

MACROPHYTES AS INDICATORS OF ECOLOGICAL STATE OF SURFACE WATER

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Abstract: This work represents an advantage of using macrophytes as indicators for ecological state class prediction based on orthophosphate anions concentrations instead of calculating water quality index, Serbian Water Quality Index (SWQI) concretely. Calculating of SWQI requires standard laboratory methods of water sampling that include sampling chemical parameters such as pH, temperature, orthophosphate anions, ammonium ions, total organic nitrogen concentrations, temperature, conductivity, values of biological oxygen demand, oxygen saturation in percents and amount of suspended solids. Macrophytes, as an official biological parameters for prediction of ecological state of rivers, are recognized as good predictors of ecological state classes based on concentrations of orthophosphate anions. *Phragmites australis L.* is an indicator species for river sections that belong to IV class of ecological state based on orthophosphate anions concentrations. For all river sections where presence of this macrophyte was detected during Joint Danube Survey 3 (JDS 3) scientific research expedition was calculated Serbian Water Quality Index (SWQI). Values of SWQI predicted good ecological state even for sampling points where among concentrations of orthophosphate anions river section belong to IV class of ecological state. This fact lead us to conclude that *in situ* prediction of ecological state of river according to orthophosphate anions concentrations is more specifically by presence of macrophyte *Phragmites australis L.* then by calculating quality index that requires expensive chemical analysis.

Key words: macrophytes, orthophosphates, SWQI

INTRODUCTION

Assessing and prediction quality of surface water is an extremely complex task for which there is no established general algorithm. Developing a low cost model for ecological assessment of large rivers is a challenging task. According to Water Frame Directive 2000/60/EC (WFD) parameters for ecological state prediction are divided into biological, chemical, physico – chemical and hydromorphological groups of parameters [1]. Macrophyte presence belong to biological group of parameters for ecological state prediction, and orthophosphate anions concentration values are official chemical indicators of ecological state [2]. Serbian Environmental Protection Agency (SEPA) developed Serbian Water Quality Index (SWQI) for predicting surface water quality according to selected chemical parameters. Calculation of SWQI is based on pH values, temperature, conductivity, amount of suspended solids and concentrations of ammonium, orthophosphate anions, total organic nitrogen and oxygen saturation values. Each of selected parameters used for calculating of SWQI value has it's own weight (wi) and quality index (qi). Online calculator of SWQI is available on official site of Serbian Environmental Protection Agency (SEPA) [3].

Danube River basin, as the second longest river in Europe that flow through 19 countries makes Danube the world's most international river [4]. For purpose of Joint Danube Survey 3 (JDS 3) scientific expedition organized by *International Commission for the Protection of the Danube River* (ICPDR) Danube River basin was divided on 68 sampling sites for sampling all official parameters for ecological state prediction proposed by Water Frame Directive 2000/60/EC (WFD) [2,4]. Both, left and right river sides, were included in this investigation. The total number of sampling sites was 123, because some of sampling sites were inaccessible. In paper Krtolica et al. (2021) is described developed model of Feed Forward Neural Networks (FFNN), based on dataset collected during this scientific research activity, where macrophyte presence determined by Kohler's five grade scale among Danube River basin were used as input variables, and classes of ecological state based on

orthophosphate anions concentrations were outputs [5]. In that modelling is confirmed significant impact of *Phragmites australis L.* as indicator species for river sections that against to orthophosphate anions concentration belong to IV class of ecological state. According to concentration of orthophosphate anions 96 from 123 JDS sampling sites belong to IV class of ecological state (0.1 – 0.19 mg/L) (Table 1). Macrophyte species *Phragmites australis L.* was detected on all of these sampling points [6]. Macrophytes are large enough plants suitable to the naked eye determination, so they are “easy-to-detect” parameters for ecological state prediction. In accordance with that fact prediction of ecological state based on orthophosphate anions, using *Phragmites australis L.* presence as indicator, is advantageable method in field of ecology and environmental engineering.

For purpose of this paper for all JDS sampling points where *Phragmites australis L.* was detected on river sections that according to orthophosphate anions concentrations belong to IV class of ecological state was calculated value of Serbian Water Quality Index (SWQI)[3]. For calculation of SWQI values of oxygen saturation and biological oxygen demand were excluded. Values of SWQI predicted good ecological state even for sampling points where river section according to orthophosphate anions concentration belong to IV class of ecological state. In keeping with that fact prognosing of ecological state of river section based on orthophosphate anions concentrations is more specifically by presence of macrophyte *Phragmites australis L.* as compared with prediction based on SWQI index.

MATERIAL AND METHODS

Study area

Danube is 2850 km long river, so after the Volga, is the second longest river in Europe and the longest river in European Union. Danube flows through much of Central and Southeastern Europe, from it's source in Germany to river mouth in Romania. Danube basin size is 801.463 km². Sampling points among Danube river determined in the frame with Joint Danube Survey 3 expedition, where macrophytes and chemical parameters were sampled, are presented in Fig.1.



Figure 1. Macrophytes and orthophosphate anions concentration sampling points along Danube River basin

https://www.researchgate.net/figure/Overview-of-the-Joint-Danube-Survey-3-JDS3-sampling-points-along-the-river-Danube-The_fig1_277348358

Aquatic macrophytes

Macrophytes are official biological parameters for ecological state prediction proposed by Water Frame Directive (WFD).

Aquatic macrophytes are aquatic photosynthetic organisms, large enough to see with the naked eye, that actively grow permanently or periodically submerged below, floating on, or growing up through the water surface [7].

Submersed macrophytes has significant role in nitrogen and phosphorus cycling processes, which both depends on dissolved oxygen concentrations in water [8].

Macrophyte type *Phragmites sp.* is one of the most widely distributed wetland plant genera worldwide. *Phragmites australis L.* is an emergent macrophyte species, sensitive to the increase of nutrients concentrations in water. *Phragmites australis L.* is a good indicator of eutrophication in water ecosystems and shows increase of biomass in eutrophic habitats [9].

Orthophosphates in surface water

In river ecosystems phosphorus is a key limiting factor for controlling primary production and also stimulate processes of eutrophication [10]. Orthophosphate anions concentration values in water above 0.8 mg/L extensively accelerate process of eutrophication [6]. Orthophosphoric acid, as triprotic acid, by electrolytic dissociation in aquatic environment gives 3 types of orthophosphate anions (PO_4^{3-} , HPO_4^{2-} and H_2PO_4^-). Orthophosphate anions in water occur due to intensive urbanization and agricultural production, so as due to discharging of sanitary installations. In Serbian part of Danube River basin amounts of phosphorus emission that originate from agricultural activities is above 75 kg/km² per year, and that is the highest amount of phosphorus emission along all Danube River basin [11]. Eutrophication caused by high amounts of orthophosphate anions has negative impact on dissolved oxygen concentration level in surface water [10,11].

Dataset

Presence of macrophyte species *Phragmites australis L.*, and values of orthophosphates anions concentrations among Danube River basin were gathered from dataset collected during Joint Danube Survey 3 scientific expedition [4]. For all sampling points among Danube River basin dataset included values of selected parameters for both sides of river. For river classification based on orthophosphate anion concentrations was used scheme that include 7 classes of ecological state [5,6].

Table 1. Classification of Danube river sections according to orthophosphate anions concentrations [PO_4^{3-}]

| Ecological state class | [PO_4^{3-}] |
|------------------------|------------------------|
| I | 0 – 0.019 |
| II | 0.02 – 0.039 |
| III | 0.04 – 0.09 |
| IV | 0.1 – 0.019 |
| V | 0.2 – 0.49 |
| VI | 0.5 – 0.8 |
| VII | > 0.8 |

Serbian Water Quality Index (SWQI)

Serbian Water Quality Index is a descriptive indicator based on the Water Quality Index methodology which uses ten chosen quality parameters (Oxygen Saturation, Biological Oxygen Demand (BOD5), Ammonium ion concentration, pH, Total Oxidized Nitrogen and Orthophosphate anions concentrations, Suspended solids, Temperature, Conductivity and *E.Coli* /MPN) as an input in form of ten values (qi) representing surface water quality that are summarized as one index on a 0-100 scale. Each parameter doesn't have the same influence on the final, indexed overall water quality, thus each parameter has an appropriate weight (wi) where the sum of all weights equals to 1. SWQI score in the range of 72-78 corresponds to good ecological state (II class) [12].

RESULTS AND DISCUSSION

Analysing dataset collected in Joint Danube Survey 3 scientific expedition across all Danube River basin where according to orthophosphate anions concentration river section belong to IV class of ecological state, and *Phragmites australis L.* was occurred in all sampling points. In JDS 3 dataset in all of selected sampling points beside orthophosphate anions concentration were measured values of pH, total organic nitrogen, suspended solids, temperature and conductivity. All of those parameters were used for calculating Serbian Water Quality Index (SWQI). Values of SWQI determined good ecological state even for sampling points where among concentration of orthophosphate anions river section belongs to IV class of ecological state. According to that fact prediction of ecological state of rivers based on orthophosphate anions concentration is more precisely using presence of macrophytes, and that is also low – cost and eco - friendly method for ecological class prediction.

Table 2. List of SWQI scores for Joint Danube Survey (JDS) sampling points with *Phragmites australis L.* presence where orthophosphate anions concentrations indicate IV class of ecological state

| JDS sampling point with <i>Phragmites australis L.</i> | Orthophosphate anion concentration (mg/L) | SWQI value |
|--|---|------------|
| JDS 1 (L) | 0.11 | 75 |
| JDS 1 (R) | 0.11 | 75 |
| JDS 2 (R) | 0.12 | 75 |
| JDS 7 (R) | 0.11 | 75 |
| JDS 13 (L) | 0.12 | 73 |
| JDS 13 (R) | 0.12 | 73 |
| JDS 15 (L) | 0.1 | 76 |
| JDS 15 (R) | 0.1 | 76 |
| JDS 17 (L) | 0.14 | 73 |
| JDS 18 (L) | 0.17 | 73 |
| JDS 18 (R) | 0.17 | 73 |
| JDS 19 (R) | 0.1 | 75 |
| JDS 20 (R) | 0.13 | 76 |
| JDS 25 (L) | 0.17 | 73 |
| JDS 25 (R) | 0.17 | 73 |
| JDS 42 (L) | 0.14 | 75 |
| JDS 43 (L) | 0.18 | 75 |
| JDS 45 (L) | 0.14 | 76 |
| JDS 46 (L) | 0.13 | 78 |
| JDS 46 (D) | 0.13 | 78 |
| JDS 52 (L) | 0.17 | 76 |
| JDS 66 (L) | 0.15 | 73 |
| JDS 66 (D) | 0.15 | 73 |

* L- left river side

**R – right river side

CONCLUSION

Values of Serbian Water Quality Index (SWQI) based on official chemical parameters for ecological state class prediction proposed by Water Frame Directive (WFD) for all the sampling points where river section site belong to IV class of ecological state according to orthophosphate anions concentration prognoses good ecological state.

According to that fact we can conclude that on SWQI value of orthophosphate anion concentration doesn't have the most significant impact. *In situ* prediction method for ecological state class based on orthophosphate anion concentrations is noticing macrophyte species *Phragmites australis L.* Presence of *Phragmites australis L.* in river basin section indicate that orthophosphate anion concentrations on that river section are in range of 0.1 – 0.19 mg/L or higher. River sections with high levels of orthophosphates indicate purification treatment and control of pollutants sources. Even if value of Serbian Water Quality Index signify good ecological state levels of orthophosphates in water may indicate IV class of ecological state.

Prediction of high levels of orthophosphates in surface waters using presence of macrophytes is low – cost and eco – friendly method that should have more attention by scientific researchers.

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AGRICULTURE AND THE IMPACT OF AN INVISIBLE THREAT

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Abstract: The traditional definition of noise is "unwanted or disturbing sound". Noise becomes unwelcome when it interferes with normal activities (such as sleeping or talking) or disrupts or impairs quality of life. The fact that you can't see, taste or smell it probably explains why it hasn't received the same attention as other types of pollution like air or water pollution. The air around us is constantly filled with noise, but most of us probably wouldn't say we're surrounded by noise. For some, however, the constant and escalating source of noise tends to be annoying. This "annoyance" can have serious consequences, especially for overall health.

Manufacturing agriculture produces high levels of noise. The following study shows a series of measurements on various agricultural machinery in different situations and the data received from the laptop connected to Sound Level Meter and Arduino Nano receiver with sound sensor attached [1].

Key words: noise pollution, cabin sound propagation, sound

INTRODUCTION

In agriculture noise is the most frequent exposure, but up to recent years it was rarely recognized. It affects the hearing organ of farmers [2]. Because of a great variety of machines used on farms and a changing magnitude of exposure to noise, noise has to be studied extensively. The aim of our study was to recognize and evaluate annual exposure to noise among private farmers engaged in plant production.

The middle ear is made up of three tiny bones or ossicles that transmit noise vibration to the inner ear. Noise will not affect the middle ear unless the sound impact or pressure is so great as to cause the bones to dislodge or fracture. The inner ear is highly susceptible to damage from overall exposure to loud noise. It is composed of hair-like structures that transmit noise messages to the brain by changing mechanical energy to electrical energy. With repeated noise exposure, hair cells are destroyed, causing substantial hearing loss [3].

A recent study performed in New Zealand showed that noise in farm activities lay in a range between 84.8 to 86.8 dB(A) and hearing losses were consistent with this level of exposure. Age, driving tractors without cabs, and working with metal were important risk factors. The same study showed that majority of farmers involved in the study have a moderate risk of hearing loss, but a significant minority is at high risk [4].

In an Asian study, performed on 335 Thai farmers, found that a very high prevalence of clinical (> 25 dB HL threshold) hearing loss was observed in this study (50–55%) in the high-frequency band (3–6 kHz) [5].

Therefore, the goal of this study was to determine the level of exposure to noise of the operator of a modern tractor and combine, both used at large scale in Romania.

MATERIAL AND METHODS

Sound pressure analysis was conducted in the cabins of a tractor and a combine with DT-8852 sound meter, in various load scenarios. Sound level meters are frequently used in noise pollution studies to determine almost any type of noise, but especially for the industrial fields, environmental protection and airport noise [3]. The SPL (Sound Pressure Level) measurement application uses the built-in microphone to measure the volume of noise in decibels (dB), displaying a reference.