TOTAL COLIFORM AND FECAL COLIFORM COMMUNITY DYNAMICS IN NEWLY BUILT WASTWATER TREATMENT LAGOONS

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DINAMIKA ZAJEDNICA UKUPNIH KOLIFORMNIH I FEKALNIH KOLIFORMNIH BAKTERIJA U NOVOIZGRAĐENIM LAGUNAMA ZA PREČIŠĆAVANJE VODE

Apstrakt

Konstruisani vetlandi se koriste za prečišćavanje otpadnih voda zbog svoje efikasnosti, isplativosti izrade sistema i pozitivnog uticaja na životnu sredinu. Fekalne koliformne bakterije predstavljaju indikatore zagađenja voda jer ukazuju na potencijalno prisustvo patogenih mikroorganizama kao i drugih zagađujućih materija, a dospevaju u vodene ekosisteme direktno iz kanalizacionih sistema, ali i difuznih humanih i životinjskih otpadnih materija. Zbog toga je ovo istraživanje usmereno na praćenje dinamike preživljavanja ukupnih koliformnih i fekalnih bakterija u otvorenom površinskom konstruisanom vetlandu sa emerznom vegetacijom. Preživljavanje mikroorganizama, kao i njihova distribucija u vetlandima, zavisi od tipa vetlanda, ali i drugih ekoloških pojava koje utiču na njihov razvoj, gubitke i uništenje. U pogledu prečišćavanja otpadnih voda, vetlandi imaju učinak kao biofilteri, jer se u njima kombinovanjem fizičkih, hemijskih i bioloških procesa vrši uklanjanje kontaminanata. Fekalne koliformne bakterije se vezuju za suspendovane čestice, koje se zadržavaju na biljkama iz vetlanda i po njihovoj žetvi se zajedno sa biljkama uklanjaju iz sistema. U ovoj studiji je ispitivana efikasnost novoizgrađenog vetlanda, koji se nalazi na istraživačkom poligonu "Mali Dunav" u Centru za ribarstvo i primenjenu hidrobiologiju (CEFAH) Poljoprivrednog fakulteta, Univerziteta u Beogradu, fakultetskog dobra "Radmilovac". U tu svrhu je konstruisan

vetland koji se sastoji iz jedne ulazne lagune, namenjene za predtretman vode i još dva bazena, u kojima se prirodno tretira površinska otpadna voda i otpadna voda iz domaćinstava. U ovom radu ispitivane su vrednosti ukupnih i fekalnih koliformnih bakterija, petodnevna biohemijska potrošnja kiseonika (BPK_5), i ukupne suspendovane materije. Istraživanje je započeto u martu 2012.godine i završilo se u februaru 2013.godine. Za praćenje indikatorskih organizama, kao što su ukupne i fekalne koliformne bakterije korišćene su standardne mikrobiološke metode uzorkovanja i tretiranja uzoraka u laboratoriji. Tokom jednogodišnjeg perioda praćenja parametara na mesečnoj bazi, vrednosti BPK_5 su varirale od 15 mg/L do 52 mg/l, a vrednosti TSS od 2.0 mg/L do 89.6 mg/L. Na godišnjem nivou prosečne vrednosti ovih parametara nisu prelazile propisani limit. Mesečno opterećenje sistema sa ukupnim koliformnim bakterijama se kretalo od 5.0×10^2 CFU/ml do 5.19×10^5 CFU/ml, a opterećenje fekalnim koliformnim bakterijama je variralo od 5.0×10^1 CFU/ml do 1.4×10^3 CFU/ml. Prosečna godišnja vrednost opterećenja sistema ukupnim koliformnim bakterijama je iznosila 9.93×10^3 CFU/ml, a fekalnim koliformnim 4.05×10^3 CFU/ml. Na kraju perioda ispitivanja prosečna vrednost ukupnih koliformnih bakterija u efluentu je umanjena za 50%, a prosečna vrednost fekalnih koliformnih bakterija za isti period je redukovana za 97%. Smanjenje brojnosti fekalnih koliformnih bakterija ukazuje da je primena konstruisanih vetlanda opravdana za korišćenje u svrhe obuhvaćene ovim istraživanjem. Radi dodatnog poboljšanja efikasnosti rada vetlanda potrebno je primeniti neke od sledećih mera: povećati raznovrsnost emerzne vegetacije, formirati dodatne ćelije kojima će se poboljšati hidraulički proticaj u vetlandu, da bi se dostigle još niže vrednosti fekalnih koliformnih bakterija u efluentu.

Ključne reči: *konstruisani vetlandi, ukupne koliformne, fekalne kolifomne, BPK_5, TSS*

Key words: constructed wetlands, total coliforms, fecal coliforms, BPK_5, TSS

INTRODUCTION

Low food supply and water scarcity worldwide has brought great attention to water quality and its safe usage in various human activities in last decades. In this sense constructed wetlands have been widely used and recognized as environmentally friendly, very efficient and cost effective means for wastewater treatment. In Serbia, high percentage of rural and suburban households use septic tanks for disposal of domestic wastewater. Septic tanks are considered to be highly effective and environmentally safe, when properly designed and well maintained. Unfortunately, there is a lot of evidence for majority of septic tanks in suburban areas to be either improperly made or malfunctioned - leading to their leakage and consequently to polluting of surrounding soil, waterbodies and ground water.

An extensive literature exists on the design and use of treatment wetlands for different kinds of wastewater and water quality applications (e.g., Reed et al. 1995; Kadlec and Knight 1996, Vymazal. J 1998; Tchobanoglous et al. 2003, Crites et al. 2006; Kadlec and Wallace 2009). Diverse factors such as temperature, ultraviolet radiation, unfavorable chemical conditions, sedimentation that occurs in constructed wetlands makes it a hostile environment for pathogenic organisms (E.Smith et al., 2005). The survival, faith and distribution of microorganisms in wetlands depend on the type of constructed wetland as well as associated phenomena influencing their death, losses and growth.

Constructed wetlands in this sense act like biofilters combining physical, chemical and biological processes (Kadlec and Knight, 1996, Werker et al., 2002) in which fecal coliforms are being removed from water by attaching to suspended solids that are further trapped by wetland vegetation.

In regard to this widespread problem, the aim of this investigation was to study the efficiency of a newly built constructed wetland located at the experimental site „Little Danube" of the CEFAH, Faculty of Agriculture School Estate "Radmilovac", aiming to reduce pollution of a little stream that exists in this small suburban area of Belgrade. The investigation conducted in this research is dealing with dynamics of total coliform and fecal bacteria in free-water surface constructed wetland with emergent vegetation.

MATERIAL AND METHODS

A free-water surface constructed wetland consisted of one pretreatment lagoon and two cells, treating surface runoff and domestic wastewater, were evaluated in this study for total and fecal coliform bacteria presence, BOD_5 values and total suspended solids (TSS). Two of the three cells were planted to cattail (*Typha spp.*).

Monitoring of total and fecal coliforms started in March 2012 and was completed in February 2013, in all wetland cells (i.e.: L_1 – pretreatment lagoon, L_2 – first treatment lagoon, L_{3in} – inlet of second treatment lagoon, L_{3out} – outlet of second treatment lagoon). Samples were collected on a monthly basis at the influent ends of each system's cell and after the filters (60 cm in width), positioned at 1.5 m distance from the inlet pipe, in sterile sample plastic bags, and transported to the microbiological laboratory of Faculty of Agriculture on ice to minimize population changes in the tested water. Samples were prepared by transferring 20 ml of water sample in 180 ml flasks with peptone solution, in sterile conditions and homogenized in rotation mixer set at 250 rpm for 20 minutes. The samples were afterwards diluted serially and analyzed for total and fecal coliforms by pour plate technique. Appropriate sample volumes, in triplicate were poured onto the plates with Brilliance E.coli/coliform Selective Agar (Oxoid CM1046) and incubated for 24h at 37°C to enumerate total coliforms and for 24 h at 44°C for enumeration of fecal coliforms and expressed in $\log_{10}$CFU/ml.

The standard 5-day BOD (BOD_5) test was used to assess reduction of biochemical oxygen demand. Samples were stored at less than 5°C for 24 hours, and after standardized procedure of solution buffering were incubated at 20°C in BOD incubator.

TSS were determined gravimetrically following filtration through glass-fiber membrane filters (APHA, 1992).

RESULTS AND DISCUSSION

The average concentrations of total coliforms entering the constructed wetland in pretreatment lagoon, L_1, were 9.98×10^3 CFU/ml during the examined year. Outlet concentrations of total coliforms for the investigated period were 4.40×10^4 CFU/ml.

Bacterial indicators of fecal contamination showed average influent concentrations of 4.05×10^3 CFU/ml for the examined period, and 1.13×10^1 CFU/ml average concentrations at the outlet end of wetland. This indicates that the reduction of *E.coli* at the outlet end of wetland was 97% at the end of conducted observations (Keith R.Hench et al., 2003).

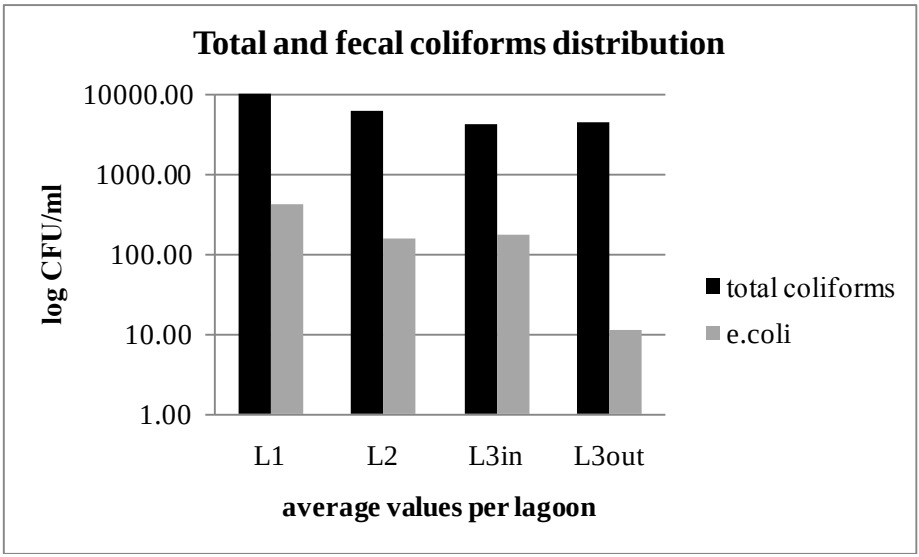

Figure 1. – Distribution of total and fecal coliforms

Influent BOD_5 levels varied insignificantly between system's lagoons, ranging from 15 mg/l to 52 mg/l through the examined year. The highest mean concentrations were in March, in year 2012, and slightly exceeded recommended values by EPA (30 mg/l) in March, April and June of the same year. All the other values in investigated period were below the threshold (Table 1).

Table 1. Average levels of BOD_5 and TSS

Lagoons	BOD5 mg/L	TSS mg/L
L1	31,8	30,1
L2	28,5	18,1
L3in	27,3	18,9
L3out	25,4	26,1

Wetlands are known to be effective in reducing suspended solids. The observed average values for total suspended solids (TSS) have never exceeded permitted limits of 30 mg/L at the outlet end of CW (Fig. 2).

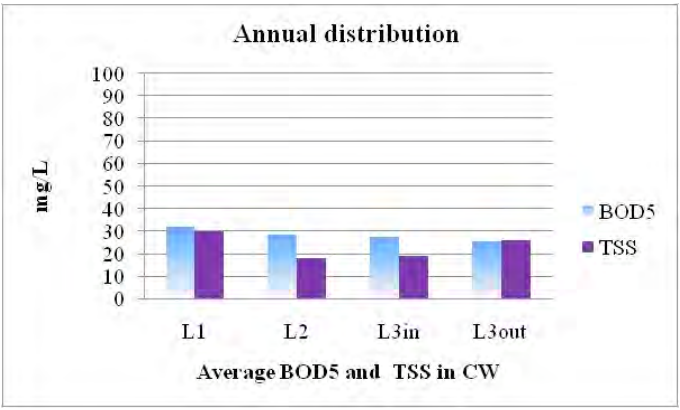

Figure 2. Annual averages of BOD_5 and TSS in wetland cells

Results demonstrated that reduction of fecal coliforms was high regardless the season of the year, and were reduced comparing to wetland loading.

CONCLUSIONS

Constructed wetlands are undoubtedly very effective and low cost systems for domestic wastewater treatment in suburban areas where standard septic tanks fail to produce environmentally safe surroundings. This study has justified the application of constructed wetlands for wastewater treatment, since the reduction of fecal coliforms was significant over the investigated period, but also has proven that further monitoring should be conducted in the following years, since the best performance is expected during the third year. Although there has been constant improvement in wetland construction over past decades, there are still obstacles to overcome in achieving sustainable, water quality regarding pathogen removal. Second year study, as well as long term study should be undertaken with possible changes in vegetation and other wetland parameters to examine the suitability of constructed wetland for treating domestic wastewater.

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