



# WATER QUALITY INDEX - WQI, AS TOOL OF WATER QUALITY ASSESSMENT

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## **Abstract**

*Water body of Skadar Lake has transboundary status, which complicate the functional and effective integrated management of its ecosystem. Protection system of Skadar Lake ecosystem is diferent in Montenegro and Albania. There is a need to establish a uniqe transboundary system of water quality control, as condition and assumption for protection of whole Lake ecosystem.*

*Permanent and systematic water quality control on Montenegrin part of Skadar Lake has been carried out on 9 measuring sites: Kamenik, Vranjina, Virpazar, Plavnica, Podhum, the Middle of Lake, Starcevo, Moracnik and Ckla, by Hydrometeorological Institute. Selected sites cover litoral zones with evidenced influence of tributaries (Moraca and Crnojevica river) and other land based sources (settlements, ground waters), as well as pelagial zones with main water mass of Lake, where there is not direct influence of land sources.*

*Assessment of water quality accoding national legislative is done for all of considering water bodies. Requested class of quality for them is A2 (of four classes: A, A1, A2, A3).*

*Lakes` water body is characteristic flow system: Directions of main water flow are Nord-West to South-East, and Nord to South.*

*On Montenegrin side, the main antropogenic impact to lakes` water quality is relieese of municipal waste waters from big settlements Podgorica, Niksic and Cetinje, by the tributaries. Untreated municipal waste waters emission is also the problem of concern at the Albanian side (Skadar town area), as well as impact from agriculture influence.*

*So, the very big quantity that inflows in lakes` water, has big influence on decrease of ecological status of water.*

*Developed Water Quality Index method permit assessment of just this view of water pollution as suitable methodology.*

*Keywords: Water quality, WQI index, Skadar Lake, Moraca river, Bojana river*

## **Introduction**

Water body of Skadar Lake has transboundary status, which complicate the functional and effective integrated management of its ecosystem. Protection system of Skadar Lake ecosystem is diferent in Montenegro and Albania. There is a need to establish a uniqe transboundary system of water quality control, as condition and assumption for protection of whole Lake ecosystem.

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## Scope and used Methodology

The available data [2] from period 2005-2009 are processed for analysis of water quality by WQI method. WQI analysis for tributary Moraca at Vukovci profile, and outflow Bojana at Fraskanjel, also is done.

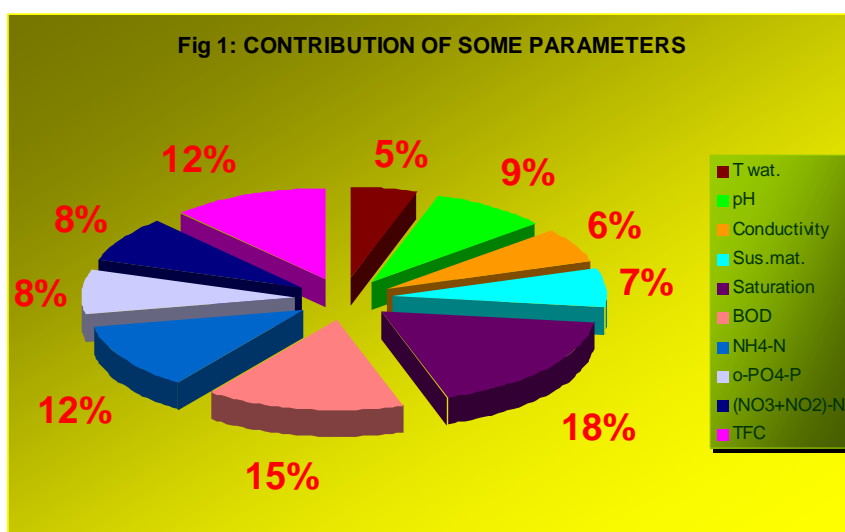
It is selected 10 parameters representing ecological status of water, by WQI: Water temperature, suspended matters, pH, conductivity, oxygen saturation, BOD<sub>5</sub>, Ammonia-nitrogen content (N-NH<sub>4</sub>), oxide-nitrogen content (NO<sub>2</sub>+NO<sub>3</sub>), ortho-phosphorus and total number of faecal bacteria. The weights ( $w_i$ ) are associated to each of these parameters, according assessed particular importance to water pollution (Fig 1). Final index WQI is given as product of  $w_i$  and measured concentration ( $q_i$ ) of each parameters. Total sum of indexes are 100, for the ideal case [1].

Water quality is assessed by descriptive indicators, presented in Table 1 [3].

**Table 1.:** Descriptive indicator of water quality

WQI Value	90-100	84-89	72-83	39-71	0-38
Water Quality Class	Excellent	Very good	Good	Poor	Very poor

Mediana, 5- and 95 percentil of average values of WQI are counted for each stations, and each years. Statistical analysis (based on standard deviation and variation coefficient) in order to assess consistency of processed data set has also been done, as well as calculation of correlation between selected sites. These calculations have been done by Excel software.



Assessment of water quality by WQI and national legislative are compared.

## Results and Discussion

Calculated WQI indexes for all of measuring sites, and each years, are given in Table 2.

As it can be seen, main indexes are of water quality class of "Very good". On the some sites, water quality index temporary goes in class "Excellent". Index was in class "Good" only in one case, at profile Podhum, in 2008.

Calculated indicators of water quality, as Mediana, 5<sup>th</sup> percentil and 95<sup>th</sup> percentil, are given in Table 3. Here, 5<sup>th</sup> percentil represent increase of water pollution and 95<sup>th</sup> percentil represent decrease of water pollution. A small difference between values of corresponding parameters for measuring sites at pelagial, indicates a similar hydrochemical characteristics of this water body.

**Table 2:** WQI values

	Mora ca	Bojana	Skadar Lake								
	Vukovci	Fraskanjel	Kamenik	Vranjina	Virpazar	Plavnica	Podhum	Middle	Starcevo	Moračnik	Ckla
2005	88	88	86	92	87	88	89	92	87	90	90
2006	92	86	85	90	86	86	88	91	89	89	89
2007	88	88	88	87	89	86	95	91	87	90	92
2008	94	90	91	91	89	92	83	93	94	93	92
2009	91	86	92	94	90	92	93	91	93	92	93

**Table 3:** Statistical parameters of WQI

	Mora ca	Bojana	Skadar Lake								
	Vukovci	Fraskanjel	Kamenik	Vranjina	Virpazar	Plavnica	Podhum	Middle	Starcevo	Moračnik	Ckla
Median	91	88	88	91	89	88	89	91	89	90	92
5-perc	88	86	85,2	87,6	86,2	86	84	91	87	89,2	89,2
95-perc	93,6	89,6	91,8	93,6	89,8	92	94,6	92,8	93,8	92,8	92,8

Consistency of obtained data series for all parameters is tested by Standard deviation (SD) and Coefficient of variation (CV, as %). Results are given in Tables 4 and 5.

Deviation of data is the smallest for water temperature, pH, conductivity and oxygen saturation. The biggest deviation is evidenced for suspended matter, ammonia, faecal coliforms, what indicates discretion data, as consequence of discontinual release and transference of these parameters in water.

**Table 4:** Standard deviation of water quality data

	T wat.	pH	Conductivity	Sus.mat.	Saturation	BOD	NH <sub>4</sub> -N	PO <sub>4</sub> -P	Ox-N	TFC
Vukovci	4	0,22	19	1	19	0,92	0,09	0,05	0,17	1224
Fraskanjel	3	0,19	22	2	11	2,51	0,19	0,04	0,40	2469
Kamenik	5	0,20	15	1	12	1,02	0,21	0,03	0,16	114
Vranjina	5	0,22	21	0	12	0,97	0,24	0,01	0,20	175
Virpazar	5	0,19	27	2	22	0,87	0,22	0,03	0,16	175
Plavnica	5	0,23	40	0	18	0,82	0,32	0,03	0,18	251
Podhum	5	0,16	24	2	26	0,71	1,25	0,01	0,19	266
Sredina	4	0,19	23	0	8	0,51	0,10	0,01	0,12	17
Starčevo	5	0,17	21	0	8	0,79	0,25	0,01	0,12	149
Moračnik	4	0,17	19	2	10	0,51	0,22	0,02	0,14	49
Ckla	4	0,16	20	0	11	0,63	0,18	0,02	0,13	95

Coefficient of data variation is the smallest for conductivity, pH, saturation and temperature, and the biggest for TFC, suspended matters, ammonia, phosphates, like mentioned standard deviations' values, because of mentioned previously reasons.

Correlation between some selected measuring sites is given in Table 6. Very high correlation evidenced for water temperature, between pelagial sites, even over 0,9. Relatively low correlation between Ckla (Lake) and Fraskanjel (Bojana), indicate a big influence of river Drim, tributary of Bojana. Similar situation is about pH and Conductivity, except for pairs Vranjina-Starcevo and especially Ckla-Fraskanjel, where has been found a negative correlation. In that second case is confirmed the already mentioned these of influence of river Drim on Bojana. Very high correlation of Suspended matter for this pair shows that this parameter comes from Lakes' water. Oxidated degradation of organic matters in tributaries is different than in Lake, but organic matters in Bojana

origin mainly from Lake. At nord-west part of Lake ammonia from nitrogen is dominant, but at south-east part and Bojana, dominant is oxygenated form of nitrogen. Faecal bacteria has local characteristics, because correlation is relatively low. Analysis shown that this matter does not comes from Podhum.

**Table 5:** Variation coefficient (in %) for water quality data

	T wat.	pH	Conductivity	Sus.mat.	Saturation	BOD	NH4- N	PO4- P	Ox- N	TFC
Vukovci	22	2	7	162	16	41	97	113	42	104
Fraskanjel	16	2	7	160	10	66	98	102	70	96
Kamenik	23	3	7	100	12	51	229	63	215	1063
Vranjina	25	3	5	100	9	56	92	216	53	156
Virpazar	21	2	9	208	18	41	130	85	90	117
Plavnica	19	3	16	200	16	60	119	92	78	93
Podhum	25	2	10	183	17	39	122	130	67	101
Sredina	12	2	7	-	8	59	98	104	145	140
Starčevo	20	2	7	128	8	68	132	94	123	132
Moračnik	17	2	6	200	8	57	137	107	125	121
Ckla	17	2	6	200	10	56	126	109	150	152

**Table 6:** Correlation coefficient of used WQ parameters between selected profiles

Correlation pairs	T wat.	pH	Conductivity	Sus.mat.	Satura tion	BOD	NH4- N	PO4- P	Ox-N	TFC
VUKOVCI- VRANJINA	0,69	0,41	0,55	-0,15	0,05	0,05	0,45	0,08	0,23	0,13
SREDINA- CKLA	0,98	0,87	0,88	-	0,29	0,26	0,59	0,56	0,93	0,39
MORAČNIK- CKLA	0,99	0,94	0,96	0,18	0,45	-0,08	0,79	0,58	0,78	0,61
SREDINA- MORAČNIK	0,98	0,81	0,86	-	0,41	0,03	0,68	0,21	0,70	0,76
PODHUM- SREDINA	0,97	0,80	0,56	-	0,59	0,23	0,51	0,10	0,69	-0,11
VRANJINA- STARČEVO	0,78	0,48	-0,07	-0,07	0,34	0,04	0,91	0,27	0,20	0,12
CKLA - FRASKANJEL	0,27	0,63	-0,20	0,83	0,38	0,48	0,95	0,42	0,73	0,02

**Table 7:** Comparison between WQI and national categorisation

National Categorisation	National categorisation as WQI values	Descriptive class
A	91-92	Exellent
A1	78-83	Good
A2	67-70	Poor

**Table 8:** Water quality by national indexes, accounting of WQI methodology

	Moraca	Boja na	Skadar Lake								
	Vuko vci	Frask anjel	Kame nik	Vranji na	Virpa zar	Plavn ic	Pod hum	Midd le	Starce vo	Mora cnik	Ckla
2005	A	A	A	A	A	A	A	A	A	A	A
2006	A	A	A	A	A	A	A	A	A	A	A
2007	A	A	A	A	A	A	A	A	A	A	A
2008	A	A	A	A	A	A	A1	A	A	A	A
2009	A	A	A	A	A	A	A	A	A	A	A

Water bodies at all measuring sites are categorised in A2 class, by national legislative. The legislative foreseen four class of water quality: A, A1, A2 and A3. These classes expressed as coresponded WQI



values, in Table 7. As it can be seen, requested class A2 corresponds to "Poor" class in WQI classification. Counted in that way, national classification is given in Table 8. All measuring sites have had water quality class "A", ie. "Excellent", except site Podhum in 2008., where was "A1", ie. "Good". Measuring results shown much more better quality of water than requested level.

## Conclusion

Skadar Lake's Water quality is assessed by different methodologies, the Water Quality Index, then official methodology from national legislative. These different methods can light the water quality from different angles, in the aim of ensuring the better and more objective picture of quality state of water. The analysis carried out on water quality parameters for Skadar Lake (all 9 stations), tributary Moraca (mouth station Vukovci) and outflow Bojana (station Fraskanjel), in the period 2005-2009.

WQI method has shown that water quality was mainly "very good", sometimes it was "excellent", and only one time was "good" at Podhum profile, in 2008.

Comparison between WQI and official national method has shown that all profiles were in "A" class, except Podhum in 2008, which was in class "A1". This is much better water quality class, then requested class, and also from the class determined by official method. This means that official categorisation is more strict than WQI.

Used statistical analysis has shown the most variation of data for ammonia, phosphates and faecal coliforms, as consequence of the way of effluent emission, as well as destiny of these parameters in water. The lowest variation of data is determined for water temperature, pH, Conductivity and saturation of oxygen.

Correlation analysis has shown very high correlation for water temperature, pH, Conductivity. Other parameters had a local characteristics, especially SM, BOD, phosphates and TFC. Influence of Drim to Bojana water quality was significant.

## References

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