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INFLUENCE OF DRIVING FORCES ON BIOTIC COMMUNITIES IN LOTIC AQUATIC SYSTEMS (SOUTH-EASTERN OF DANUBE DELTA)

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Abstract

It is known that interactions between drivers of change including hydromorphological modification, nutrient loading, acid deposition and contamination by hazardous substancesand climate change represents sourcesof environmental pressuresfor biotic communities.This studywas done by surveying the ecological status described in EU Water Framework Directive using the biological quality elements: composition and abundance, diversity, sensitive/tolerant species, biomass (phytoplankton, macro invertebrates)inone of the most productivesocio-ecological system. The assessment of biological assemblages was based onlaboratory data, results of field experiments over three-year period (2009-2011) and aspects of hydrophysical, hydrochemical and ecological change, those being early indicators of climate change in aquatic ecosystems. Under reduced flow, combined with increasing temperature, phytoplankton biomass increased; in contrast the flood pulses have caused dilution effects on nutrients, and therefore significantlylower phytoplankton biomass.The floods and changes in flow regimes have also, an impact onthe bed and bank structures, so the benthic macro invertebratesdiversity was reduced, was observed the loss of sensitive taxa and changes in community composition. A strong reduction in nonpoint inputs of pollutants would be necessary to be counterbalance the possible climate-induced effects on biological assemblages.

Keywords: Danube Delta, water quality, biological assemblages, regional changes, disturbed environment

1. INTRODUCTION

Lotic aquatic ecosystems are dynamics systems characterized by great variability which is getting compounded by increasing anthropogenic activity. They have been defined as those systems comprising human communities, socioeconomic interactions, and biophysical processes co-occurring in space and time. The ecological status of rivers globally is influenced by increasing human land-use pressure (Allan, 2004). The effects of land use on the physical (Roth, Allan & Erickson, 1996; Norris et al., 2007), chemical (Herlihy, Stoddard & Johnson, 1998; Harris, 2001) and biological properties (Harding et al., 1999; Van Sickle et al., 2004) of rivers and streams have been well documented. Recently, broad-scale assessments at larger spatial scales have become more common and there has been a strong focus on assessing biotic endpoints to infer the ecological condition of rivers, based on the hypothesis that biological integrity will directly reflect physical and chemical integrity (Clapcott et. al, 2012). Evaluation of the biotic community of a water body provides a sensitive and cost effective means. The Danube Delta is one of the most important wetland systems in Europe. During the last few decades, the driving forces has driven the evolution of the Danube Delta, especially St. Gheorghe branch, to their present conditions. This has resulted in important changes of both water quality and structure of the food chain. It is well known that water is a renewable resource and acceptable quality is important for human health, ecological and economic reasons, but human activity can cause great damage to the natural aquatic systems. Managing the water cycle in a sustainable way is the key to protect natural resources and human health (Fuerhacker,2009).We contend that while the existence of lotic ecosystems is based on the presence of flowing water, community structure, population dynamics and the functional processes are strongly influenced by temporal variations in flow (Biggs, 2005). The aim of this study was to investigate the influence of driving forces on biotic communities and to establish the ecological status of the investigated lotic aquatic ecosystem. To address this goal, we compliedWater Framework Directive requirements.

2. MATERIALS AND METHODS

2.1 Study area

The Danube Delta is the second largest river delta in Europe (5800 km^2) after the Volga. It forms a highly productive transition zone between the Danube River system and the Black Sea. The fluvial delta

(49%) is strongly influenced by river water from the southern Danube branch, Sfântu Gheorghe. In the last century, several channels were dredged and meanders removed with the purpose of improving navigation (Pavel, 2009, Tiron, 2009). Those hydro geomorphological changes consisted mainly in cutting and shortening about 35 km which induced sediment flow alteration transported by the Danube into the Black Sea (Dobre, 2010). The informations about geographical position of the sampling sections are represented in Figure 1.

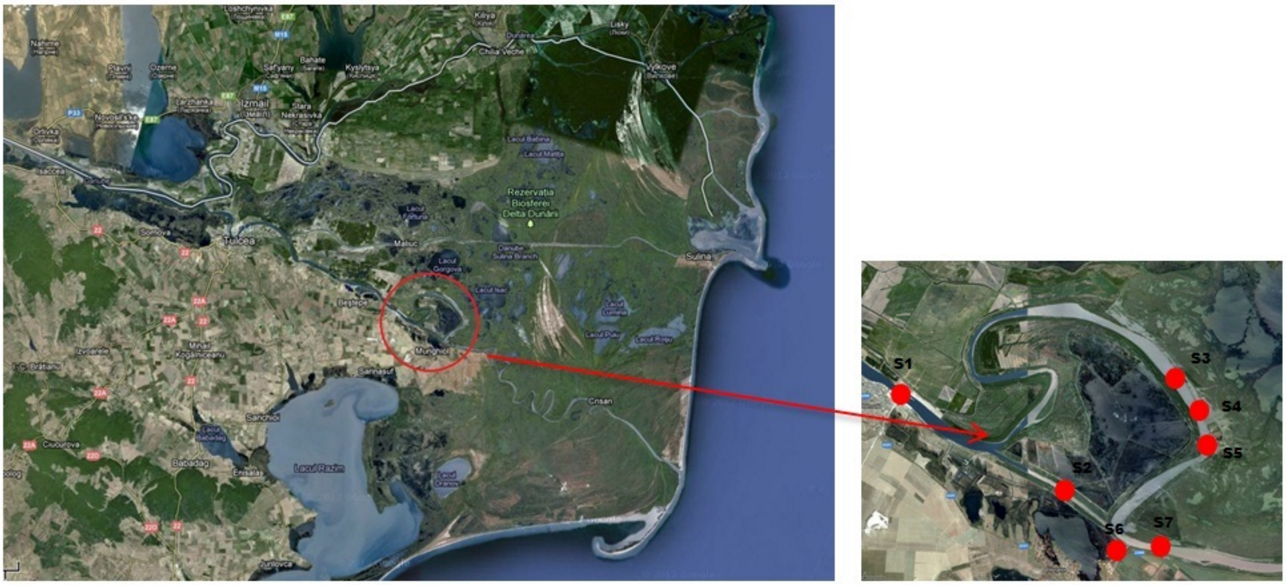

Figure1.Geographic mapof the studied Danube Delta branch with the sampling sections: S1 Mahmudia, S2 Artificial Channel, S3 Upstream Uzlina, S4 Uzlina, S5 Downstream Uzlina, S6 Murighiol, S7 St.Gheorghe Branch

2.2 Sampling and Methodology

Due to the need for a timely implementation of the Water Framework Directive (WFD; EC/2000/60), most European countries have begun the process of revising and adapting their assessment systems, so that quality evaluations are performed according to the new directive. The WFD currently aims at reaching good ecological status for all European water bodies by 2015 andsets out a number of strict recommendations for this to be achieved. In a quite complex overall picture, uncertainty in biological quality evaluations plays a relevant role because it can create an unbalanced allocation of environmental or economic resources (Buffagni et al., 2009).

It is known that interactions between driving forces including hydro morphological modification, nutrient loading, acid deposition and contamination by hazardous substances andclimate change represents sources of environmental pressures for biotic communities.

Degradation of water quality and aquatic ecosystem cannot be explained only on the basis of priority pollutants monitoring. Chemical analysis can identify substances and metabolites, but provide no information on their biological and ecological effects. Although it is difficult to establish always direct causality links between a list of pollutants and a list of biological phenomena (Andersen et al, 2004).

Samples were collected from seven control sections situated along Sfantu Gheorghe branch, where the human activities have left their mark.The main quality elements for the classification of ecological status analyzed in lotic aquatic ecosystems according to WFD are biological parameters (diversity,sensitive/tolerant species,composition and abundance,biomass (phytoplankton, macro invertebrates)) and chemical and physical elements supporting the biological elements: general: thermal conditions, oxygenation conditions, salinity, acidification status, nutrient conditions, specific pollutants, pollution by all priority substances identified as being discharged into the water body, pollution by other substances identified as being discharged in significant quantities into the water body.

The samples for biological analysis were taken with special and adequate sampling equipment and were preserved in 4% formaldehyde solution. The investigations for all sampling campaigns were performed according to standards methods and methodologies.

3. RESULTS AND DISCUSSIONS

The assessment of biological assemblages was based on laboratory data, results of field experiments over three-year period (2009-2011) and aspects of hydro physical, hydro chemical and ecological change. In terms of temporal organization, this program ran with a monthly sampling frequency in accordance with the recommendations of the specific guides and was directly influenced by biotic compartment - phytoplankton, zooplankton and benthic macroinevertebrates. This was set for captured important stages of life cycles and fluctuation fields of the main factors that influencing the control structure and functions of biotic populations (Stoica, in press).Concerning the hydro physical, hydro chemical aspects, during February 2009 – October 2011 in surface water samples were determined 12.159 values in all sampling sites and in sediment were determined 7913 values for physical and chemical indicators. In control section S6 - Murighiol the organic load measured as COD, BODexceededthe limit for quality class II. The main cause of pollution is represented by navigation activities, and the present of a fuel filling station, also confirmed by the presence of petroleum in concentrations approaching to the limit value for quality class II (S6 -Murighiol, S7 - St. Gheorghe branch). In S1 - Mahmudia, S4 - Uzlinacontrol sections located near tourist complexes, but also in S6 – Murighiol and S7 - St. Gheorghe branch where agriculture influences are felt, were recorded overtaking of nutrient concentrations (ammonium, nitrite, nitrate, total nitrogen) and pesticides (DDD / DDT / DDE) predominant in S7control section.

The phytoplankton analysis in all control sections highlighted in terms of numerical abundance and biomass the presence ofoligo-betamezosaprobediatoms species (*Naviculagracilis* (o-β), *Asterionellaformosa* (o-β), *Cymbellaventricosa* (o-β), *Diatomaelongatum* (o-β)), betamesosaprobespecies (*Amphipleurapellucida* (β), *Synedraacus*(β), *Nitzchiasigmoidea* (β) or Chlorophytabetamezosaprobe species (*Pediastrumboryanum* (β), *Scenedesmusacuminatus* (β)). The highest values forphytoplankton numerical density as well as biomass during February 2009- October 2011, were recorded in S6 (Murighiol) and S7 (Sf. Gheorghe branch)(fig.2, fig. 3). Diatoms and Chlorophyta contributed about 90% in total biomass.

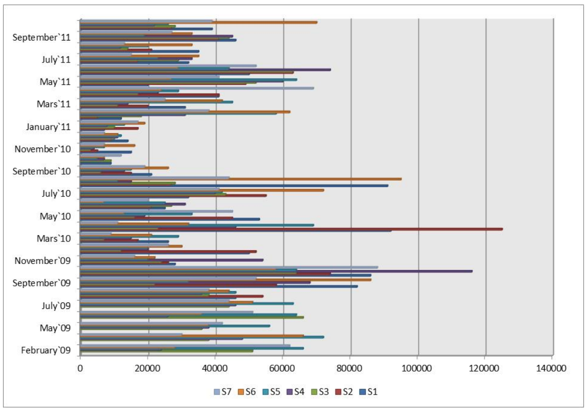

Figure 2.Variation of phytoplankton numerical density during 2009-2011

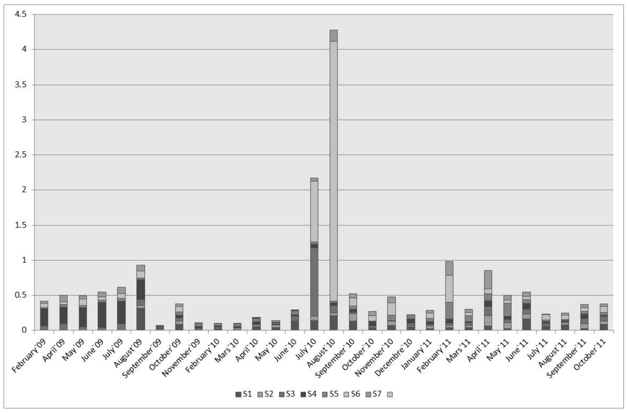

Figure 3.Variation of phytoplankton biomass during 2009-2011

Due to heavy rains in 2010, were recorded concentrations of total phosphorus and total nitrogen above the limit allowed in the aquatic ecosystem, leading to the increase of phytoplanktonnumerical density and phytoplankton biomass production causing immobilization of other nutrients and limiting the amount of light entering in the ecosystem (LPELC, 2009; Cioaca, 2009; Węsławski 2011). Nutrient concentrations showed a strong interdependence between the effects of phytoplankton biomass resultingthe change of dominant processes: primary productivity from breathing. Thus, phytoplankton biomass increased with nutrient concentration in March 2010 - January 2011, resulting in disturbances within the food chain (eg, growth of macro invertebrate grazers). Also, in a low flow conditions, increasing global temperature and radiation, has led to increased phytoplankton biomass and respiration in S2, S5 and S7 in the period February to April 2011.The increase of algal biomass production rate resulted in the immobilization of large amounts of oxygen dissolved in water fororganic matter degradation, accumulation of excess amounts of nutrients, which caused disturbances on the natural flow of nutrients and increasing mortality rates in the consumers.

It is considered that sections S4, S6 and S7 are critical and can potentially affect the ecological status of water body confirmed by the biotic community analysis in this area characterized by reduced dissolved oxygen in water which led to significant reduction of planktonic organisms (phytoplankton, zooplankton).

From previous studies made on the distribution of metals in sediment, there is a clear increase in metals concentrations. At ecosystem level the metal circuit configuration is different depending on their properties and biocenosesstructure. The majority cycling sector channels originate from water tank and represented the metals dissolved fraction. These channels are open mainly by phytoplankton and macrophytes, which multiplies the flow of metal density thousands of times. In sediment, where is located the highestquantity, metals are mobilized by physicochemical processes and biological processes involving benthic fauna.

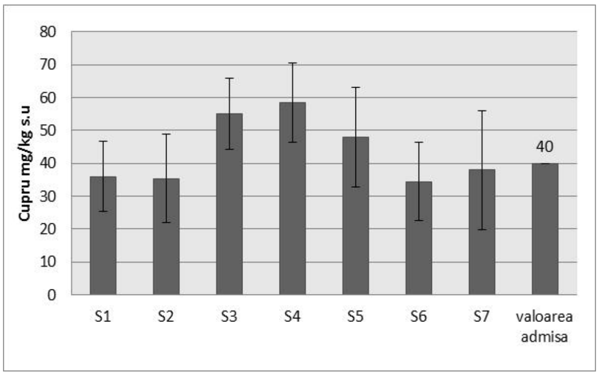

Figure 4. The median variation for Cu depending on the allowed value

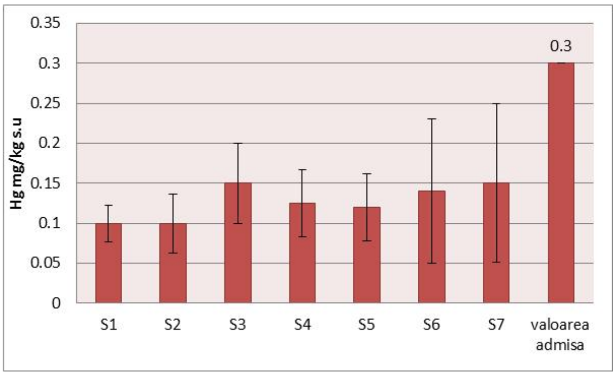

Figure 5. The median variation for Hg depending on the allowed value

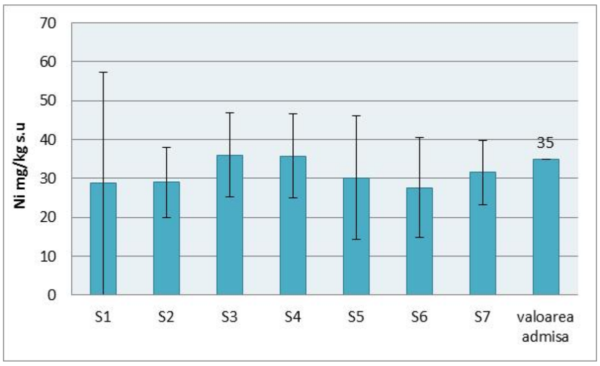

Figure 6. The median variation for Ni depending on the allowed value

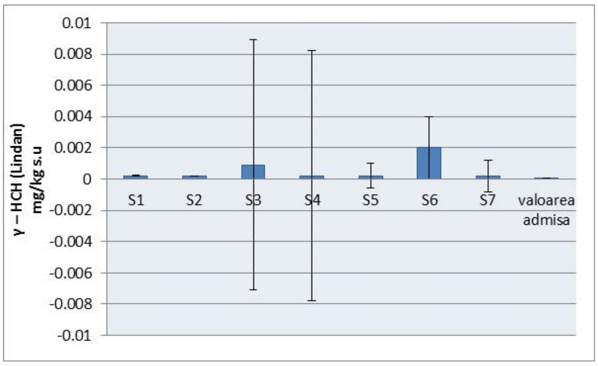

Figure 7.The median variation for lindane depending on the allowed value

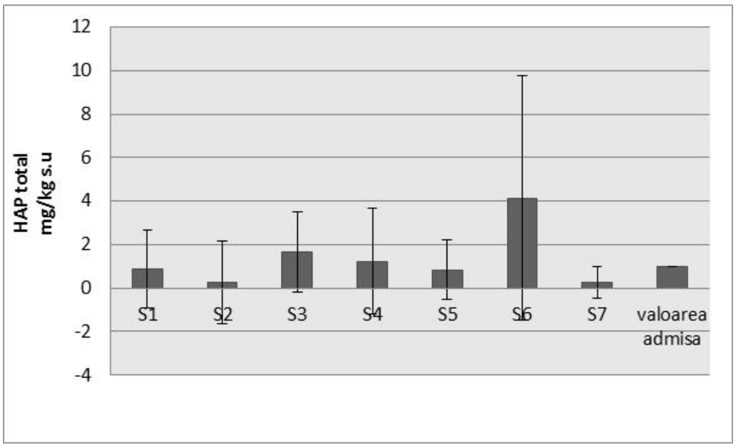

Figure 8. The median variation for HAP depending on the allowed value

Taking into account the WFD requirements and graphs displayed in Figure 4 – Figure 8 wererecordednormal limits overcomefor heavy metals (Cu and Ni) inS3 - Upstream Uzlina and S4 - Uzlinacontrol sections, S5 - AvalUzlina (Cu), the share of these metals in other sections are under limit value for quality standards, but very close to it. Mercury was present in concentrations below the permissible limit. The levels of PAHs were high in S3 - Upstream Uzlina, S4 - Uzlina, S6 - Murighiolsections due to shipping activities.Inall control sections were recorded significant overtaking for γ - HCH (lindane).

Decomposition processes leading to decreased dissolved oxygen, have replaced sensitive species with tolerant, often foreign species (*Corbiculafulminea*).As a result of those driving forces inbiotic community was found the highly tolerant of pollution species (Oligochaeta, Chironomida).

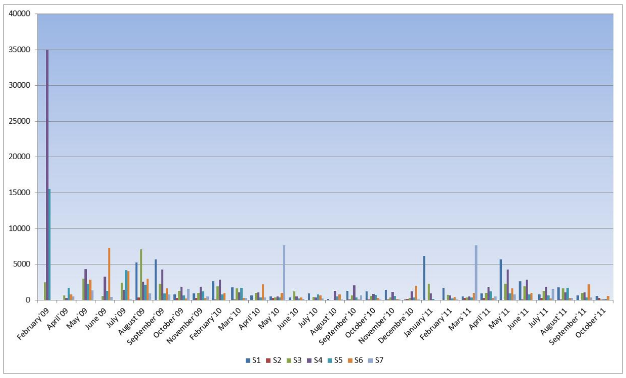

Figure 9.Variation of benthic macro invertebrates numerical density during 2009-2011

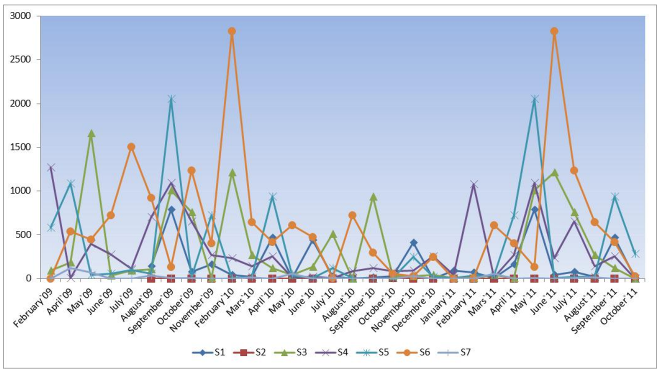

Figure 10.Variation of benhic macro invertebrates biomass during 2009-2011

The highest numerical density value were recorded in January 2011 at S1 (Mahmudia) control section (6200 nr.exp / sqm) and in March 2011 at S7 (Sf. Gheorghe branch) control section (7680 no. exp / sqm). In August 2009, atS2 (Artificial Channel) control section numerical density recorded a lower value (380 nr.exp / sqm), a high percentage starring Oligochaeta (Figure 9).In terms of biomass, molluscs are most important species identified in the south-east of the Danube Delta. Because of their size, Bivalva own more than 80% of the total biomass, followed by gastropods (between 10% and 35%). Oligochaeta, Chironomida and crustaceans although most abundant groups, they have a minor role in total biomass. The majority of β-mezosaprobespecies induceda good ecological state on whole water body.

4. CONCLUSIONS

In lotic aquatic ecosystem was addressed simultaneously two types of monitoring - first physical-chemical analysis, which provides information about environmental factors in a short time and analysis of biological elements, providing information on the ecological state of aquatic ecosystem over a period of time.In the present study, according to WFD ecological assessment of aquatic ecosystems monitored was the integration of both water quality elements.

During February 2009 – October 2011 - 20.072 physical and chemical indicators values in all sampling sites were determined. Due to shipping activities, agriculture production, tourist activities, climate change, the levels of organic load, nutrients, pesticides (DDD / DDT / DDE, γ – HCH), metals in aquatic ecosystems studied were high.Decomposition processes leading to decreased dissolved oxygen, have replaced sensitive species with tolerant, often foreign species. Nevertheless, further studies will be needed to confirm and refine our results. A strong reduction in nonpoint inputs of pollutants would be necessary to be counterbalancing the possible climate-induced effects on biological assemblages.

Future close monitoring will be necessary for insuring compliance with WFD, and for refining standards and understanding of the local situation, but with relevance for the wider international community.

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