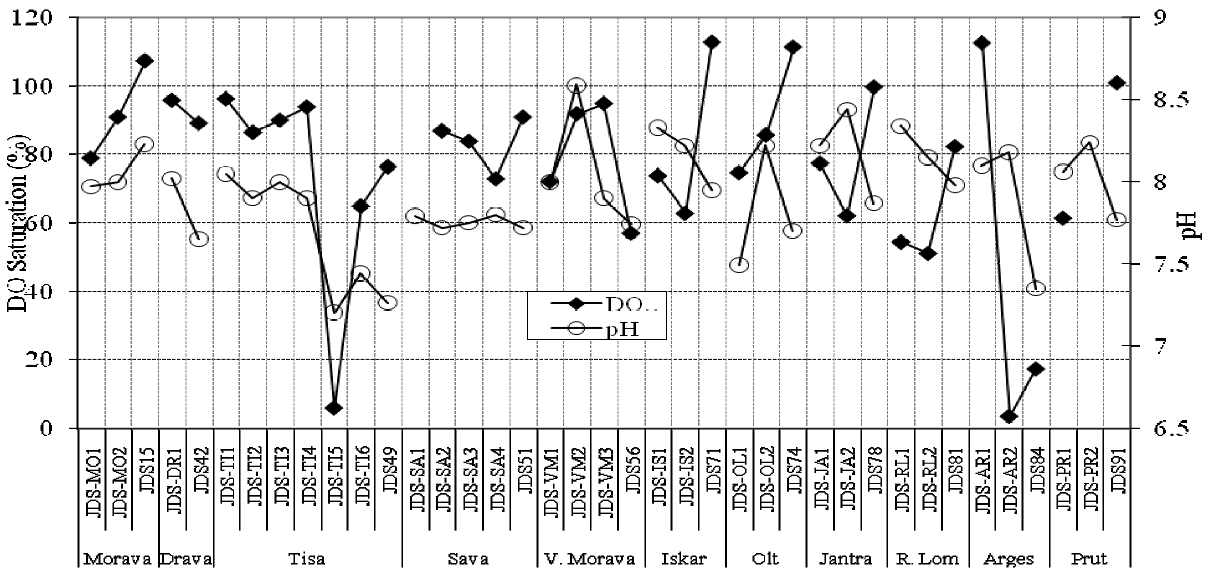


Figure 6: Variation in pH and dissolved oxygen content in water samples for the longitudinal surveys on major tributaries



3.3 Alkalinity

Alkalinity values along the Danube river - presented in Figure 7 - ranged within 2.3mmol/l and 4.4mmol/l, with the minimum value measured at river km 1216 (*Upstream Tisa*) and the maximum at km 2600 (*Upstream Iller*). As regards the spatial distribution, a decreasing line from the upper to the middle and lower Danube is noticed. In mouth of the tributaries, relatively higher alkalinity values (over 7mmol/l) were measured in the *Sió* and *Russenski Lom*, but with no influence on the downstream sampling sites.

The longitudinal surveys on major tributaries showed slight decreasing profiles from upstream to downstream in the case of *Tisa* and *Olt* tributaries, while increasing trend was visible along *Velika*

Morava, *Jantra*, *Russenski Lom* and *Arges* tributaries. Rather low alkalinity (0.8 mmol/l) was measured at JDS-IS2 – see Figure 8.

Figure 7: Variation in *alkalinity* values for the Danube River and selected tributaries during JDS2

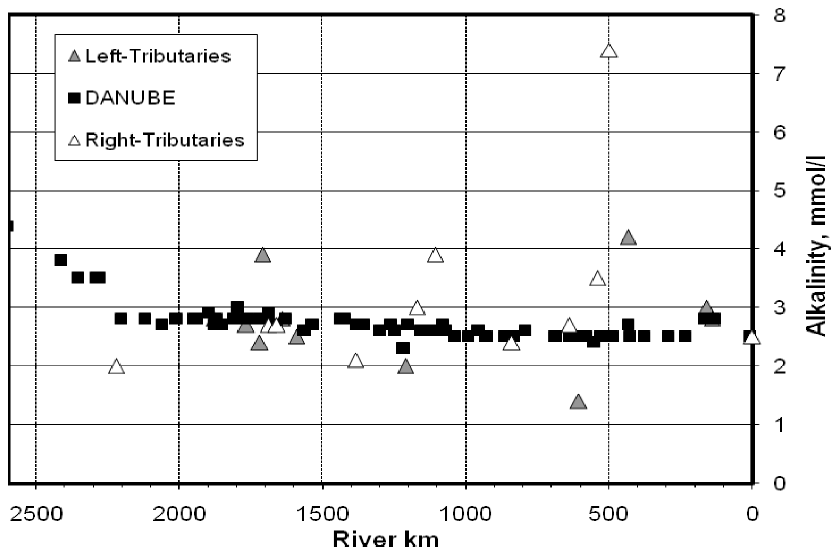
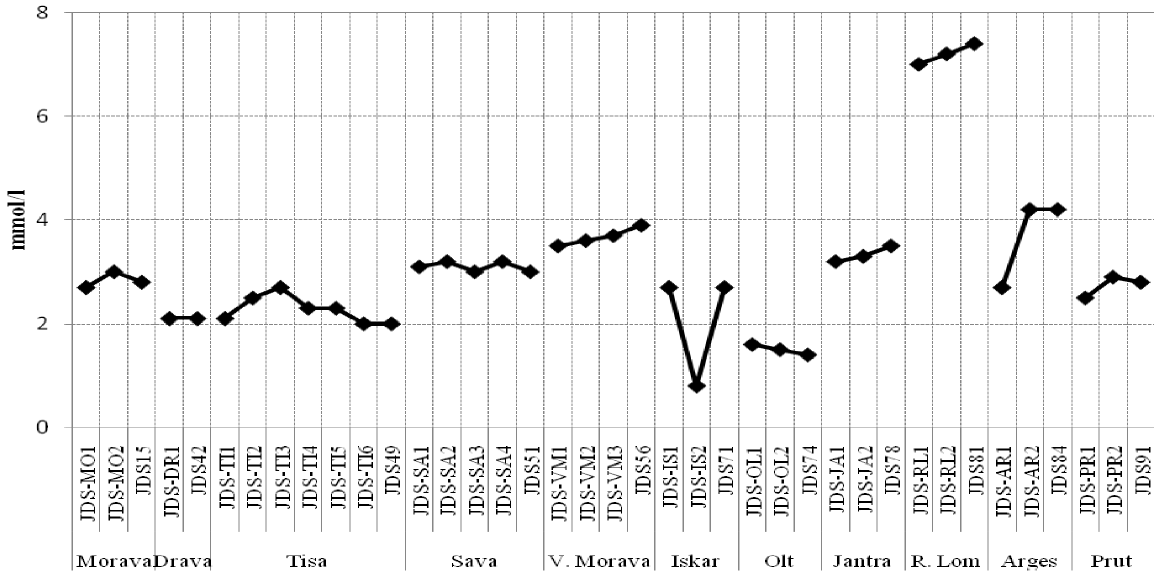


Figure 8: Variation in alkalinity in water samples for the longitudinal surveys on major tributaries

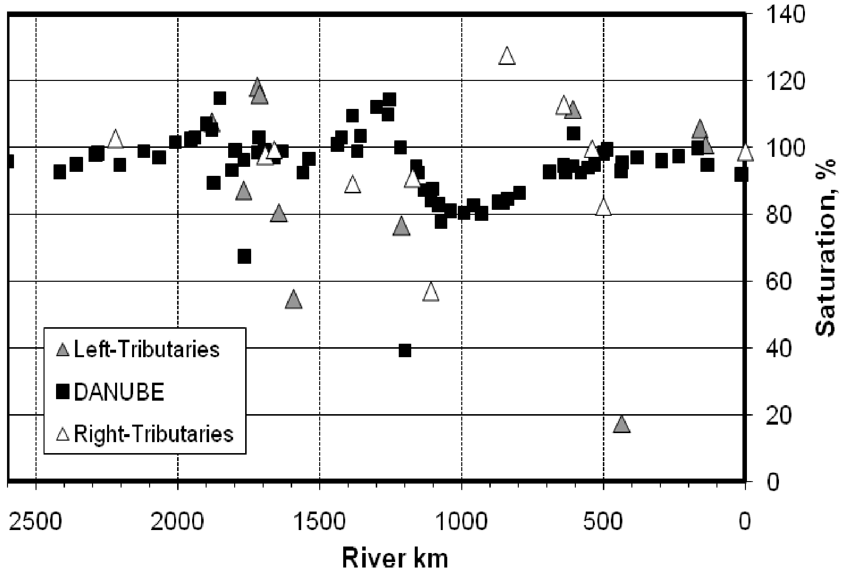


3.4 Dissolved Oxygen

Dissolved oxygen content in the Danube River ranged within a relative large interval, between 3.49 and 10.10 mg/l (39.3 and 114.9% respectively) – see Figure 9. The general profile was almost similar to the pH one, with an increasing line in the upper Danube which continuously went into the middle stretch, reaching the maximum value at river km 1852 (10.10 mg/l in *Gabcikovo reservoir*), except for the value recorded at river km 1869 (7.66 mg/l in *Bratislava*). Downstream *Gabcikovo*, a decreasing profile was noticed, with oxygen saturations slightly below the equilibrium level. A more prominent decreased value (67.1%) was measured at river km 1761 (*Iza/Szony*). The following middle Danube reach was characterized by a significant increasing oxygen trend, with saturation values from 96.8% at river km 1533 (*Paks*) to 114.5% at river km 1252 (*Downstream Novi-Sad*). A distinctive profile was recorded on the *Rackeve-Soroksar Danube arm*, on which oxygen depletion occurred: from 80.6% at start (river km 1642) to 54.7% at the end of the arm (river km 1586), depletion well correlated with the pH values decreasing for these sites. The minimum oxygen content along the Danube River (39.3%) was measured at river km where the minimum pH value was measured as well – km 1200 (*Downstream Tisa*) despite the fact that on the *Tisa* tributary (at confluence with the Danube River) a much higher value was recorded (76.5%). Following *downstream Novi-Sad*, a prominent decreasing in oxygen saturation values was present, mainly in the *Iron Gates* stretch due to possible denitrification process occurring in this reservoir. Along the lower course of the Danube River, an increasing trend in oxygen saturation is visible, up to the equilibrium level at river km 18 (*Vilkovo – Chilia arm*).

The variation interval for oxygen content in mouth of the tributaries was much larger than for the Danube itself, from 1.67 mg/l and 11.02 mg/l (17.4 and 127.9% respectively). If the maximum value, measured in the *Timok*, was a consequence of high primary production, also well correlated with the chlorophyll value of 53.3µg/l, the minimum value, measured in the *Arges*, was mainly caused by the high amount of untreated waste waters usually discharged by a major municipal sewage system.

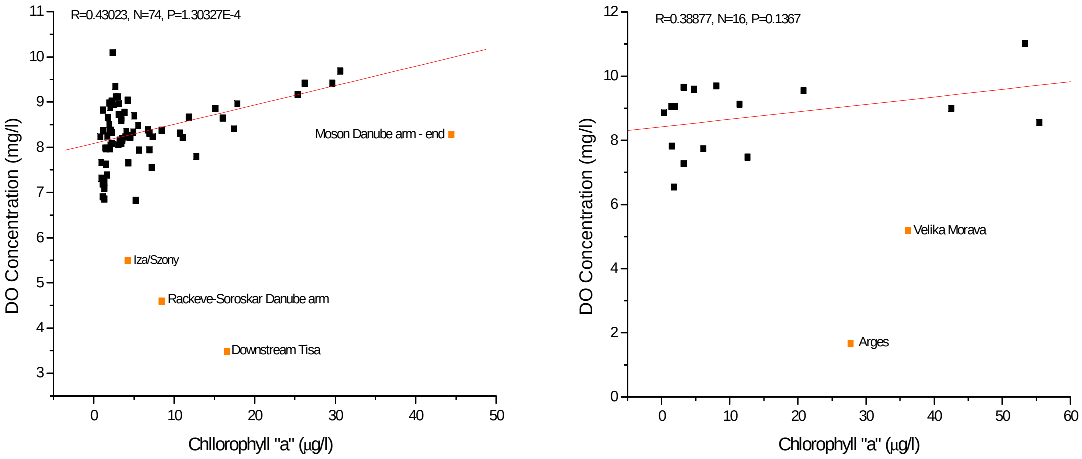
Figure 9: Variation in *oxygen saturation* values for the Danube River and selected tributaries during JDS2



In order to have a more comprehensive assessment of the dissolved oxygen content in relation with primary production, correlation between this parameter and chlorophyll „a" is shown in Figure 10a) for the Danube and 10b) for tributaries at the confluence, but very significant correlation factors were not found (R=0.43023, N=74, P=1.30327E-4 for the Danube River and R=0.38877, N=16, P=0.1367 for mouth of the tributaries)..

As already mentioned, the dissolved oxygen saturation along the major tributaries was well correlated with the biochemical processes in the water column, increased primary production leading to a higher oxygen content and hence higher pH values – see Figure 6. In one sampling site on *Tisa* tributary (JDS-TI5) and one site on *Arges* (JDS-AR2) extremely low oxygen was found (6% and 3.5% saturation respectively).

Figure 10a) and b): Correlation between DO concentration and chlorophyll “a” in the Danube River a) and tributaries b)



3.5 Comparison with Joint Danube Survey 1 (August – September 2001)

In order to fulfil one of the specific objectives of JDS2 – to compare the results with outcomes of the JDS1, a brief comparison of the results obtained during JDS2 with the ones of the first similar survey has been made (for the common sampling sites along the Danube and selected tributaries), based on which the following observations can be done:

- *water temperature* profiles are relatively similar for the Danube River, except for the *Iron Gates* area, where lower values were measured during JDS2. For selected tributaries, water temperatures were higher during JDS2 for the *Inn*, *Hron* and *Ipoly* while for the *Sió, Tisa, Sava, Veliko Morava* and *Olt* significantly lower temperature values were measured during JDS2 – see Figure 11;
- *conductivity* values measured in JDS2 with the ones from JDS1 is shown in Figure 12: as expected, the two data sets were highly comparative both for the Danube River and selected tributaries, except for the *Olt* and *Russenski Lom*, where higher conductivity was found during JDS2 and the *Jantra*, where lower conductivity was measured in JDS2;
- when compared with the *pH* values measured during JDS1- Figure 13, the values found in JDS2 were relatively similar, except for the river stretch located in the middle Danube, between rkm 1692 and rkm 1424, where pH values found in JDS1 were higher than the ones measured during JDS2; most of the tributaries had pH values from JDS2 lower than the one from JDS1;
- *alkalinity* values were almost similar with the ones measured six years ago for the Danube River, except for the value from river km 532 (*Downstream Jantra*), where a higher value was found in JDS1. For tributaries, negative differences between JDS2 and JDS1 data set appeared in the case of *Jantra* and positive for the *Russenski Lom* and *Arges* respectively – see Figure 14;
- when compared with JDS1, the *dissolved oxygen saturations* measured during JDS2 were generally slightly lower in the upper reach of the Danube River and significantly lower in the middle reach. Starting with rkm 1300 (*Ilok/Backa Palanka*), JDS2 values are higher than the ones from JDS1 and this profile remains relatively similar also in the lower Danube – see Figure 15. As regards the oxygen in the selected tributaries, most of them had higher content in JDS2.

Figures 11: Comparison between temperature values from JDS2 and JDS1

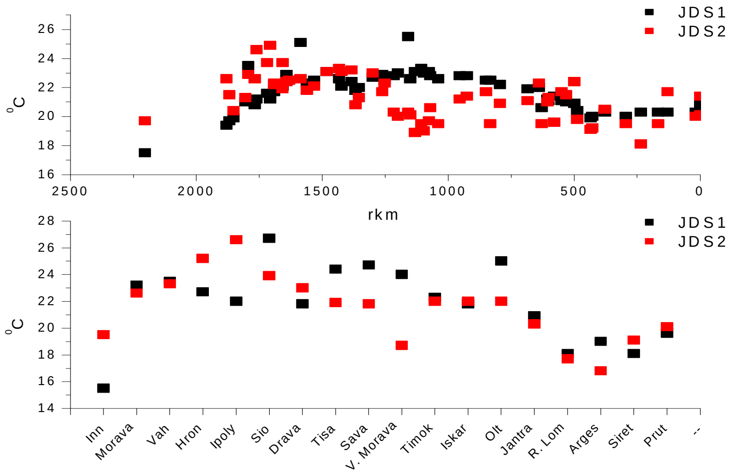


Figure 12: Comparison between conductivity values from JDS2 and JDS1

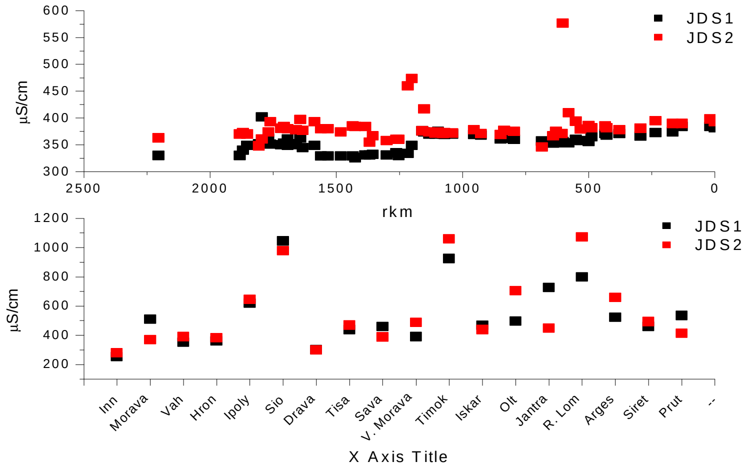


Figure 13: Comparison between pH values from JDS2 and JDS1

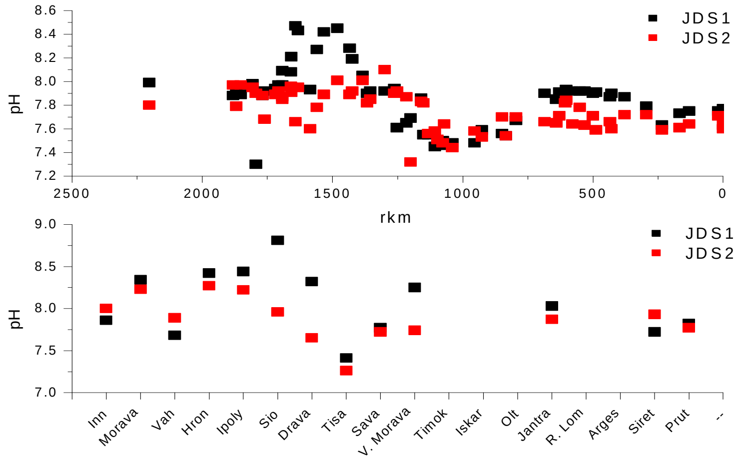


Figure 14: Comparison between alkalinity values from JDS2 and JDS1

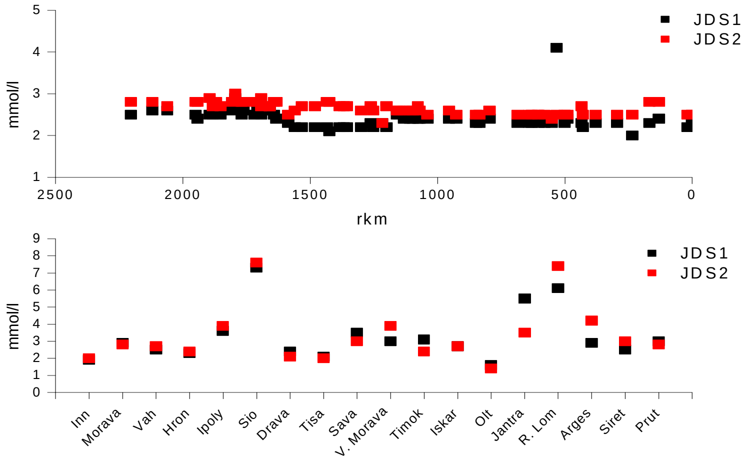
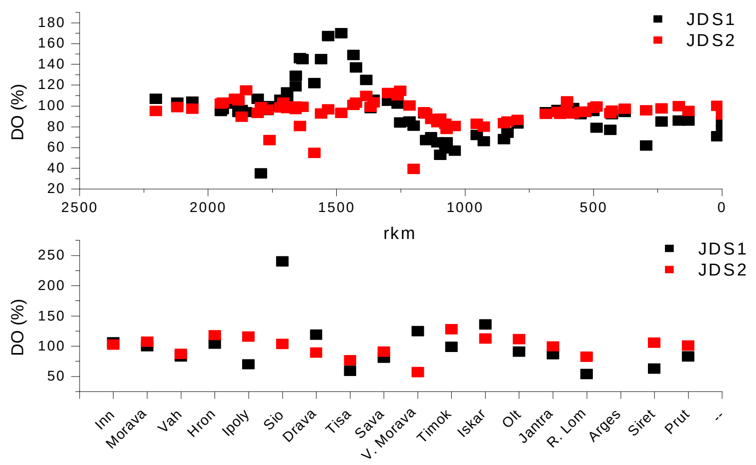


Figure 15: Comparison between *dissolved oxygen saturation* values from JDS2 and JDS1



3.6 Water Quality Assessment

The water quality assessment for the JDS2 general characteristics results was carried out based on three different approaches: the Austrian and the Czech proposals (which are WFD compliant) and the ICPDR classification system (used for TNMN purposes only).

3.6.1 Water Quality Assessment according to WFD compliant criteria

According to the JDS2 data compilation based on the criteria set in the two above mentioned proposals (shown in Table 3 and Table 4) a preliminary and partial attend for the evaluation of the ecological class of the Danube and selected tributaries given by the general physico-chemical quality elements is presented in Table 5 and Table 6 respectively.

Table 3: Numeric criteria used for the general physico-chemical quality elements according to the *Austrian* proposal

<table>
<tr><th>Quality Element</th><th>Parameter to be assessed</th><th>Type of criteria</th><th>High Class</th><th>Good Class</th></tr>
<tr><td>Temperature conditions</td><td>Temperature (^{0}C)</td><td>98 Percentile</td><td>15 – 25</td><td>20 – 28</td></tr>
<tr><td>Oxygenation conditions</td><td>Dissolved Oxygen (Saturation - %)</td><td rowspan="2">90 Percentile</td><td colspan="2">80 - 120</td></tr>
<tr><td>Acidification conditions</td><td>pH</td><td colspan="2">6 - 9</td></tr>
</table>

Table 4: Numeric criteria (Environmental Quality Standards - EQS) used for the general physico-chemical quality elements according to the *Czech* proposal

<table>
<tr><th>Quality Element</th><th>Parameter to be assessed</th><th>Type of criteria</th><th>EQS</th><th>Type of criteria</th><th>EQS</th></tr>
<tr><td>Temperature conditions</td><td>Temperature (^{0}C)</td><td rowspan="3">90 Percentile</td><td>25</td><td rowspan="3">Annual Average (AA)</td><td>14</td></tr>
<tr><td>Oxygenation conditions</td><td>Dissolved Oxygen (Concentration – mg/l)</td><td>>6</td><td>>9</td></tr>
<tr><td>Acidification conditions</td><td>pH</td><td>6 - 8</td><td>6 - 8</td></tr>
</table>

Table 5: Preliminary ecological class evaluation for the general physico-chemical parameters based on the *Austrian* proposal

<table>
<tr><th rowspan="4">Parameter to be assessed</th><th colspan="10">Indicationon ecological quality class (Number of JDS2 sampling sites)</th></tr>
<tr><th colspan="5">Danube River</th><th colspan="5">Tributaries</th></tr>
<tr><th rowspan="2">High Class</th><th rowspan="2">Good Class</th><th colspan="3">Non-complying “good class”</th><th rowspan="2">High Class</th><th rowspan="2">Good Class</th><th colspan="3">Non-complying “good class”</th></tr>
<tr><th>Number of sites</th><th colspan="2">JDS2 position</th><th>Number of sites</th><th colspan="2">JDS2 position</th></tr>
<tr><td>Temperature</td><td>78</td><td>0</td><td>0</td><td>-</td><td>-</td><td>16</td><td>2</td><td colspan="3">0</td></tr>
<tr><td rowspan="5">Dissolved Oxygen (Saturation)</td><td colspan="2" rowspan="5">73</td><td rowspan="5">5</td><td>rkm 1761</td><td>Iza/Szony</td><td colspan="2" rowspan="5">14</td><td rowspan="5">4</td><td>rkm 1215</td><td>Tisa</td></tr>
<tr><td>rkm 1586</td><td>Rackeve-Soroksar Danube Arm - end</td><td>rkm 1103</td><td>Velika Morava</td></tr>
<tr><td>rkm 1200</td><td>Downstream Tisa/Upstream Sava (Belegis)</td><td>rkm 845</td><td>Timok</td></tr>
<tr><td>rkm 1071</td><td>Banatska Palanka/Bazias</td><td rowspan="2">rkm 432</td><td rowspan="2">Arges</td></tr>
<tr><td>rkm 926</td><td>Vrbica/Simijan</td></tr>
<tr><td>pH</td><td colspan="2">78</td><td colspan="3">0</td><td colspan="2">18</td><td colspan="3">0</td></tr>
</table>

Table 6: Preliminary ecological status evaluation for the general physico-chemical parameters based on the *Czech* proposal (EQS as Annual Average)

<table>
<tr><th rowspan="4">Parameter to be assessed</th><th colspan="4">Indicationon ecological quality class (Number of JDS2 sampling sites)</th></tr>
<tr><th colspan="2">Danube River</th><th colspan="2">Tributaries</th></tr>
<tr><th colspan="2">Meet the EQS</th><th colspan="2">Meet the EQS</th></tr>
<tr><th>Yes (Good Class)</th><th>No (Moderate Class)</th><th>Yes (Good Class)</th><th>No (Moderate Class)</th></tr>
<tr><td>Temperature[2]</td><td>78</td><td>0</td><td>16</td><td>2</td></tr>
<tr><td>Dissolved Oxygen (Concentration)</td><td>10</td><td>68</td><td>9</td><td>9</td></tr>
<tr><td>pH</td><td>74</td><td>4</td><td>15</td><td>3</td></tr>
</table>

According to Tables 5-6, the following observations can be done:

- *based on the Austrian proposal:*

    a. *Danube River:*

[2] Given the JDS2 timing (August-September), the water temperature evaluation was done taking into account the EQS as C90 (25^{0}C) and not as AA (14^{0}C)

i. *all sampling sites are characterised by the "high" or "good" class given by pH and "high" class by temperature;*

ii. *as regards the dissolved oxygen saturation, five sampling sites do not comply with the "good class" criterion: river km 1761 (*Iza/Szony*), river km 1586 (*Rackeve/Soroskar Danube arm-end*), river km 1200 (*downstream Tisa*), river km 1071 (*Banatska Palanka/Bazias*) and river km 926 (*Vrbica/Simijan*);*

b. *Tributaries:*

i. *from the pH point of view, all tributaries are in the "high"or "good" class" while most of them (88.8%) are in the "high" class when temperature is taken into account. Two tributaries presented temperature values above the limit for "high class" (*Hron *and* Ipoly*);*

ii. *similar to the Danube River, the most restraint parameter is dissolved oxygen, for which four tributaries do not comply with the "good class" criterion, three of them with lower oxygen content (*Tisa, Velika Morava *and* Arges*) and one tributary with oversaturation (*Timok*).*

The overall indication on ecological class given by the general physico-chemical conditions based on the Austrian proposal is presented in Table 7.

Table 7: General overview on the indicative ecological class given by the general physico-chemical quality elements (thermal, oxygenation and acidification conditions) – JDS2 sampling sites for water

JDS2 Code	Country	Station	Danube type	rkm	Quality Class
JDS1	DE	Upstream Iller	1	2600	1
JDS2	DE	Kelheim – gauging station	2	2415	1
JDS3	DE	Geisling power plant	2	2354	1
JDS4	DE	Deggendorf	2	2285	1
JDS5	DE	Niederalteich	2	2278	1
JDS6	DE, AT	/Inn, rkm 4.2		2225	1
JDS7	DE, AT	Jochenstein	3	2204	1
JDS8	AT	Upstream dam Abwinden-Asten	3	2120	1
JDS9	AT	Upstream dam Ybbs-Persenbeug	3	2061	1
JDS10	AT	Oberloiben	3	2008	1
JDS11	AT	Upstream dam Greifenstein	4	1950	1
JDS12	AT	Klosterneuburg	4	1942	1
JDS13	AT	Wildungsmauer	4	1895	1
JDS14	AT	Upstream Morava (Hainburg)	4	1881	1
JDS15	AT, SK	/Morava (rkm 0.08)		1880	1
JDS16	SK	Bratislava	4	1869	1
JDS17	SK, HU	Gabcikovo reservoir	4	1852	1
JDS18	SK, HU	Medvedov/Medve	4	1806	1
JDS19	HU	/Moson Danube Arm – end (rkm 0.1)	4	1794	1
JDS20	SK, HU	Komarno/Komarom	5	1768	1
JDS21	SK	/Vah (rkm 0.8)		1766	1

JDS22	SK, HU	Iza/Szony	5	1761	>2
JDS23	SK, HU	Sturovo/Esztergom	5	1719	1
JDS24	SK	/Hron (rkm 0.5)		1716	2
JDS25	SK, HU	/Ipoly (rkm 0.7)		1708	2
JDS26	HU	Szob	5	1707	1
JDS27	HU	Upstream end of Szentendre Island	5	1692	1
JDS28	HU	/Upstream end of Szentendre Island (arm)	5	1692	1
JDS29	HU	Budapest upstream	5	1659	1
JDS30	HU	/Budapest (old Danube) end of S.arm	5	1658	1
JDS31	HU	/Rackeve-Soroksar Danube Arm - start	5	1642	1
JDS32	HU	Budapest downstream	5	1632	1
JDS33	HU	Adony/Lórév	5	1605	1
JDS34	HU	/Rackeve-Soroksar Danube Arm - end		1586	>2
JDS35	HU	Dunafoldvar	5	1560	1
JDS36	HU	Paks	5	1533	1
JDS37	HU	/Sio (rkm 1.0)		1497	1
JDS38	HU	Baja	6	1481	1
JDS39	HU	Hercegszanto	6	1434	1
JDS40	HR, RS	Batina	6	1424	1
JDS41	HR, RS	Upstream Drava	6	1384	1
JDS42	HR	/Drava (rkm 1.4)		1379	1
JDS43	HR, RS	Downstream Drava (Erdut/Bogojevo)	6	1367	1
JDS44	HR, RS	Dalj	6	1355	1
JDS45	HR, RS	Ilok/Backa Palanka	6	1300	1
JDS46	RS	Upstream Novi-Sad	6	1262	1
JDS47	RS	Downstream Novi-Sad	6	1252	1
JDS48	RS	Upstream Tisa (Stari Slankamen)	6	1216	1
JDS49	RS	/Tisa (rkm 1.0)		1215	>2
JDS50	RS	Downstream Tisa/Upstream Sava (Belegis)	6	1200	>2
JDS51	RS	/Sava (rkm 7.0)		1170	1
JDS52	RS	Upstream Pancevo/Downstream Sava	6	1159	1
JDS53	RS	Downstream Pancevo	6	1151	1
JDS54	RS	Grocka	6	1132	1
JDS55	RS	Upstream Velika Morava	6	1107	1
JDS56	RS	/Velika Morava		1103	>2
JDS57	RS	Downstream Velika Morava	6	1097	1
JDS58	RS	Starapalanka – Ram	6	1077	1
JDS59	RS, RO	Banatska Palanka/Bazias	7	1071	>2
JDS60	RS, RO	Irongate reservoir (Golubac/Koronin)	7	1040	1
JDS61	RS, RO	Donji Milanovac	7	991	1
JDS62	RS, RO	Irongate reservoir (Tekija/Orsova)	7	954	1
JDS63	RS, RO	Vrbica/Simijan	8	926	>2

JDS64	RS, RO	Iron Gate II	8	865	1
JDS65	RS, RO	Upstream Timok (Rudujevac/Gruia)	8	849	1
JDS66	RS, BG	/Timok (rkm 0.2)		845	>2
JDS67	RO, BG	Pristol/Novo Selo Harbour	8	834	1
JDS68	RO, BG	Calafat	8	795	1
JDS69	BG, RO	Downstream Kozloduy	8	685	1
JDS70	BG, RO	Upstream Iskar (Bajkal)	8	640	1
JDS71	BG	/Iskar (rkm 0.3)		637	1
JDS72	BG, RO	Downstream Iskar	8	629	1
JDS73	RO, BG	Upstream Olt	8	606	1
JDS74	RO	/Olt (rkm 0.4)		605	1
JDS75	RO, BG	Downstream Olt	8	602	1
JDS76	RO, BG	Downstream Turnu-Magurele/Nikopol	8	579	1
JDS77	RO, BG	Downstream Zimnicea/Svishtov	8	550	1
JDS78	BG	/Jantra (rkm 1.0)		537	1
JDS79	RO, BG	Downstream Jantra	8	532	1
JDS80	BG, RO	Upstream Ruse	8	500	1
JDS81	BG	/Russenski Lom		498	1
JDS82	BG, RO	Downstream Ruse/Giurgiu	8	488	1
JDS83	RO, BG	Upstream Arges	8	434	1
JDS84	RO	/Arges		432	>2
JDS85	RO, BG	Downstream Arges, Oltenita	8	429	1
JDS86	RO, BG	Chiciu/Silistra	8	378	1
JDS87	RO	Upstream Cernavoda	9	295	1
JDS88	RO	Giurgeni	9	235	1
JDS89	RO	Braila	9	167	1
JDS90	RO	/Siret (rkm 1.0)		154	1
JDS91	RO, MD	/Prut (rkm 1.0)		135	1
JDS92	RO, UA	Reni	9	130	1
JDS93	RO, UA	Vilkova - Chilia arm/Kilia arm	10	18	1
JDS94	UA	/Bystroe canal (to be confirmed)	10	8	1
JDS95	RO	Sulina - Sulina arm	10	0	1
JDS96	RO	Sf.Gheorghe - Sf.Gheorghe arm	10	0	1
		Proposal for ecological quality class	Assessment class		
		High Class	1		
		Good Class	2		
		Non-complying with good class	>2		

According to Table 7 it can be concluded that five sampling sites located on the Danube River itself do not comply with “good” ecological class: river km 1761 (*Iza/Szony*), river km 1586 (*Rackeve/Soroskar Danube arm-end*), river km 1200 (*downstream Tisa*), river km 1071 (*Banatska Palanka/Bazias*) and river km 926 (*Vrbica/Simijan*). Two tributaries (*Hron* and *Ipoly*) are in “good” class and four of them (*Tisa*, *Velika Morava*, *Timok* and *Arges*) do not comply with the “good” class criteria.

- *based on the <u>Czech proposal</u>:*
    a. *Danube River:*
        i. *all sampling sites comply with the EQS set for temperature;*
        ii. *for dissolved oxygen, only ten sampling sites comply with the EQS, the rest of the JDS2 sampling sites had oxygen content below the EQS level;*
        iii. *four sampling sites are above the EQSs set for pH: river km 2008 (*Oberloiben*), river km 1481 (*Baja*), river km 1384 (*Upstream Drava*) and river km 1300 (*Ilok/Backa Palanka*).*
    b. *Tributaries:*
        i. *two tributaries had water temperature above the EQS for this parameter (*Hron *and* Ipoly*);*
        ii. *for dissolved oxygen, half of the selected tributaries do not meet the EQS for this parameter (*Vah, Sió, Drava, Tisa, Sava, Velika Morava, Jantra, Russenski Lom *and* Arges*);*
        iii. *three of them present pH values higher than the EQS set for this element (*Morava, Hron *and* Ipoly*).*

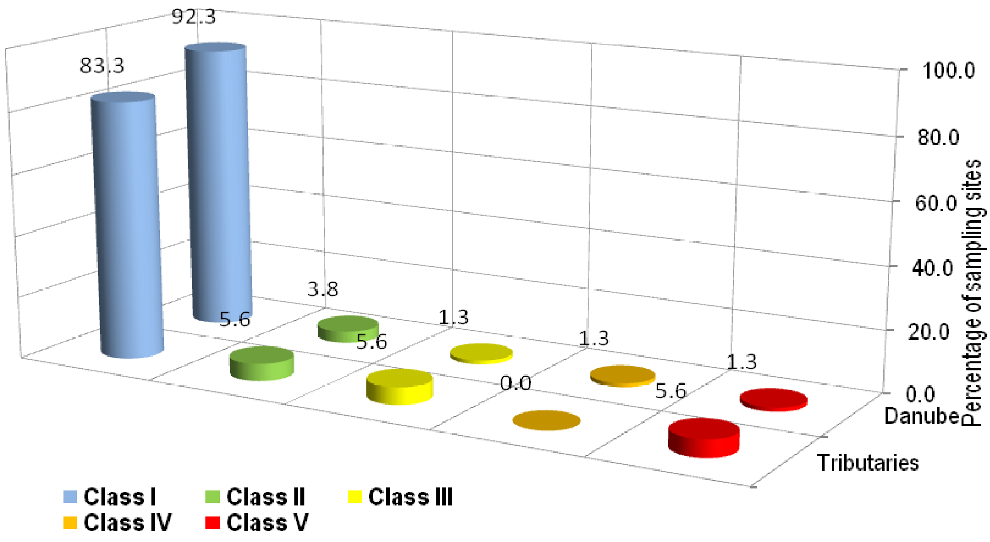
When compared the information given by the application of the two WFD compliant classification schemes, it can be noticed that the results obtained for temperature and pH are relatively similar, but they significantly differ as regards the dissolved oxygen: while five sampling sites on the Danube and four at the mouth of tributaries respectively do not comply with the Austrian criterion for "good" class, sixty-eight sites on the Danube and half of the tributaries at the confluence do not comply with the Czech "good" class criterion. Hence, a jointly agreed system of WFD compliant criteria at the Danube Basin level needs to be developed in the near future.

3.6.2 Water Quality Assessment according to the TNMN Five Quality Classes (non-WFD compliant)

In the TNMN Water Quality Scheme, five classes are used for assessment with target value being the limit value of Class II. From the category of physico-chemical quality elements, class limits are set for dissolved oxygen concentration only. Therefore, for this parameter, distribution (in percentages) of sampling sites into the five quality classes for the Danube River and selected tributaries is shown in Figure 16. Based on this distribution, the following could be noticed:

- *most of the sampling sites located on the Danube River were found with dissolved oxygen concentrations characteristic to Class I (72 sites out of 78);*
- *from the rest of the sampling sites on the Danube, three of them (river km 1642 -* /Rackeve-Soroksar Danube Arm – start, *river km 1071 -* Banatska Palanka/Bazias *and river km 926 -* Vrbica/Simijan*) comply with the target value (Class II) and one site is placed in each of the quality Classes III (river km 1761 -* Iza/Szony*), IV (river km 1586 - /*Rackeve-Soroksar Danube Arm – end*) and V (river km 1200 -* Downstream Tisa/Upstream Sava*);*
- *relatively similar situation is valid for mouth of the tributaries, for which 15 out of 18 are in Class I and one tributary (*Tisa*) complies with the target value. Two tributaries at the confluence had oxygen concentrations "falling" in the Class III (*Velika Morava*) and V respectively (*Arges*).*

Figure 16: Percentages of sampling sites into five water quality classes for dissolved oxygen concentrations according to TNMN classification scheme:



4 Conclusions

- Water temperature distribution during JDS2 ranged within the specific pattern for the given timing of the survey (August – September), both for the Danube and mouth of the selected tributaries. A maximum profile was recorded in the middle reach of the Danube River, a favourable factor for the primary production process in this stretch.
- Conductivity values followed a quasi-constant profile. In the upper Danube stretch, the low salt content of the *Inn* tributary influenced the downstream reach due to the comparability in flow values. As regards the rest of the selected tributaries at the confluence, even if some of them had relatively higher conductivity values, no significant influence on the downstream stretch was present, except of the *Olt* tributary, which slightly increased the conductivity measured at the downstream sampling site.
- The general pH variation profile along the Danube River can be well linked with the biochemical processes in the water, the primary production and respiration along with bacterial decomposition of algal detritus. Given the JDS2 usual sampling time (during daylight) primary production exceeded organic decomposition leading to increasing pH values and dissolved oxygen content, mainly visible in the middle reach of the Danube, characterized by slow flowing and relatively shallow reaches. A significant decreasing profile was visible in the *Iron Gates* area. A good correlation between pH and oxygen saturation was found in the case of mouth of three tributaries (*Morava, Hron* and *Ipoly*), reflecting primary production process.

- Alkalinity values in the Danube River and mouth of the tributaries generally ranged within the normal scope for natural buffer capacity waters. A slight decreasing profile from upper to middle and lower reaches was observed.
- Dissolved oxygen pattern along the Danube River was relatively similar with the pH one, with two higher profiles in the upper and middle reaches respectively, in good correlation with primary production occurrence. Most of the sampling sites had oxygen saturation over 80%. Only three sampling sites on the Danube course and side arm respectively had rather low oxygen content (saturation less than 70% at river km 1761-*Iza/Szony*, 1586-*Rackeve-Soroksar Danube Arm* – end and 1200-*Downstream Tisa*). Tributaries at the confluence had dissolved oxygen slightly higher than the Danube itself, with over-saturation values occurring in 10 out of 18 selected tributaries. As regards the minimum oxygen content, the most critical situation appeared at the mouth of the *Arges* tributary, due to the discharge of totally untreated municipal wastewater.
- The longitudinal surveys on major tributaries generally showed increasing profiles from upper sites down to the confluence with the Danube River in the case of alkalinity and conductivity. The specific bio-chemical activity for the timing of the survey (end of summer) was emphasized by the good correlation between dissolved oxygen saturation and pH values.
- When compared with JDS1 results from 2001, the following issues are to be mentioned:
    - the profiles of the two surveys were relatively similar for the Danube River in the case of temperature, conductivity and alkalinity, except for a few local differences;
    - the pH values were similar, except for the river stretch located in the middle Danube, between rkm 1692 *(/upstream end of Szentendre Island - arm)* and rkm 1424 (*Batina*), where pH values found in JDS1 were higher than the ones measured during JDS2; the same trend of variation appeared in the case of selected tributaries;
    - the dissolved oxygen saturations measured during JDS2 were generally slightly lower in the upper reach of the Danube River and significantly lower in the middle reach (primary production was more pronounced in this reach during JDS1). In the lower Danube, JDS2 values were generally higher than the ones from JDS1. Most of the tributaries had higher dissolved oxygen contents in JDS2.
- The water quality assessment for the JDS2 results was being carried out based on three different approaches: the Austrian and the Czech proposals (which are WFD compliant) and the Trans National Monitoring Network of ICPDR (TNMN) classification system (used for TNMN purposes only). It is noteworthy that the information resulting from the application of the Austrian and TNMN assessment schemes is very much similar, but they significantly differ from the Czech system in the case of dissolved oxygen parameter. Therefore, a jointly agreed system of WFD compliant criteria at the Danube Basin level needs to be developed in the near future.

5 Bibliography

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