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CRNOGORSKO DRUŠTVO ZA ZAŠTITU MATERIJALA I ŽIVOTNE SREDINE
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MODELOVANJE SORPCIJE ARSENA NA AKTIVIRANOM CRVENOM MULJU

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Izvod

U radu se predlaže i analizira matematički model sorpcije arsena (As(III) i As(V)) na različitim sorbensima na bazi crvenog mulja. Rješavanjem modela dobijena je Lagergrenova jednačina koja se koristi za izračunavanje očekivanih vrijednosti adsorbovanog arsena iz rastvora. Rezultati dobijeni prema modelu pokazuju dobru saglasnost sa rezultatima eksperimentalnih ispitivanja. Manja odstupanja rezultata se objašnjavaju postojanjem sporednih faktora koji nisu uzeti u obzir u matematičkom modelu. Ova odstupanja su najmanja u slučaju kada se primjenjuje adsorbens AB. Uočene razlike između rezultata postaju sve manje sa povećanjem vremena kontakta rastvora sa odgovarajućim adsorbensom. Matematičkim modelom potvrđeno je da sa povećanjem koncentracije As(V) u početnom rastvoru raste i procenat njegove adsorpcije. Model predviđa da se uklanja veća količina As(V) ukoliko se koristi veća masa AB-a u rastvoru.

Ključne riječi: *Bauksol, aBauksol, AB, adsorpcija, matematički model*

Uvod

Arsen (As) se u prirodi nalazi u atmosferi, zemljištu, stijenama, prirodnim vodama i organizmima. Sastavni je dio zemljine kore. Nalazi se u širokom opsegu koncentracija (u prirodnim vodama od 0,5 do 5000 μg/dm^3). Čisti, elementarni arsen se rijetko nalazi u prirodi i uglavnom se sreću njegova jedinjenja sa kiseonikom, sumporom i hlorom, odnosno neorganska jedinjenja arsena. U jedinjenjima, neorganskim i organskim, arsen je zastupljen u različitim valentnim stanjima +5, +3, 0 i -3.

Sva jedinjenja arsena su toksična, ali je toksičnost organskih jedinjenja manja od neorganskih [1]. Međunarodna agencija za istraživanje kancera uvrstila je arsen među kancerogene. Višegodišnja konzumacija vode za piće koja sadrži nivoe arsena blizu propisanih ili veće, značajno povećava rizik pojave kancera kože i tumora bešike, bubrega, jetre i pluća. Smrtna doza arsen(III)-oksida (arsenika) za čovjeka prosječne mase iznosi 65 mg, bilo da je količina uzeta odjednom ili više puta u manjim količinama [1].

Globalni problem je uklanjanje arsena prilikom obrade vode za piće savremenim i alternativnim tehnologijama, zbog toga što su EPA i drugi međunarodni standardi smanjili MDK (maksimalno dozvoljena koncentracija) arsena sa 50 na 10 μg/dm^3 [2, 3].

Medju različitim tehnologijama koje se koriste za uklanjanje arsena iz voda adsorpcione metode spadaju u jedne od najčešće korišćenih [4]. Adsorpciona sredstva koja se najčešće koriste su aktivna glinica, jonoizmjenjivačka smola, aktivni ugalj, zeolit, elementarno gvožđe ili jedinjenja gvožđa, organski polimeri, kaolinska glina i kvarcni pijesak, a stalno se radi na iznalaženju novih materijala u cilju poboljšanja kvaliteta uklanjanja i smanjenja cijene koštanja cijele operacije [4]. Jedan od takvih materijala koji se u poslednje vrijeme dosta ispituje jeste crveni mulj, kao i razni materijali na bazi crvenog mulja. Crveni mulj je otpadni materijal koji nastaje za vrijeme proizvodnje aluminijuma iz boksitne rude baznim luženjem. U toku prosječnog Bajerovog procesa, fabrika oslobađa 1-2 tone crvenog mulja po toni proizvedenog aluminijuma, tako da je on lako dostupan u velikim količinama. Crveni mulj ima veliki afinitet prema arsenu. Razlog je visok sadržaj oksida i hidroksida Fe i Al koji jako dobro adsorbuju arsen [5]. U ranijim eksperimentima detaljno su ispitani sledeći sorbenti: Bauksol, aBauksol i AB, koji predstavljaju aktivni crveni mulj i materijale modifikovanog crvenog mulja. Ispitana je kinetika sorpcije As(III) i As(V), zavisnost sorpcije od

početne koncentracije arsena, kao i zavisnost sorpcije od mase sorbenta [6].
Razvoj analitičkog modela je od velikog značaja za analizu sorpcije arsena. Stoga je cilj ovog rada bio da se razvije matematički model koji bi predvidjao ove adsorpcione procese. Kao provjera validnosti korišćenja modela u radu je vršeno poredjenje rezultata dobijenih matematičkim modelom i eksperimentalnih rezultata.

Rezultati i diskusija

U cilju razvoja analitičkog modela potrebno je naći vezu između:

1. vremena i koncentracije arsena koji se adsorbuje,
2. početne koncentracije As(V) i koncentracije As(V) koji se adsorbuje i
3. koncentracije AB-a i koncentracije As(V) koji se adsorbuje.

Da bi se pronašle ove zavisnosti izvedena je Lagergrenova jednačina.

Neka je:
x(t) - koncentracija arsena (As(V) ili As(III) u zavisnosti od konkretnog slučaja) koji je adsorbovan u trenutku t,
a_1 - početna koncentracija arsena,
a_2 - koncentracija sorbenta (Bauksola, aBauksola ili AB-a u zavisnosti od konkretnog slučaja),
k - konstanta brzine adsorpcije arsena (As(III) ili As(V)) (nepoznata).
U trenutku $t = 0 \Rightarrow x(t) = 0$, a količina adsorbovanog arsena se opisuje diferencijalnom jednačinom:

$$\dot{x} = k\left(a_1 - x\right)\left(a_2 - x\right) \qquad (1)$$

Iz jednačine (1) slijedi:

$$\int \frac{dx}{\left(a_1 - x\right)\left(a_2 - x\right)} = k\int dt \qquad (2)$$

$$\frac{1}{a_2 - a_1}\ln\frac{a_1 - x}{a_2 - x} = kt + c \qquad (3)$$

pri čemu se c određuje za t = 0. Stoga je:

$$\frac{1}{a_2 - a_1}\ln\frac{a_1}{a_2} = c \qquad (4)$$

Uvrštavanjem jednačine (4) u jednačinu (3), dobija se Lagergrenova jednačina (5), koja se koristi za izračunavanje očekivanih vrijednosti adsorbovanog arsena iz rastvora:

$$\frac{1}{a_2 - a_1}\ln\frac{a_1 - x}{a_2 - x} = kt + \frac{1}{a_2 - a_1}\ln\frac{a_1}{a_2} \qquad (5).$$

Konstanta brzine adsorpcije arsena se računa na osnovu sledećeg izraza:

$$k = \frac{1}{\left(a_1 - a_2\right)t}\ln\frac{a_2\left(a_1 - x\right)}{a_1\left(a_2 - x\right)} \qquad (6).$$

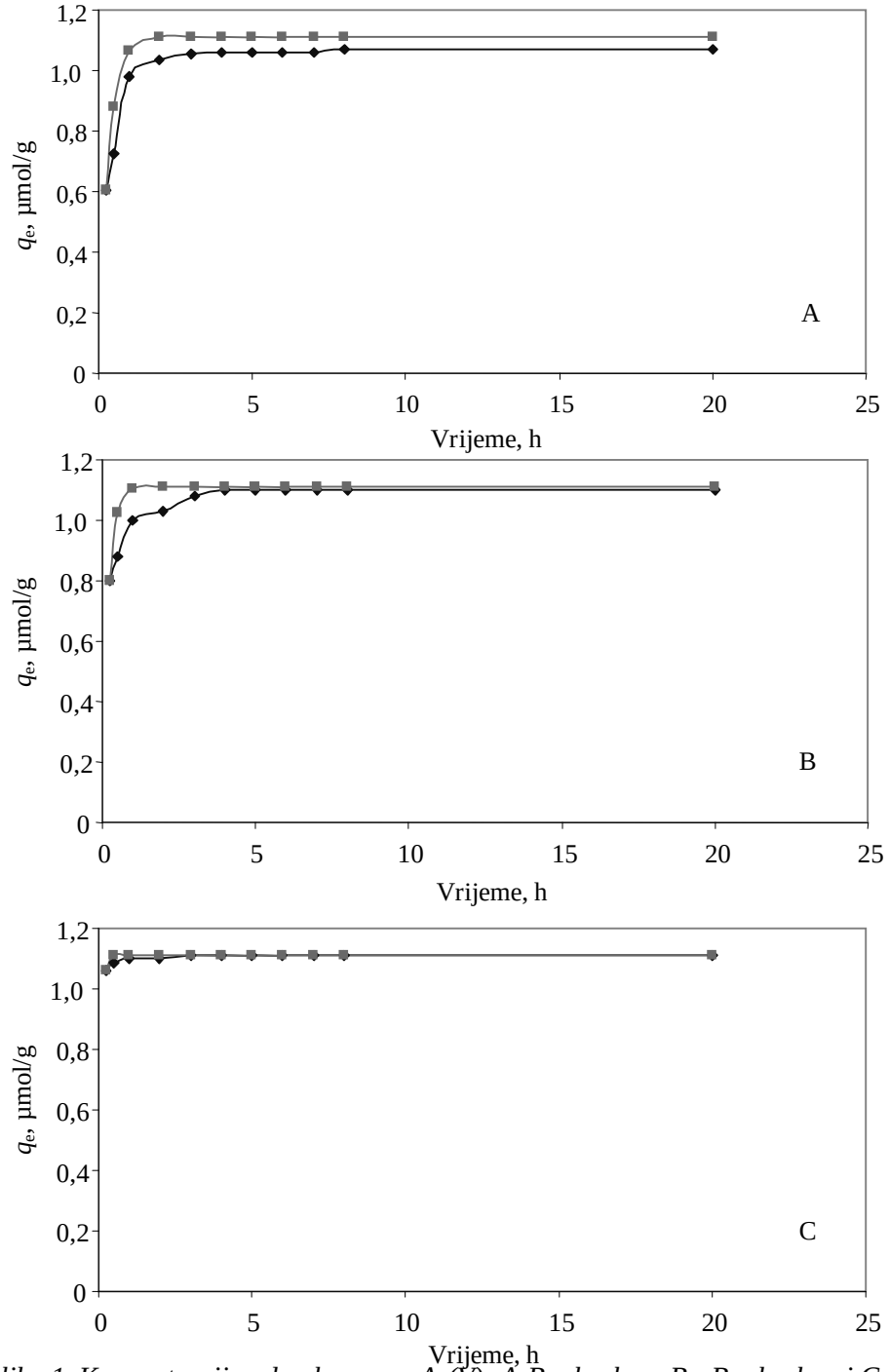
Analiza efikasnosti uklanjanja As(V) pomoću matematičkog modela

Kalibracija modela se sastoji u odredjivanju konstante k koja daje najbolju korespodenciju rezultata modela sa eksperimentalno dobijenim vrijednostima. Vrijednost k se određuje na osnovu jednačine (6), tako što se u jednačinu uvrste eksperimentalne vrijednosti x = 0,271 mg/dm^3 za Bauksol, x = 0,36 mg/dm^3 kada je u pitanju aBauksol, i x = 0,4774 mg/dm^3 za AB, koje se dobijaju nakon miješanja rastvora As(V) (početne koncentracije 0,5 mg/dm^3) sa odgovarajućim adsorbensom (čija je koncentracija 6 g/dm^3) u vremenskom intervalu t = 0,5 h. Na osnovu izračunate vrijednosti k (koja, kad se primjenjuje Bauksol iznosi k = - 5,2 · 10^{-4} mg/dm^{3}h, aBauksol k = - 8,48 · 10^{-4} mg/dm^{3}h, i AB k = - 2,064 · 10^{-3} mg/dm^{3}h), prema Lagergrenovoj jednačini određuju se koncentracije As(V) koje se adsorbuju u odgovarajućim vremenskim intervalima (nakon 30 min, 1 h, 2 h, 3 h, 4 h, 5 h, 6 h, 7 h, 8 h, 20 h).
Koncentracije adsorbovanog As(V) nakon miješanja rastvora sa Bauksolom, aBauksolom i AB-om tokom odgovarajućih vremenskih intervala, dobijene iz Lagergrenove jednačine predstavljene su na slici 1. Na slici su, radi poređenja, predstavljene i koncentracije adsorbovanog As(V) dobijene eksperimentalnim putem.
Sa slike 1 jasno se vidi da matematički model predviđa nešto bržu adsorpciju As(V) u odnosu na adsorpciju koju pokazuju eksperimentalni rezultati u slučaju sva tri adsorbensa.

Prema matematičkom modelu već nakon 2 h Bauksolom se ukloni 99,8% As(V), dok su eksperimentalna mjerenja pokazala da je posle 4 h adsorbovano 99% As(V) i da nema promjena čak ni posle 20 h miješanja.

Prema modelu aBauksol, kao i Bauksol, nakon 2 h ukloni 99,8% As(V), dok se skoro potpuno uklanjanje aBauksolom ostvaruje ranije, odnosno 5 h nakon početka reakcije. Prema eksperimentalnim mjerenjima nakon 4 h miješanja ukloni se 99% As(V) i nema promjena ni posle 20 h.

Model već nakon 2 h predviđa skoro potpunu adsorpciju As(V) AB-om. Prema eksperimentalnim mjerenjima nakon 4 h od početka reakcije ukloni se 99,8% As(V) i nema promjena ni posle 20 h.



Slika 1. Koncentracije adsorbovanog As(V): A-Bauksolom, B-aBauksolom i C-AB-om u funkciji vremena prema eksperimentalnim rezultatima◆ i prema matematičkom očekivanju ■

Kao što se vidi i iz eksperimentalnih mjerenja, matematički model predviđa bržu adsorpciju As(V) AB-om i aBauksolom u poređenju sa Bauksolom. Jasno je i da su odstupanja rezultata dobijenih eksperimentalno od rezultata očekivanih matematičkim modelom najmanja u slučaju kada se primjenjuje AB. Razlog neslaganja eksperimentalne reakcije sa modelom je vjerovatno u sporednim faktorima koji nisu uzeti u obzir u matematičkom modelu. Takođe se uočava da razlike između rezultata postaju sve manje sa povećanjem vremena miješanja.

Analiza efikasnosti uklanjanja As(III) pomoću matematičkog modela

Vrijednost *k* kad je u pitanju adsorpcija As(III) se određuje na osnovu jednačine (6), kao i kod As(V), tako što se u jednačinu uvrsti eksperimentalna vrijednost $x = 0{,}274$ mg/dm^3 za Bauksol, $x = 0{,}33$ mg/dm^3 kada je u pitanju aBauksol, i $x = 0{,}4$ mg/dm^3 za AB, koje se dobijaju nakon tretiranja rastvora As(III) (početne koncentracije 0,5 mg/dm^3) odgovarajućim adsorbensom (čija je koncentracija 6 g/dm^3) u vremenskom intervalu $t = 0{,}5$ h. Na osnovu izračunate vrijednosti *k* (koja, kad se primjenjuje Bauksol iznosi $k = -5{,}316 \cdot 10^{-4}$ mg/dm^{3}h, aBauksol $k = -7{,}2 \cdot 10^{-4}$ mg/dm^{3}h, i AB $k = -1{,}075 \cdot 10^{-3}$ mg/dm^{3}h) prema Lagergrenovoj jednačini određuju se koncentracije As(III) koji se adsorbuje u odgovarajućim vremenskim intervalima (nakon 30 min, 1 h, 2 h, 3 h, 4 h, 5 h, 6 h, 7 h, 8 h, 20 h).

Koncentracije adsorbovanog As(III) nakon miješanja rastvora sa Bauksolom, aBauksolom i AB-om tokom odgovarajućih vremenskih intervala, dobijene iz Lagergrenove jednačine predstavljene su na slici 2. Na slici su, radi poređenja, predstavljene i koncentracije adsorbovanog As(III) dobijene eksperimentalnim putem.

Sa slike 2 se uočava da se prema očekivanju matematičkog modela adsorpcija As(III) sa sva tri adsorbensa odvija nešto brže nego što su to pokazali eksperimentalni rezultati.

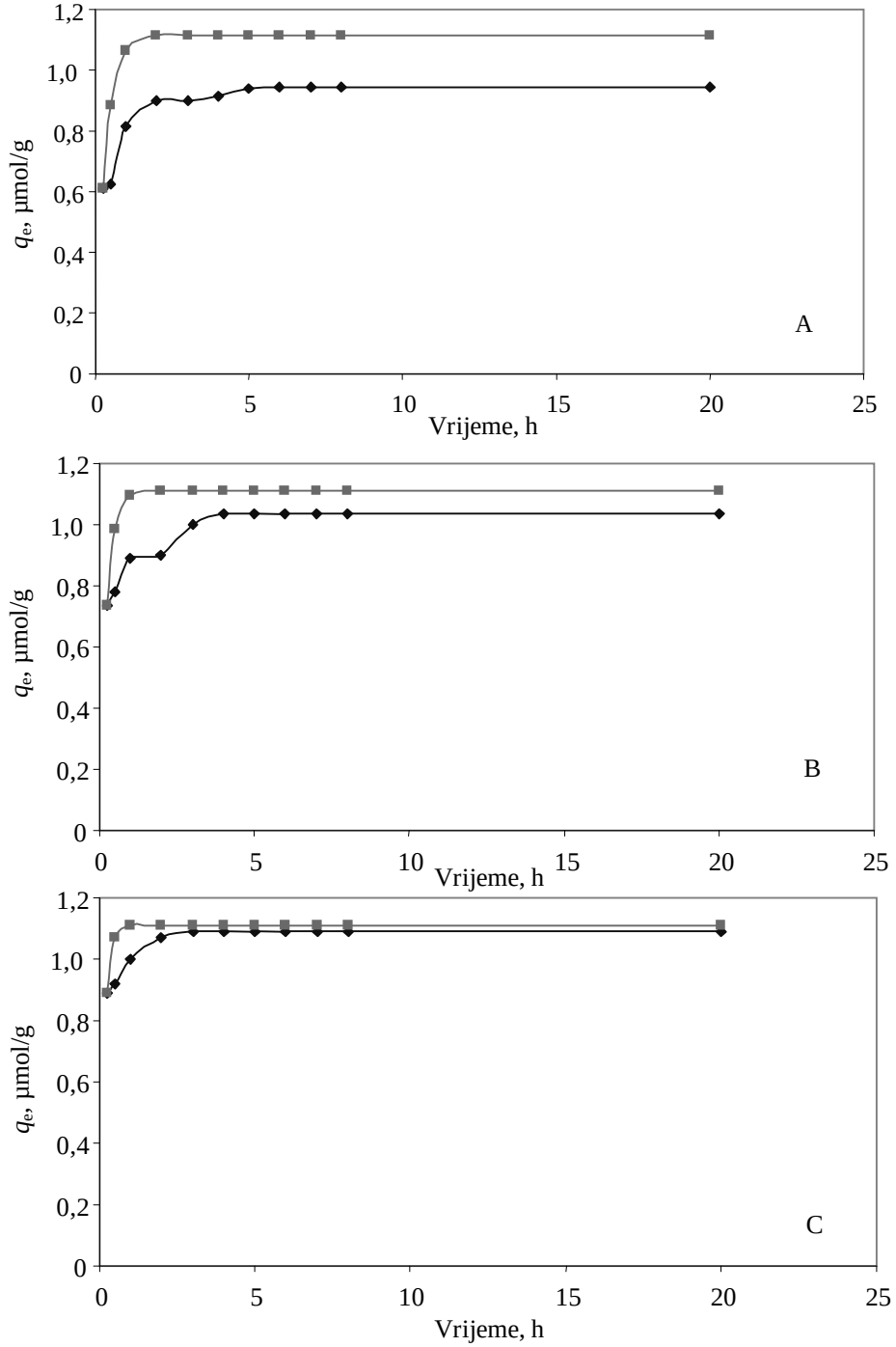
Model predviđa skoro potpunu adsorpciju As(III) Bauksolom 8 h nakon početka reakcije, dok su eksperimentalna mjerenja pokazala da se nakon 6 h uklanja 84,8% As(III) i ta se vrijednost ne mijenja ni nakon isteka 20 h.

Zapaža se da model predviđa skoro potpuno uklanjanje As(III) aBauksolom nakon 6 h. Eksperimentalno se aBauksolom nakon 4 h ukloni 93% As(III) i nakon toga se postiže ravnoteža.

Prema modelu AB već nakon 1 h adsorbuje 99,8% As(III), a praktično potpuno uklanjanje se ostvaruje 4 h nakon početka reakcije, dok su eksperimentalna mjerenja pokazala da se nakon 3 h miješanja ukloni 98% As(III) i da nema promjene ni nakon isteka 20 h. Zapaža se da je AB efikasniji u odnosu na aBauksol i Bauksol pri adsorpciji As(III).

I u slučaju adsorpcije As(III) AB se pokazao kao najefikasniji adsorbens, kako prema očekivanju matematičkog modela, tako i prema eksperimentalnim rezultatima. Uočava se da razlike između rezultata dobijenih u jednom i drugom slučaju postaju znatno manje sa povećanjem vremena miješanja. Takođe su odstupanja rezultata dobijenih eksperimentalno od onih očekivanih modelom najmanja u slučaju primjene AB-a. Razlog neslaganja eksperimentalne reakcije sa modelom je vjerovatno u sporednim faktorima koji nisu uzeti u obzir u matematičkom modelu.

Odstupanja rezultata dobijenih eksperimentalnim putem za As(III) od onih koje predviđa matematički model su znatno veća u odnosu na odstupanja koja se javljaju kada je u pitanju adsorpcija As(V) istim adsorbensom.

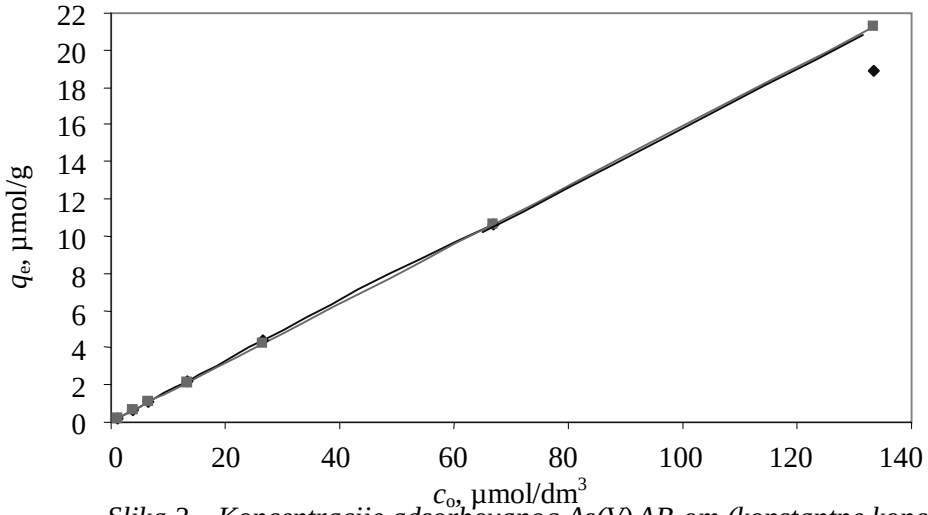


Slika 2. Koncentracije adsorbovanog As(III): A-Bauksolom, B-aBauksolom i C-AB-om u funkciji vremena prema eksperimentalnim rezultatima ◆ i prema matematičkom očekivanju ■

Analiza zavisnosti sorpcije od početne koncentracije arsena prema matematičkom modelu

Vrijednost *k* pri uklanjanju As(V) AB-om u zavisnosti od početne koncentracije As(V) u rastvoru se određuje na osnovu jednačine (6), tako što se u jednačinu uvrsti eksperimentalna vrijednost x = 0,0955 mg/dm^3, koja se dobija nakon tretiranja rastvora As(V) (početne koncentracije 0,1 mg/dm^3) AB-om (čija je koncentracija 6 g/dm^3) u vremenskom intervalu t = 1 h. Na osnovu izračunate vrijednosti *k*, koja u ovom slučaju iznosi $k = -5{,}17 \cdot 10^{-4}$ mg/dm^{3}h, prema Lagergrenovoj jednačini određuju se koncentracije As(V) koji se adsorbuje iz rastvora

odgovarajućih početnih koncentracija (0,3 mg/dm^3, 0,5 mg/dm^3, 1 mg/dm^3, 2 mg/dm^3, 5 mg/dm^3, 10 mg/dm^3).
Koncentracije adsorbovanog As(V) AB-om u zavisnosti od početne koncentracije As(V) u rastvoru, prema vrijednostima dobijenim iz Lagergrenove jednačine predstavljene su na slici 3. Na slici su, radi poređenja, predstavljene i koncentracije adsorbovanog As(V) dobijene eksperimentalnim putem.

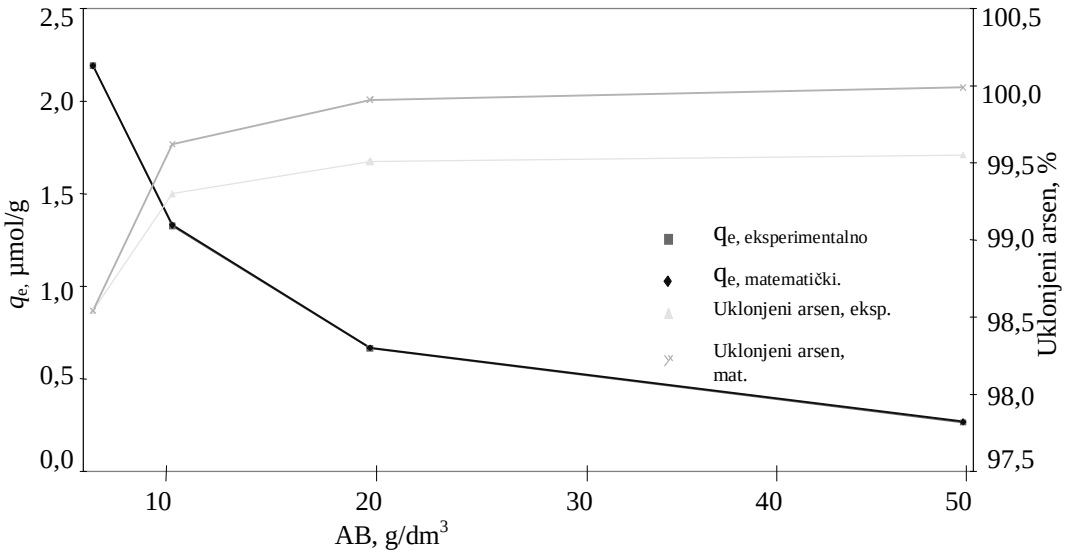


Slika 3. Koncentracije adsorbovanog As(V) AB-om (konstantne koncentracije 6 g/dm^3) u zavisnosti od početne koncentracije As(V) u rastvoru prema eksperimentalnim rezultatima ◆ i prema matematičkom modelu ■

Sa slike 3 se vidi da matematički model, kao što su pokazali i eksperimentalni rezultati, očekuje da sa porastom početne koncentracije As(V) u rastvoru raste i procenat njegove adsorpcije. Međutim, model predviđa manji stepen uklanjanja. U oba slučaja trend rasta se zaustavlja na koncentraciji As(V) u početnom rastvoru od 0,5 mg/dm^3 (kada se prema modelu ukloni 95,6% As(V)). Dok prema eksperimentalnim rezultatima procenat adsorpcije opada sa daljim povećanjem koncentracije As(V) u početnom rastvoru, model predviđa smanjenje, zatim povećanje, da bi na kraju opet došlo do smanjenja procenta uklanjanja. Razlog neslaganja eksperimentalne reakcije sa modelom je vjerovatno u sporednim faktorima koji nisu uzeti u obzir u matematičkom modelu.

Analiza zavisnosti sorpcije od mase sorbenta prema matematičkom modelu

Vrijednost *k* pri uklanjanju As(V) AB-om u zavisnosti od koncentracije adsorbensa se određuje na osnovu jednačine (6), tako što se u jednačinu uvrsti eksperimentalna vrijednost x = 0,9854 mg/dm^3, koja se dobija nakon tretiranja rastvora As(V) (početne koncentracije 1 mg/dm^3) AB-om (čija je koncentracija 6 g/dm^3) u vremenskom intervalu t = 1 h. Na osnovu izračunate vrijednosti *k*, koja u ovom slučaju iznosi $k = -7{,}04 \cdot 10^{-4}$ mg/dm^{3}h, prema Lagergrenovoj jednačini određuju se koncentracije As(V) koji se adsorbuje iz rastvora pomoću AB-a odgovarajuće koncentracije (10 g/dm^3, 20 g/dm^3, 50 g/dm^3).
Koncentracije adsorbovanog As(V) AB-om, u zavisnosti od koncentracije adsorbensa, prema vrijednostima dobijenim iz Langergrenove jednačine predstavljene su na slici 4. Na slici su, radi poređenja, predstavljene i koncentracije adsorbovanog As(V) dobijene eksperimentalnim putem.



Slika 4. Koncentracije adsorbovanog As(V) (konstantne početne koncentracije 1 mg/dm^3) AB-om u zavisnosti od koncentracije AB-a prema eksperimentalnim rezultatima i prema matematičkom modelu

Kao što je i pokazano eksperimentalnim rezultatima, na osnovu slike 4 se vidi da matematički model predviđa da uklanjanje As(V) raste sa povećanjem koncentracije AB-a. Međutim model očekuje veću adsorpciju As(V) sa povećanjem koncentracije adsorbensa. Razlog manjeg neslaganja eksperimentalne reakcije i modela je vjerovatno u sporednim faktorima koji nisu uzeti u obzir u matematičkom modelu.

Zaključci

Matematički model predviđa bržu adsorpciju arsena (As(V) i As(III)) AB-om i aBauksolom u poređenju sa Bauksolom. Odstupanja rezultata dobijenih eksperimentalno od rezultata očekivanih modelom najmanja su u slučaju kada se primjenjuje AB. Razlog neslaganja eksperimentalne reakcije sa modelom može se objasniti sporednim faktorima koji nisu uzeti u obzir u matematičkom modelu.

Uočene razlike između rezultata postaju sve manje sa povećanjem vremena kontakta rastvora sa odgovarajućim adsorbensom.

Kapacitet AB-a prema modelu odgovara kapacitetu eksperimentalnih određivanja.

Matematičkim modelom potvrđeno je da sa povećanjem koncentracije As(V) u početnom rastvoru raste i procenat njegove adsorpcije.

Model predviđa da se uklanja veća količina As(V) ukoliko se koristi veća masa AB-a u rastvoru.

Opšti zaključak je da bi se ovaj matematički model mogao uspješno koristiti za predvidjanje sorpcije arsena na ispitivanim materijalima.

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MODELING SORPTION OF ARSENIC ON ACTIVATED RED MUD

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Abstract

This paper proposes and analyzes a mathematical model of sorption of arsenic (As(III) and As(V)) on different sorbents on the basis of red mud. The Lagergren equation, used to calculate the expected values of the adsorbed arsenic from solution, is obtained by solving model. The results obtained by the model show good agreement with the experimental results. Minor deviations of results can be explained by secondary factors that were not taken into account by the mathematical model. These deviations are the smallest in the case when adsorbent AB is used. The observed differences between the results become less with increasing contact time of the solution with appropriate adsorbent. Mathematical model has been confirmed that with increasing concentration of As(V) in the initial solution increases the percentage of its adsorption. The model predicts that greater mass of AB removes a greater amount of As(V).

Keywords: *Bauxsol, aBauxsol, AB, adsorption, mathematical model*

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DEPLETED URANIUM IN SERBIA - BEHAVIOR AND CONSEQUENCE

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ABSTRACT

Environmental contamination caused by radionuclides, in particular by uranium and its decay products is a serious problem worldwide and the common subject of the nowadays scientists investigations. It is estimated that the technologically enhanced naturally occurring radioactive materials (TENORM) caused by nuclear and non-nuclear technologies, significantly increased natural radioactivity in the last thirty years. On the other hand, in recent years, often refers to "new pollutant" – depleted uranium (DU). It is estimated that during the Gulf War, the Bosnia and Yugoslavia war, and the invasion of Iraq approximately 1.4 million DU missiles were used. During the NATO aggression,1999. year, in former Yugoslavia were bombing 112 sites in Kosovo and Metohija, 12 locations in southern Serbia and 2 location in Montenegro (peninsula Lustica) with depleted uranium (DU) ammunition. On this occasion around 10 tonnes of DU was introduced into environment. The degree of contamination ranges from the bottom limit of 200 Bq/kg to 235,000 Bq/kg in sample of soil, mainly agricultural land, or 1 000 times above the natural level. Within the international mission, UNEP and FOCUS and the engagement of national experts only partially carried out decontamination of endangered sites of depleted uranium. Today, unfortunately, encounter with "invisible threat" use of depleted uranium ammunition, with highly radioactive and chemotoxic effect on human health, causing in the last twelve years enormous increase in cancer rates and number of newborns with genetic changes. This paper reviews some relevant aspects of environmental contamination with depleted uranium, uptake and behavior in the food chain with indicators of impact on human health and gives an overview of the different remediation processes available.

Keywords: *depleted uranium, behavior, consecquence, human health, remediation*

1. DEPLETED URANIUM – CHARACTERISTICS

Uranium is a naturally occurring metal that consists of three radioactive isotopes: U^{238}, U^{235} and U^{234}. The concentration by weight is approximately 98.3% U^{238}, 0.72% U^{235} and 0.006% U^{234}, with half-life 4,5 billions yr., 700 millions yr, 240 000 yr. Uranium is ubiquitous in the environment and found in low levels within all rock, soil, and water. This is the highest-numbered radioactive element to be found naturally in significant quantities on earth. A typical concentration of U^{238}, as the main isotope, in the earth's crust is between 0.5 to 10 g/t, with activity from 5 to 125 Bq/kg. For U^{235} the activity concentration is 0.2 to 5 Bq/kg (UNEP,1999).

Depleted Uranium (DU) is a by-product of nuclear fuel cycle that occurs in the process of isotope 235U separation from the natural uranium, whereby its concentration decreases from 0.7% up to 0.2-0.3% . The use of uranium as nuclear fuel requires its enrichment with isotope ^{235}U so that the percentage of the uranium-235 isotope is increased, typically to 3 to 5%. In that way extracted depleted ^{238}U is no longer economically valuable and has a status of radioactive waste (Rajković, 2001).

Estimated that worldwide over 1.1 million tons of DU lie on dumpsites, a minimum of 46 thousand tons are added to this every year.

Exactly and the term depleted reminds of safety is based upon the fact that dangerous γ -and β - radiation is of very low intensity and α-radiation

is with emphasized low intensity and does not take into account its destructive biological effects . Some basic data on DU are given in Table 1.

*Table 1. Depleted Uranium (^{235}U 0,2%, ^{238}U 99,8%)**

Izotope	Mass portion, **U %**	**Specific activity (Bq/mg OU)**
^{238}U	99,799	12,38
^{235}U	0,2000	0,16
^{234}U	0,0010	2,29
		Σ 14.83

* Browne et al. 1986

DU has a specific activity of 14.83 Bq/mg which is approximately 40% less radioactive than natural uranium (25.4 Bq/mg). Gamma radiation of depleted uranium rate is low, -48 keV. The concentration of ^{234}U is very low, according to its small atomic mass (Morgan, 1980). Chemical properties of of natural and depleted uranium are identical and their chemical toxicity, which was discovered in two centuries ago, does not depend on isotopic composition. Depleted uranium has been approved by the U.S. Department of Defense for the production of ammunition and missiles containing the 0.2% of the isotopes ^{235}U and 0.0003% of isotope ^{236}U (AEPI, 1995). Depleted uranium is very dense (19.05 g/cm^3), for almost 70% desener than lead (11.35 g/cm^3), has a greater penetration of the lead , kinetic energy of the bullet with depleted uranium does not cause an explosion and because these characteristics DU has been used for a munition production (Rajković, 2001).

2. USE OF DU AMMUNITION IN PAST WARS

In wars of the past 20 year (1991 Gulf War, the Bosnia and Serbia war, and the 2003 invasion of Iraq) approximately 1.4 million DU missiles were used. During Gulf War I (1990–1991), approximately 320 tonnes (equivalent to over 1 million 30-mm rounds) of DU munitions were used by the US forces and approximately 1 ton of DU was fired from UK tanks. During the Bosnia–Herzegovina conflict (1994–1995), approximately 3 tonnes of DU was fired in NATO airstrikes, and about 10 tonnes of DU was fired during the 1999 Kosovo conflict (Bleise et al., 2003). During the 2003 Iraq War, approximately 2 tonnes of DU was fired by the UK MOD (MOD, 2008), the amount of DU fired by USA forces has not yet been disclosed, but speculative figures range between 170 and 1700 tonnes (UNEP, 2007).
Generally there are no precise data on the amounts of the used DU ammunition during the past wars. Table 2. are given different sources.

Table 2: Amounts of DU (tonnes) dispersed into the environment, during previous wars, according to various sources

COUNTRY	**period of conflict**	**DU dispersed into the environment [tonnes]**	**source**
Iraq and Kuwait Gulf War	1990–1991	**300- 321**	Bleise et al,2003; Hamilton, (2001) Handley-Sidhuaet al.,2011.
Gulf War	1990–1991	**258**	The Royal Society, 2001
Bosnia–Herzegovina	1994–1995	**2,750**	The Royal Society, 2001
Bosnia and Herzegovina	1995	**3**	Hamilton, 2001; Bleise et al., 2003
Serbia and Montenegro (Kosovo conflict)	1999	**10**	Bleise et al., 2003; UNEP, 2001; Zunić et al.,2008; Rajković and Đorđević, 2006.
Serbia and Montenegro	1999	**1**	Hamilton, 2001; Bleise et al., 2003
Serbia and Montenegro	1999	DU was used on 112	UNEP, 2001, 2002a, b

		locations mainly Kosovo	
Serbia and Montenegro (Kosovo conflict)	1999	**11**	Hamilton, 2001; Bleise et al., 2003; . http://worldnuclear.org/info/inf14.html
Kosovo conflict	1999	**8.5**	The Royal Society, 2001
Iraq War	2003	**170-1700**	MOD, 2008; (UNEP, 2007.
Iraq War	2003	**> 30**	Jia et. al., 2006
Iraq War	2003	**1000**	Paul Brown,2009.

2.1. Depleted uranium on the territories of former Federal Republic of Yugoslavia

During the Kosovo conflict NATO aircraft used DU weapons, what is argumented with the action map displayed in Figure 1. According to data from the Pentagon, hundred missions flights of the A-10 "Thunderbolt" aircraft launched about 31,000 rounds only at Kosovo and Metohija (at 112 locations) and 3000-5000 bullets at southern Serbia (12 sites) and at the Lustica Peninsula, Cape Arza, Montenegro (2 sites). That means that according to official data on Yugoslavia landed around 10 tons of depleted uranium (UNEP, 2001; 2002a, b).

According to estimates of Yugoslav Army at Kosovo and Metohija were launched around 50,000 cartridges or about 13,550 kg of ammunution containing depleted uranium.

In the tested soil samples from most endangered sites, areas of Vranje, Bujanovac and Presevonear near the Macedonian border, during the NATO aggression measured radioactivity was 230 to 1100 times higher than the allowed, in the range of 5580 to 235,000 Bq/kg

Fig. 1. Sites identified as being targeted by ordnance containing DU (UNEP 2001).

3. BEHAVIOR OF DEPLETED URANIUM AMMUNITION AFTER LAUNCHING

After firing, the projectile with depleted uranium burns for about 10% of its weight during the flight. Confronted with the target, 18-70% of the penetrators body ignites and oxidizes in the flame (US Army Chemical School,1995).

Kinetic energy of a penetrator does not results in an explosion due to a relatively low melting temperature of uranium (1132 °C) and its pyrophoric properties. When confronted with target, frontal surface of penetrator lights up and releases the extremely high energy which causes an increase in temperature to about 800° C (Morgan,1980; SAIC, 1990). Because of its extremely high density penetrator goes

through 6-9 cm thick steel with a very characteristic small, round entrance hole. Bottom of For Thus, depleted uranium accumulates (deposites) on the surface of land in the form of burnt bullet pieces, fine dust particles (< 5 microns) or by combustion exeedes into uranium oxides.

Because of its thermo-chemical instability uranium primarily occurs in the non stechiometric U(VI) oxide form of UO_2^{+x} (where $0 < x < 0.4$). Further oxidation lead to the formation of mixtures oxides containing insoluble UO_2 and water soluble UO_3 building uranyl ion, UO_2^{+2} (Rostker, 1998; Ebingen et al.,1998; Harley et al.,1999; AT SDR, 1997).

Under the oxidizing conditions uranium, in the soluble form of uranyl ions, is able to move through the environment and so come into the all of living organisms. Under the reduction conditions, most of the uranium is in the solid state insoluble form of ceramic oxides (Rajkovic, 2001). The main threat to the environment originates from produced aerosols. At the initial phase their dominant presence is in the air, and subsequently in the soil and water.

3.1. Depth contamination - Penetration of the undamaged (unburnt) DU missiles in the soil

The behavior of DU penetrators have been studied Erikson et al,(1990), who determined that the uranium from these penetrators mainly corrode into the water soluble hydrated U (VI) oxide.

Migration potencial of the uranium inicially depends on the chemical composition of local soil and water and DU oxidative product. The mobility of the dissolved uranium product is subject to Eh, pH and the presence of the complex agents at local groundwaters. Uranium (VI) exists in the solution as uranyl ion (UO_2^{+2}) and its more mobile than U (IV) because it easier builds soluble complexes with complex ligands from the water. For the carbonates and the phosphates have been found to be very important for these processes. Transportation of soluble uranium may also be accelerated by dilution, as it reduces the concentration of uranium in groundwaters and the surface waters. These reactions include ion-exchange reactions and the specific adsorption of uranium with the organic substances, clay minerals, Fe (III) and the oxy hydroxide which are commonly present in soils.

It was determined that land, if it is acidic, can cause an increase mobility of uranium ions, as well as the balance of sorption processes. Authors have also studied adsorption capacity of different soil types and found that soils with high content of carbonates have the lowest absorption capacity, probably by building a soluble uranyl carbonates like UO_2CO_3, $[UO_2(CO_3)_2]$ or $[UO_2(CO_3)_2]$. Under the aerobic conditions, iron also could play a crucial role in the control of uranium movement in soil. Uranium can built complexes with iron which is located in number of soil salts. Furthermore, uranium can adsorbs humic acid present in soils. Complexation with organic compounds affects the reduction rate of uranium migration through the land even for several orders of magnitude. (Duff et al. 2002).

Uranium (including depleted uranium) environmental pathways and potential risk to human health are shown in Figure 2.

3.2.Dotted contamination: contact with the burnt remains of the projectile

In case of that burnt remains of the projectile (penetrators) with depleted uranium remain on the ground surface, a point contamination directly around the place where missile was fell can occur. On these locations, the surface soil is contaminated with small fragments of depleted uranium oxides or parts of the projectile liner. After the removal of small fragments and uranium oxides, the liner parts of surface layer of soil 3-5 cm thick, speed of impulses falls abruptly. On Cape Arza were 144 such locations (Vukotic, 2002).

3.3. Superficial contamination: the origin of uranium oxides aerosol

When the penetrator strikes a solid target and firing, oxides of uranium are forming aerosols comprising particles microscopic in size, invisible to the naked eye and ordinary microscope, but detectable by radiometric methods. According to some literature data, 50-96% particles in the air have a diameter smaller than 10 microns (usually about 5 microns) and 17-48% of these particles are water soluble. All particles generated when confronted with the a target are potentially respiratory toxic (ARDEC, 1991). Depending on the timezones conditions (wind rose, the type precipitation ..) depleted uranium aerosols can be scattered from the 150m to 5km away from the points of impact (Gršić,2002; Parkhurst et al.,1995).

At the Cape Arza was performed monitoring of the air during cleaning-up in the spring of 2002.

Collected air samples were analyzed by high-resolution alfa spectrometer. The obtained value for the concentration of uranium was approximately ten times higher from those referent for the air (Radenković,2004)

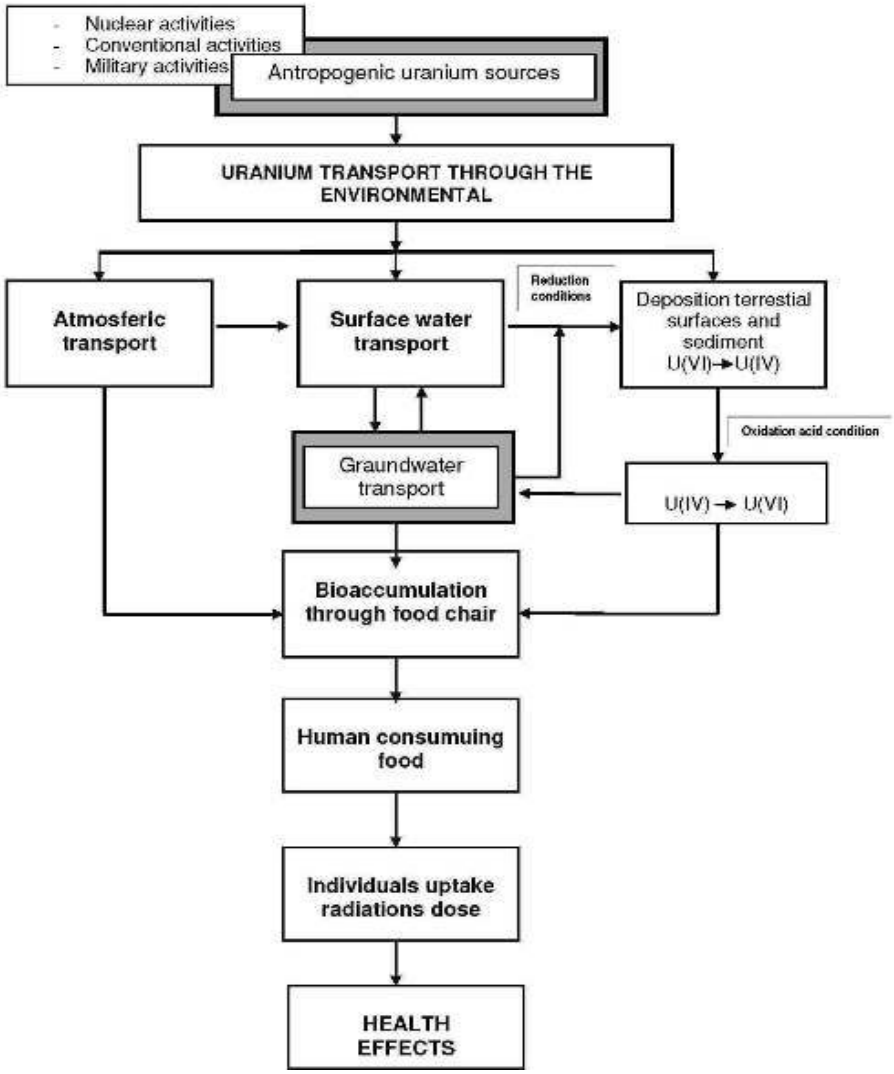

Figure 2. Uranium environmental pathways and potential risk to Human health (sources:http://www.atsdr.cdc.gov/toxprofiles/tp104-c5.pdf)

4. MONITORED FOR RADIOACTIVITY ON SERBIAN TERRITORY

Keeping in mind that during the NATO bombing campaign in 1999, ammunition with depleted uranium has been used, the investigations regarding the consequences of depleted uranium application followed immediately. The aim was to review all the utilization aspects of ammunition with depleted uranium: the military, contamination of the environment and activity on the population and ecological aspects of law.

The results showed that Uranium, applied to the soil as Uranium oxide, is dissolved and can be absorbed by plants by physicochemical and biological processes. After three years up to 40% of the supplied Uranium was converted into mobile species. Such mobile Uranium species can either be absorbed by plants or leached from the soil to water bodies. In the tests of FAL the Uranium contents supplied by the plants directly depended on the Uranium concentrations in the soils. In respect to the total Uranium content of the soil 0.4 - 0.6 %, or in respect to the available Uranium share 5-6 % went over to above ground of plants from the soil.

Radenkovic et al.,(2008) investigated what happened with released DU corrosion products in

three years elapsed, in soil (Bratoselce, southern Serbia) contaminated during the military actions,by applying a sequential extraction procedure as the most valuable technique for geochemical fractionation and speciation of radionuclides in soils. Depleted uranium penetrator was found in the soil at 0.5 m depth, covered with oxides. Soil samples were collected in the surrounding impact zone at the position of the projectile entrance into ground, the path through the subsurface ground, soil layer just next to DU penetrator, and different distances down along the depth profile. The specific activity of ^{238}U in the soil sample taken at the spot of the projectile entrance into the ground was about 90 kBq/kg, in the projectile path it was near 78.5 kBq/kg and in the soil layer next to the penetrator it was about 263 kBq/kg and contamination decrease with the distance from the source through the soil profile.

Dependence of the fractionation on the contamination levels and presence of weakly bonded, depleted uranium in the hot spots areas is evident (Radenkovic et al.,2008). Depleted uranium fractionation indicated an increase of mobile fraction of uranium in contaminated sites than the control, which confirms the rule that the anthropogenic uranium origin more easily included in the food chain from natural uranium. significant.

Important indicator of the presence of depleted uranium in the soil is a dysfunctional relationship isotopes activities $^{234}U/^{238}U$, $^{235}U/^{238}U$, and $^{236}U/^{238}$ U, which is entrenched in the natural uranium. Just this amended isotopic ratio of activity detected in the soil samles collected in Serbia and Montenegro , which confirms the presence of DU (Radenkovic et al.,2007; 2008).

The scientists found out that the mobilisation of Uranium grows with a decreasing fertility of the soil (minor pH value, less content of mineral plant nutrients, especially phosphorus). In the tests of FAL the uranium contents supplied by the plants directly depended on the uranium concentrations in the soils. In respect to the total uranium content of the soil 0.4 - 0.6 %, or in respect to the available uranium share 5-6 % went over to above ground of plants from the soil. (Schnug, 2005) .

5. HEALTH ASPECTS OF DEPLETED URANIUM

There is a plenty literature that enables the health impact assessment of uranium and its compounds on the health of workers exposed to the uranium impact by its mining, milling or working in the nuclear plants (McGeoghgan and Spinks,2000). But the negative health effects of uranium in the form of depleted uranium used as armour-piercing has been accentuated after the serious health problems observed both at soldiers – veterans, and at local populations, that has occurred after its application in the military conflicts in the Gulf and the Balkan wars (Durakovic, 2003; Milacic et al., 2004; Bem and Bou-Rabee, 2004). Although many researchers and authors of different reports and studies are diminishing the effects of depleted uranium to human health, there is a well-documented evidence of both chemical and radiological toxic properties of uranium isotopes that has been an area of numerous research studies and scientific reports on its organotoxic, mutagenic, teratogenic and carcinogenic effects (Durakovic, 2003).

We can talk about two types of health risks associated with uranium exposure: immediate health risks that include kidney diseases and respiratory problems, and the long-term risks which include the lung, bone or other type cancer.The chemical toxicity and radiological effect of uranium and its compounds can cause adverse health effects to human population. The toxicity type is determined by the form of uranium – low soluble aerosols of uranium will predominate in radiological toxicity, while the soluble metal forms will induce the chemical toxicity. The chemical toxicity of this radionuclide element and its compounds is similar to that for other heavy metals, for example cadmium or mercury, due to its chemical affinity to proteins which seriously disturb the process of re-absorption of glucose and amino acids If we are considering radiological effects of depleted uranium ammunition, we can split it into two parts: the acute risk of external exposure, which is by some authors negligible and internal radiological exposure, which comes from intake of depleted uranium, and which can not be venial. (Bem and Bou-Rabee, 2004). Although the depleted uranium can be considered to have less radiological impact than uranium, it has stronger chemical toxicity because of its high linear energetic transfer (LET) irradiation, the long time of body extrusion (5000 days) and the ability of different tissue deposition (Milacic et al., 2004).

The medical effects of internal exposure to uranium are depending on many factors such as: the uranium quantity intake and the impact contamination time, including also the age, sex,

genetic predisposition, and the exposure to the other materials, previous health status, radio-sensitivity of the organism, but also the diet and stress (Durakovic, 1999). The different tissue distribution studies have reported DU accumulation in the bone, kidney, reproductive system, brain, and lung, with verified genotoxic, mutagenic and carcinogenic properties, as well as reproductive and teratogenic alterations (Horan et al.,2002).

Fig. 3., represents the main pathway and the final targets for human body contamination by any form of uranium. The picture is based on many different published reports that have cited consequences of exposure to uranium, or depleted uranium, with reference to different negative effects on human health such as kidney or lung damage, diverse type of organs or tissues cancer, DNA damage (Miller et al.,2002), mutagenicity (Lin et al.,1993), and neurological deficits (Pellmar, et al. (1999). The laboratory experiments with animals that were conducted in order to asses the health risk connected with depleted uranium, have proved that DU certainly can cause appearance of leukemia and lymphoma as well as secondary myelodisplastic syndrome (Milacic et al.,2004). Although there is not clear evidence that uranium affects human central nervous system, the bioaccumulation experiments conducted on rats have showed that after exposure to repeated inhalation, depleted uranium is able to enter the brain, producing strong behavioural changes (Monleau et al.,2005).

As a consequence of uranium entry into the organism, numerous health risks appears depending on four main factors: isotopic composition, chemical composition, particle size and solubility. The same emerging pathogenic significance of uranium have chemical toxicity and radioactivity of gamma emission (^{235}U) and alpha emission (^{238}U). Kinetics of uranium in the body is very specific. Blood is a fundamental transport factor in the distribution and redistribution of toxic uranyl (U^{+6}) and uranium (U^{+4}) ions. Active role in the transport of uranium have red blood cells and plasma proteins. For about 60 minutes 95% uranium disappears from the bloodstream. The biological half-life of uranium in the body is 2 to 5000 days (Rajkovic, 2001).

5.1. "Invisible threat " of depleted uranium in Serbia after military conflict in 1999

The official data about the health conditions of populations directly or indirectly exposed to DU in Serbia after military conflict in 1999 are pretty precautionary and scanty. The data presented in different studies are at least careful and discreet because no one wants to provoke 'uranium panic' especially in the lack of money for meaningful objective international research and continuous and appropriate clean-up methodology.

In the paper presented in TI Conference, Pantelic and Golubovic (2008) have exposed the following: the data published in Serbian medical journal *'Praksis Medika'* presents that in 1997 the number of patients in Kosovska Mitrovica hospital (pneumonic-physiological department) with lung tumor was 2.6%, while in 2000 this number has significant increase to 22%. The same research presents that the urology department of the same hospital marked 1.6% patients with tumor, while in 2000, only one year after the NATO bombing with DU ammunitions, this number was 22%. The same source (Pantelic and Golubovic,2008) also indicates that in Balkan symposium held in 2005, the medical section of Serbian Academy of Science has presented data

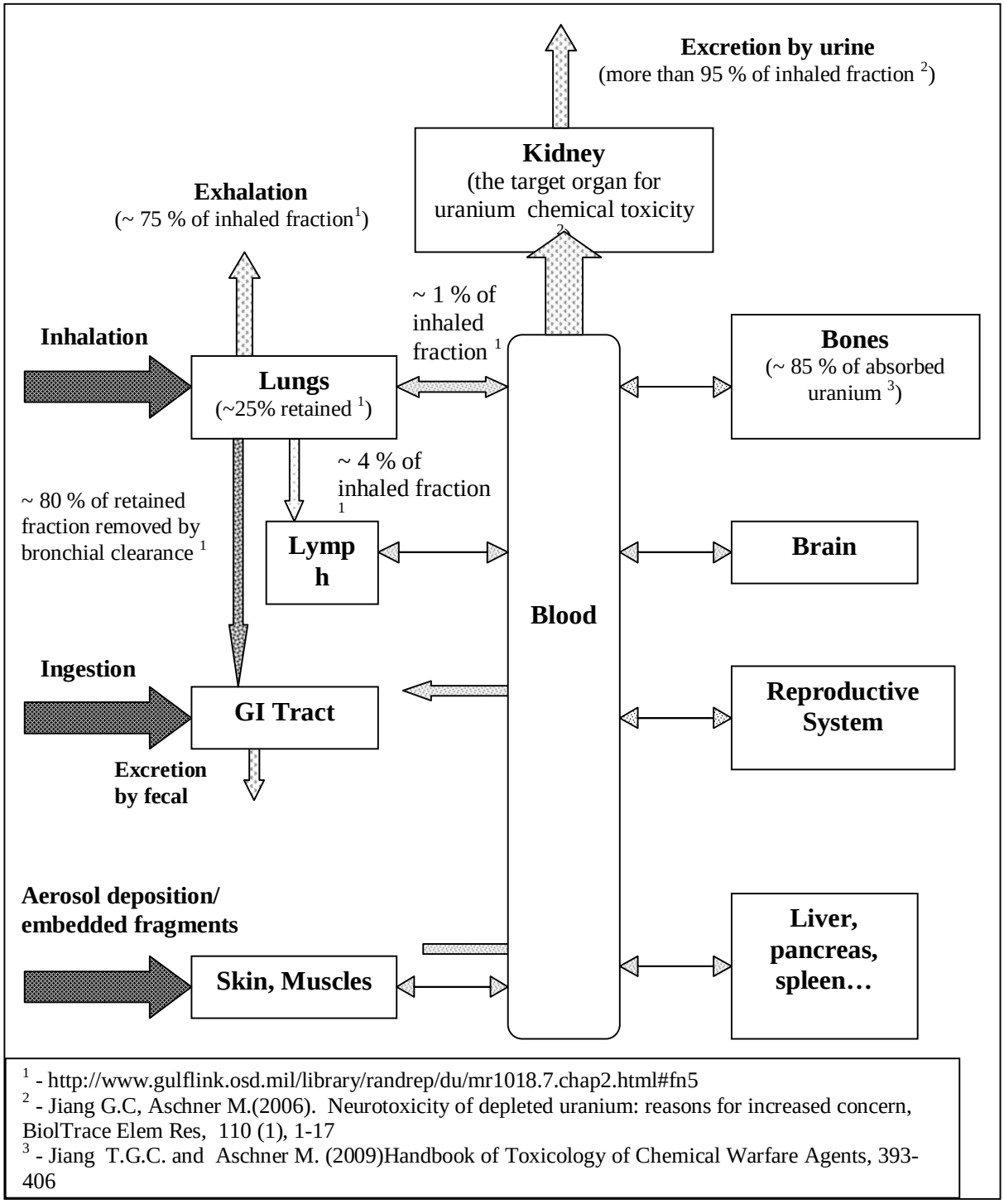

Figure 3. The main pathway of uranium in human body

concerning pregnancies, births and malformations of new born/dead babies in Serbia, in the period from 1989 to 2001. All the data collected from 30 Serbian Health centers were elaborated according to appropriate WHO methodology. These results indicate that in Serbia is present significant decrease of number of births while the number of spontaneous miscarriages (abortion) has big increase. They also highlight that after the 1999 the number of dead newborn babies has drastically increased from 50 to 357, while the number of dead babies born with malformations increased from 121 to 610. In this paper the authors have also stipulate that each year in Serbia is registered more than 30 000 new cancer patients which is, regarding the overall Serbian populations of ~7.1 million people, much more than average rate in Europe.

The authors of paper called: *The Consequences of NATO Bombing on the Environment in Serbia*, Milačić and Simić (http://irpa11.irpa.net/pdfs/1d11.pdf) have published the results of investigations that were conducted in order to asses the consequences of DU use on human health and environment after the NATO bombing. They have compared the health status of the population from Vranje region (South Serbia) and Kosovo that are directly exposed and the non exposed populations and underlined that one of the examined groups from DU contaminated region have had the certain changes in blood cells that were mainly morphological, in cytoplasm, nucleus and chromosomes, while some samples of urine of mentioned group were also contaminated with DU. The authors have concluded that although they could not expect the direct influences on human health, they also can not exclude the later consequences, so this is one of the reasons why longer and bigger scientific investigation should be necessary conducted!

The general conclusion of many authors, no matter in which direction goes their investigation is as following: in order to get insight on uranium or DU toxicity on human health, the increased and objective scientific fieldwork with appropriate laboratory measurement without any political or any other interest is necessary!

6. HYBRID TECHNOLOGY FOR REMEDIATION OF URANIUM POLLUTED SOILS

State of the environment and the concept of sustainable development have caused the emergence of new technological solutions that would reduce impact of human activities on the environment. Hybrid, combined, remediation technology for cleanup uranium contaminated media, with synergistic effects are increasingly being used for environmental and economic efficiency. Integrated management of soils contaminated with uranium, based on results obtained in Instutute for nuclear and other mineral raw materials in Belgrade. Conceptual approach is a synergy of physical, chemical and biological remediation processes and techniques. In situ treatment includes a combination phytoextraction and phytostabilisation with uranium hyperaccumulator plants with application of functional materials based on Serbian (domestic) aluminosilicate minerals.

Remediation technologies for treatment of uranium contaminated soils and groundwater could be applied as either ex situ or in situ techniques. According to Gaverilescu et al, (2009), can be classified methods and techniques for uranium removal as: Natural attenuation, Physical processes, Chemical methods, Biological methods and Electrokinetic methods. These techniques can be applied individually or in combination (hybridization) and they are presented on Figure 4.

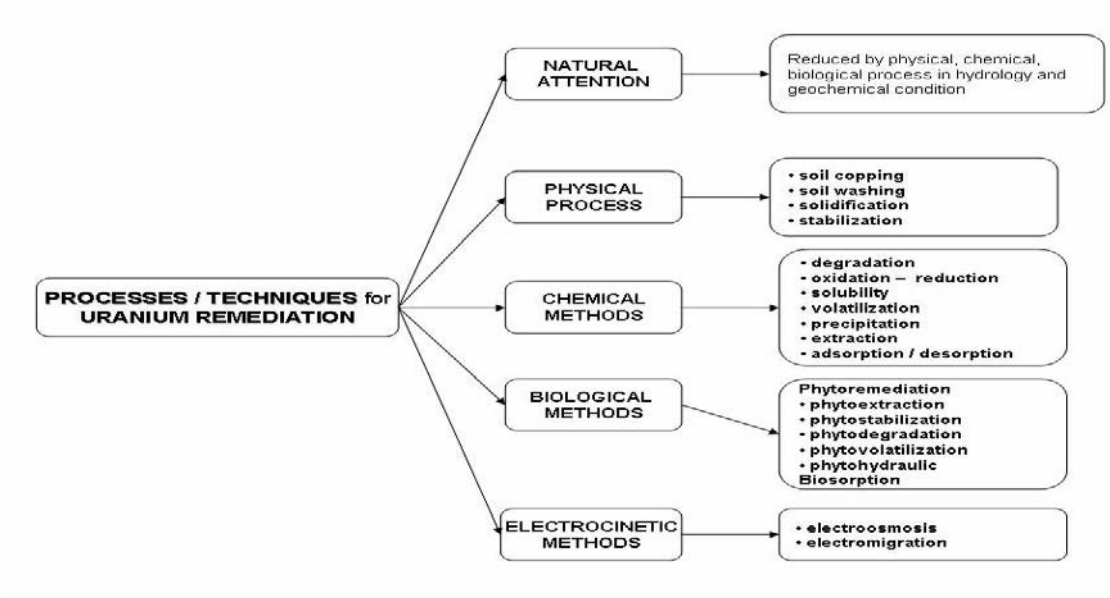

Figure 4. Processes and techniques for uranium removal

Each one of the above fundamental technical choices will direct decision makers to substantially different paths with regard to their subsequent choices, actions and potential results, making available significantly different technological options for application, within a remediation program, which involves multidisciplinary environmental research on characterization, monitoring, modelling and technologies for remediation.

Generally, remediation of soil contaminated with uranium requires a holistic approach including the use of secure "environmental friendly" materials that are cheap, easily applicable and available locally. Our results confirm the applicability of the natural and modified aluminosilicate materials (zeolite, apatite, bentonite and diatomite) individually and in mixture. The use of adsorbents with faster and stable action, together with the materials with slower acting, provide synergistic effect of reactive materials mixtures for in situ stabilization of uranium ions. Hybrid technology represents a permanent solution and means integrated management strategy for contaminated site which includes: proper selection of plants (hyperaccumulators uranium), improving mobility of uranium with amendments (organic agents) and application sequestering agents for immobilization and transformation of excess uranium, which plant didn't accept. Scheme of innovative hybrid technology for remediation of uranium polluted soils is shown in Figure 5 (Matijasevic et al., 2006; Stojanovic, 2006; Stojanovic et al.,2009; Stojanović and Milojković,2011):

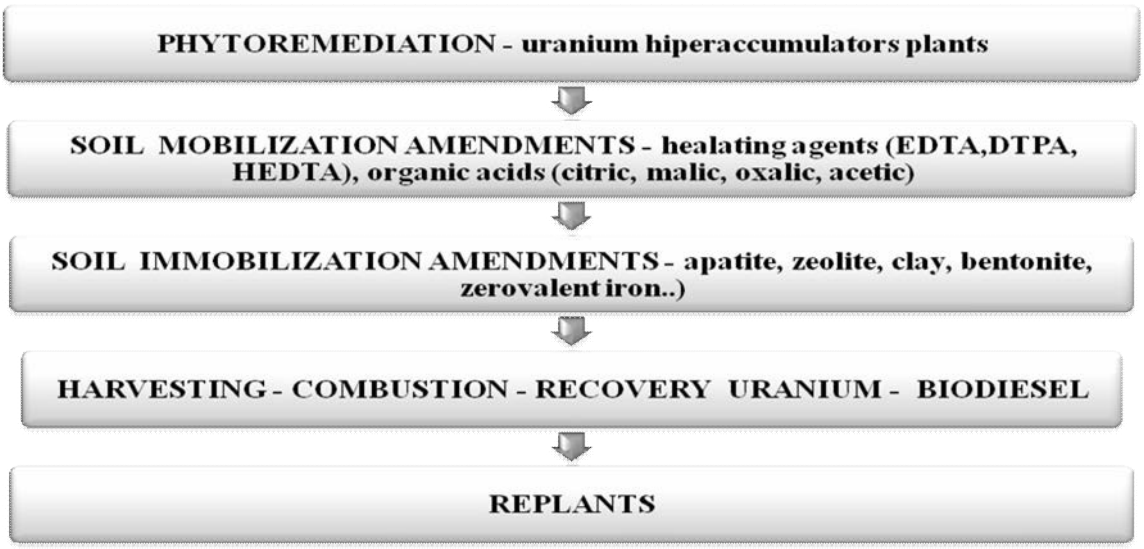

Figure 5. Hybrid technology for remediation of uranium polluted soils

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7. CONCUSION

Environmental contamination by radioactive substances has become one of the important problems of modern civilization.

Past twenty years, Serbia has faced the consequences of economic sanctions, the transition of the entire economy, the NATO bombing of the disturbed environment, obsolete technological processes. On the other hand due to lack of financial resources is not resolved the problem of Serbian decontamination of depleted uranijum. Rezults is increasing number of people suffering from cancer since 1999 year.

In the belief that the subject area of the population of ionizing radiation has neversaid or done too much, let me allow the reader to ultimately express a personal view. Exposed material is a kind of declaration of technological repentance, recognition that the development path threatened serious unintended effects, and also appeal to the attitude towards the environment and the population back from the abuse in the area of reasonable use. It is our

obligation to the world that we inherited and to the generations to come.

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CONSTRUCTED WETLANDS FOR MULTI-FUNCTIONAL WASTEWATER TREATMENT

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Abstract

The paper presents Slovenian experiences in development and implementation of constructed wetlands (CW) in the last 20 years and outlines the future plans. According to Slovenian legislation, which bases on EU directive 91/271/EEC, treatment of all municipal wastewaters must be provided until 2017. Since 1989 in Slovenia over 140 project documentations for CWs with horizontal and vertical subsurface flow were elaborated from which more than 70 were realized in Slovenia, Croatia and Italy for industry wastewater treatment (food processing, detergent factory, laundry, etc.), landfill sites, highway runoff, but most of all for municipal wastewaters from single households and settlements up to 500 PE. Constructed wetlands operate on the basis of natural processes and structures and enable elimination of pollutants from wastewater. Their successful operation proved that low-cost, decentralised naturally-based infrastructure for wastewater management reaches required outflow standards. Besides, they are becoming increasingly relevant for successful wastewater management in dispersed, topographically divided and small settlements as they promote recovery and reuse of wastewater resources and offer other ecosystem services like carbon capture and sequestration, flood control, new habitat creation, etc. Their treatment performance, cost saving possibilities and different ecosystem services will be discussed in the paper.

Keywords: *reed bed, ecosystem services, decentralised small scale wastewater treatment systems, phytotechnology*

1. Introduction

Constructed wetlands (CWs) offer effective and inexpensive solution for wastewater treatment in terms of reduction and elimination of for target pollutants like BOD, COD, N, P, pathogens, heavy metals, etc. (Kickuth, 1984). The technology was introduced in Slovenia in 1989.

Slovenia extends on an area of 20.000 km^2, touching the Alps and bordering the Mediterranean. The part south of the Sava River belongs to Balkan Peninsula. The majority of Slovenian terrain is hilly or mountainous, the exception is the flat Pannonian plain in the East and Northeast. The south-western part is a Karst Plateau (Slovene: Kras), a limestone region of underground rivers and caves, which is extremely vulnerable environment. The Karst region, covering about 44 % of the surface, is marked by shortage of surface water and soil. Beside specific geographical and natural characteristics of Slovenia, the settling structure is specific, with 59,5% of inhabitants living in the settlements with less than 5000 inhabitants or population equivalents (PE), most of them even in settlements between 200 to 500 PE. The described country characteristics arise the question of most suitable approach to wastewater management in terms of cost-efficiency, feasibility and sustainability.

In 2004, Slovenian government adopted an Operational program for municipal wastewater collection and treatment, which has to be implemented until 2018 (Anonymous, 2004). Until now, larger wastewater collection and treatment systems have been already built (for 10.000 – 360.000 PE). The tertiary treatment has to be set up until 2015 for wastewater treatment plants (WWTPs) between 2.000 and 10.000 PE. Wastewater collection and treatment systems for all small communities of up to 2000 PE, which represents about 52% of the state population, will need to be implemented by 2017. After construction of several large WWTPs with long channels and pumping stations, it has been recognised, that dispersed solutions with small

WWTPs are often much more appropriate from the financial, operational and ecological point of view. In this respect, constructed wetlands (CWs), natural small wastewater treatment plants proved to be very efficient, especially for municipal wastewater (Vrhovšek and Bulc, 1994; Urbanc-Berčič et al., 1998; Bulc et al., 2003).

Up to date, there have been 66 CWs implemented in Slovenia by Limnos group for treatment of various types of wastewater. The majority (51) of CWs is designed to treat municipal wastewater with capacity from 3 – 800 PE. There are 7 CWs treating industrial wastewater – food processing, seven treating landfill leachate and one for mitigation of highway runoff (Figure 1). As mentioned, CWs are adaptable to different types of wastewaters but also enable the adaptation to different climates. According to this, in Slovenia CWs are constructed from the Primorska region in the south west with high precipitation by the south foothills of the Alps, to the East part of the country with more continental climate. CWs are also constructed in high altitudes, namely on the 1400m above sea level on Planina Razor.

Numerous studies in different literature can be found on CWs wastewater treatment efficiency, in terms of reduction and elimination of target pollutants from wastewater such as BOD, COD, N, P, pathogens, heavy metals, etc., as well as on their investment and operational suitability compared to different other technical solutions (Kadlec & Wallace, 2009). Less attention has been put on their additional ecosystem services such as retention of hydraulic peaks, creation of new habitats, carbon capture with primary production, aesthetic appearance, water reuse, biomass production etc.

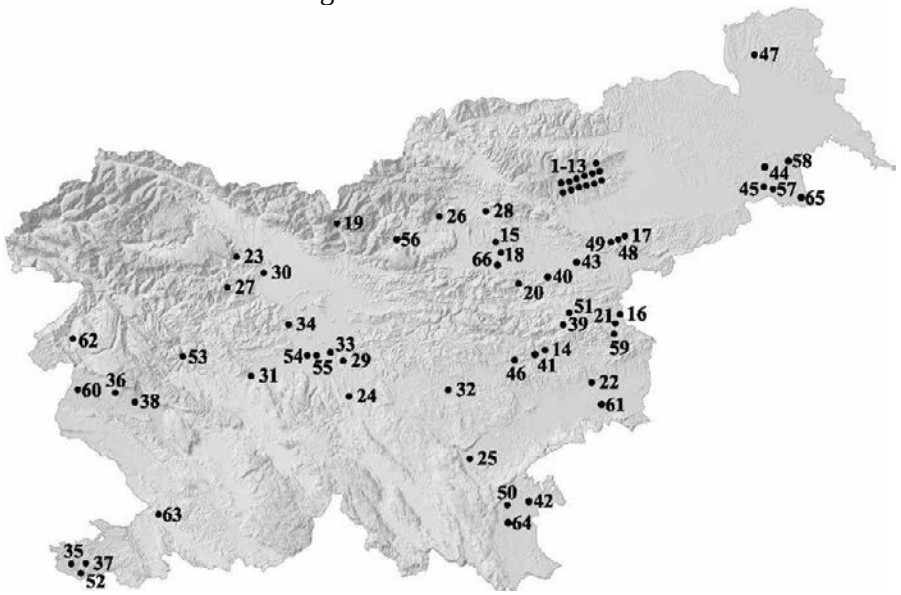

Figure 1: CWs in Slovenia built until the end of 2010. CWs listed from 1-37 are CWs treating domestic outflow from individual households (3–40 PE), from 38–51 CWs connected to municipal sewage system (25–800 PE), from 52–58 CWs built for landfill leachate treatment (100–300 PE), from 59–65 CWs for industrial outflow treatment (50–300 PE) and 66 a CW for highway runoff.

2. Materials and Methods

2.1. Design and construction of CWs for sewage treatment

The first pilot CW in Slovenia was built in 1989 at the municipal WWTP of a smaller town, while the first full-scale CW was built in Ponikva in 1991 for sewage treatment and is still in operation today. Systems were designed on the basis of hydraulic and pollution loads and Slovenian regulations for effluent discharge into the receiving waters (OG RS, 1996; OG RS, 2007). The media has an important role in treatment of wastewater, therefore, different mixture in each system in accordance with organic loads was selected. In the early systems the guidelines issued by Cooper (1990) have been followed. The initial design of Slovene CWs was largely a subsurface horizontal flow. The main attention was paid to prevent clogging. The basic design criteria were modified through selection, application and comparison of various options in situ (Urbanc-Bercic et al., 1998). After 1995, new elements were introduced into the systems with mechanical system for intermittent vertical and

horizontal flow of water through the media. After 1999 large scale constructed wetlands were hybrid systems with both horizontal and vertical flow, composed mostly of 4 treatment beds with the first and the last bed having horizontal subsurface flow. In hybrid CWs with the depth of up to 0.9 m, the vertically flowing water provides more oxygen to the system, thus increasing the efficiency rate of nitrification. Mechanical pre-treatment is in the most cases a primary sedimentation basin or a septic tank. Excavations for the treatment beds are sealed with 2 mm thick HDPE layer or clay to ensure impermeability of the system. Medium is mostly a mixture of different material (peat, sand, gravel), with specific grain size and proportion. Depths of CWs vary from 0.4 to 0.9 m, while the bottom slope from 0 to 1.5 %. CW systems cover the surface area from 20 to 1000 m^2. Beds are planted primarily with *Phragmites australis*, but also with *Schoenoplectus lacustris, Juncus effusus, J. inflexus, Carex gracillis* and *Typha latifolia*. At the CWs for individual households plants with higher aesthetic value such as yellow iris *(Iris pseudacorus*) are often used in combination with *P. australis*. Besides subsurface horizontal and vertical flow CW also other types of CWs existe, e.g. surface flow wetlands which can be planted with emergent, submerged or floating wetland plants. Surface flow wetlands are easier to construct, have lower construction costs but demand more surface area per PE and can cause bad smell, development of mosquitoes and exposure to pathogens which is not the case for subsurface flow wetlands. Surface flow wetlands are therefore preferred for treatment of less polluted wastewaters such as stormwater (Kadlec and Wallace, 2009).

Figure 2: The first constructed wetland in Slovenia was built in 1991 at Ponikva. It is still in operation today.

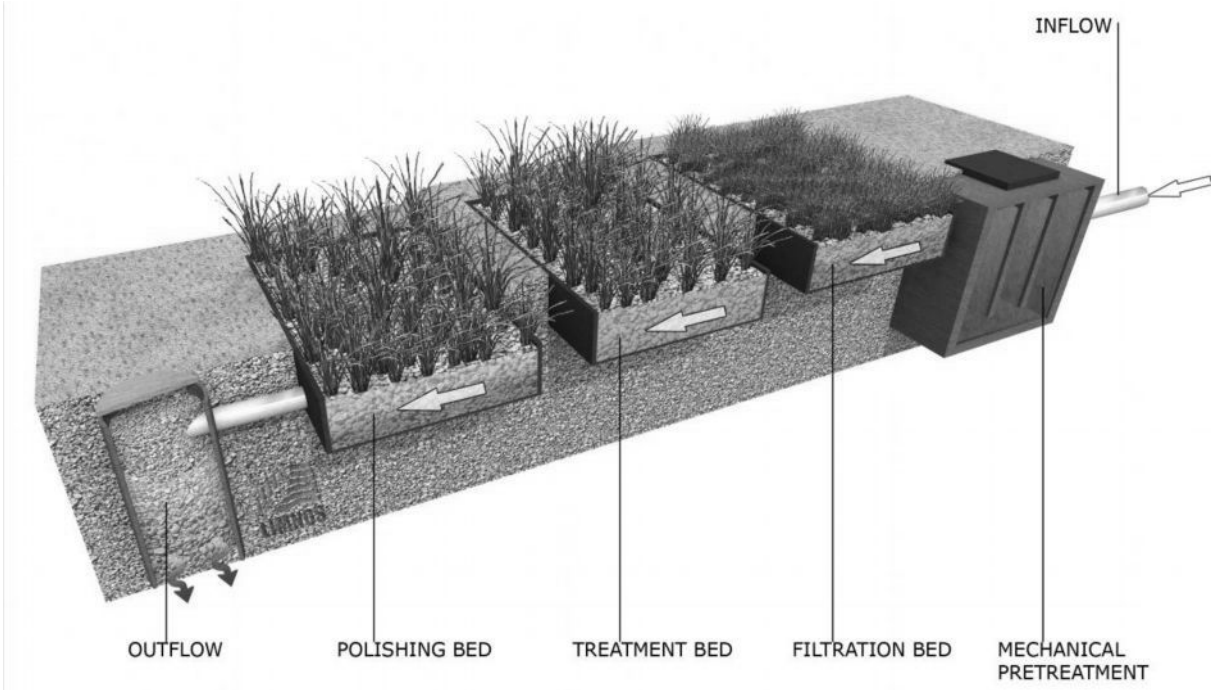

Figure 3: A scheme of design and operation of horizontal subsurface constructed wetland.

2.2. Monitoring of CWs efficiency

The paper presents analysis of treatment performance of some CWs for municipal wastewaters according to the monitoring performance regulated by the Slovenian legislation (OG RS, 2007). According to the legislation, monitoring of the COD and BOD_5 at the inlet and outlet of the small WWTPs with the capacity of less than 200 PE should be carried out every third year, for the WWTP with the capacity between 200 and 1000 PE every second year and each year for the WWTP with the capacity higher than 1000 PE (OG RS, 2007). The focus has been put on CWs with the capacity between 50 in 350 PE which are managed and in the property of the communal companies. On certain CWs, some more extensive monitoring has been performed in the framework of different research programmes. The analyses have been carried out in accredited laboratories.

2.3. Comparison of WWTP costs

For the presentation of cost efficiency of different small scale WWTPs, a data from the study on Small treatment plants on the areas of dispersed settlement have been used (Kompare et al., 2007). Their analysis was performed for WWTPs with dispersed and attached biomass, for constructed wetlands, open water lagoons, and open and closed septic tanks for 5, 10, 20, and 50 PE. Investment, operational and management costs were included in the comparison, taking into account the following parameters:

1. Analysed economic period of investment: 25 years
2. Discount rate: 6%
3. Operating period for construction elements: 25 years, 13 years for mechanical and electrical components
4. Annual tax for environmental pollution: 26 EUR/PE. 85% lowered tax for environmental pollution: 3.9 EUR/PE (the case of constructed WWTP).
5. The price for electricity: 0.1E UR/kWh
6. The price for sludge treatment from open septic tanks and biological WWTPs: 13.3 EUR/m^3
7. The price for sludge treatment from closed septic tanks: 0.52 EUR/m^3
8. The price for sludge transport with 10 m^3 cistern: 1.25 EUR/km
9. Average distance for sludge transport: 50 km.

3. Results and Discussion

3.1. Treatment efficiency of CWs for sewage treatment

The results of the regular monitoring of the efficiency of CWs for sewage treatment are presented in Table 1. The analyses were done in 2008 by accredited laboratories. The CWs were performing in accordance with the legislation requirements (OG RS, 2007).

Table 1: Analysis of performance of CWs for sewage treatment done in 2008 (spring and autumn analysis) performed by accredited laboratories.

		Ponikva at Šentjur	Velika Nedelja	Sv. Tomaž	Planina pri Sevnici	Bazga pri Sevnici
Year of construction		1992 Restoration in 1999	2001	2002	2002	2007
No. of PE connected		350	400	250	550	500
Suspended solids (mg/L)	**In**	29-35	26-82	-	-	-
	Out	10	10	-	-	-
COD (mg/L)	**In**	180-200	120-220	190-200	150	143-448
	Out	21-22	33-60	30	35	20-24
	Norm.	150	150	150	150	150
BOD5 (mg/L)	**In**	-	60-100	50-70	-	-
	Out	4	8	3	8	3.4 - 2

	Norm.	30	30	30	30	30
Tot P (mg/L)	**In**	-	2,3-11	-	-	-
	Out	-	1.2-1.4	-	-	-
Ammonium N (mg/L)	**In**	-	13-40	-	-	-
	Out	-	13-26	-	-	-

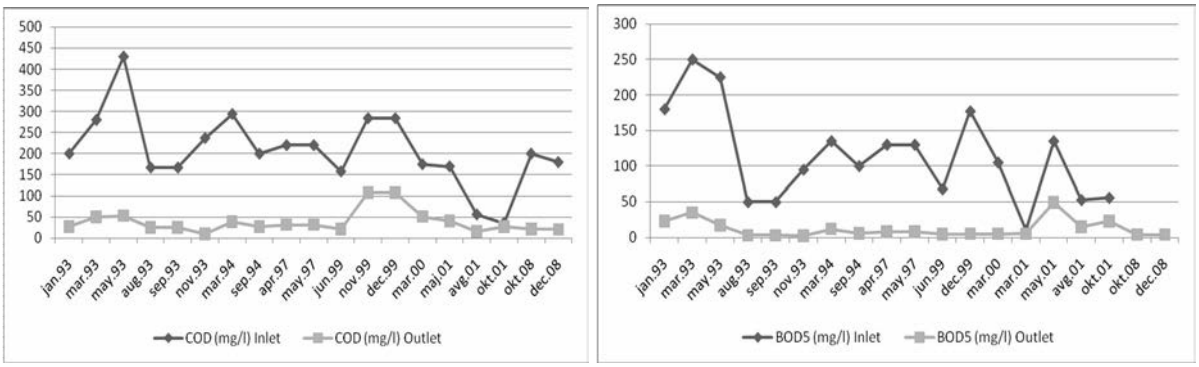

Figure 4: COD and BOD_5 at the inlet and outlet of constructed wetland in Ponikva from January 1993 to December 2008.

Data from long-term mentoring of CW at Ponikva (350 PE) are presented in Figures 4-5. It can be seen that there were higher oscillations in inlet COD and BOD_5 concentrations, while the outlet concentrations remained consistently low throughout the period, except in 1999 for COD. High detected concentrations of COD in 1999 were a consequence of a clogged media. After the replacement of the existing media (being in use from 1992) with the new one, the removal efficiency was high again. In contrast to COD and BOD_5, with constant outlet concentrations, this is not always the case for ammonia concentrations. Outlet concentrations followed the inflow concentrations and showed higher removal efficiency at higher inlet concentrations. The oscillations in removal efficiency are a result of changing oxygen conditions in the horizontal CW system, which have to be oxic in order to enable ammonia oxidation. The oxygenation of the system can be improved by vertical CW systems or intermitted vertical flow of water, which have been introduced in later CW designs. Despite phosphorous is reported by other authors (Arias and Brix, 2005) to be a problematic pollutant in terms of eliminations from wastewater, in this particular CW, efficient P removal has been detected.

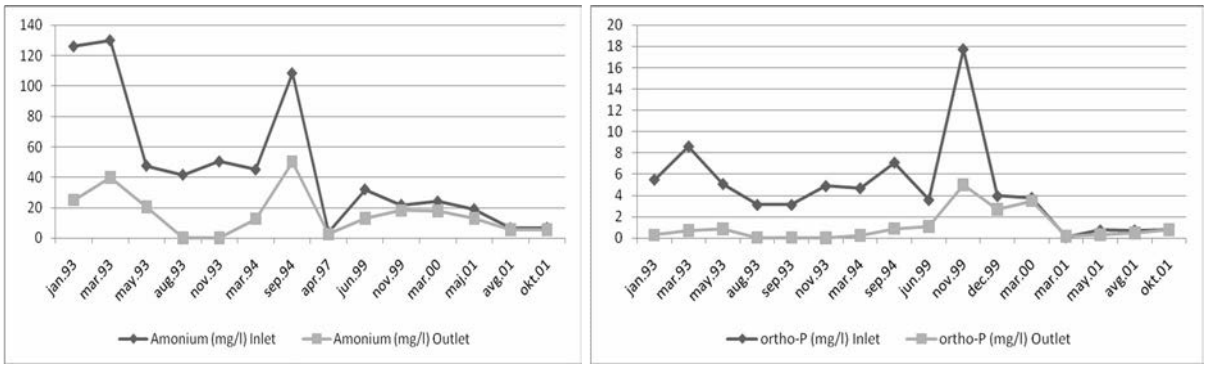

Figure 5: Ammonium and orthophosphate concentrations at the inlet and outlet of constructed wetland in Ponikva from January 1993 to August 2001.

3.2. Decentralised wastewater treatment with CWs in comparison to centralised large WWTPs

Decision between large centralised WWTPs and small decentralised systems is being a big issue. Usually, the costs of treatment per cubic meter of wastewater are being compared, which decrease with greater amount of water and favour big centralised WWTPs. However, this is not always true if we take into account specific settling

pattern due to geographical characteristic and all the investment, operational, environmental and societal costs that occur.

Table 2: Total operational and investment costs for different WWTP, presented per population equivalent (PE) and cubic meter of treated wastewater for 25 year of working period (Kompare et al., 2007).

Size of WWTP [PE]	**5**	**10**	**20**	**50**	**5**	**10**	**20**	**50**
Type of WWTP	€/PE				€/m^3			
Dispersed biomass	1,970.94	1,561.40	1,177.34	755.53	1.44	1.14	0.86	0.55
Attached biomass	1,720.73	1,278.90	1,103.61	804.19	1.26	0.93	0.81	0.59
Constructed wetland	1,180.03	934.78	704.76	452.14	0.86	0.68	0.51	0.33
Lagoon	985.52	851.06	721.97	604.52	0.72	0.62	0.53	0.44
Closed septic tank	8,133.89	7,083.52	6,398.91	6,351.30	5.94	5.18	4.68	4.64
Septic tank with outflow	820.44	664.81	575.59	519.90	0.60	0.49	0.42	0.38

Another issue are small and dispersed settlements with less than 50 PE, which are not included into the agglomerations where municipal companies are in charge for final management of wastewater (Kompare et al., 2007). In these parts, the individuals or small communities should treat wastewater by their own. The right decision about which small or micro WWTP to choose, from the point of view of investment, long-run operational and management costs, is therefore of a high importance. A dynamical analysis of cost efficiency of different micro WWTP, elaborated in 2007 for Slovenia has shown (Kompare et al., 2007), that the highest total costs have closed septic tanks, due to regular need of emptying, transport and treatment of sludge in dislocated units (Table 2). The lowest total costs by this calculation have CWs, open water lagoons and septic tanks with opened outflow. It was evident, that the costs decrease by increase of the PE connected to the WWTP. However, the analysis also showed, that in the case of dispersed settling, where individual households are 100 m or more apart, the only economically sound solution is private treatment plant for each household.

3.3. Ecosystem services of CWs compared to conventional WWTPs

The above dynamic analysis of micro WWTPs costs could, however, go further by comparing treatment efficiency, outside appearance, public acceptance and land requirements, as well as other ecosystem values. Open lagoons for municipal wastewater treatment are actually not in use in Slovenia, since they have even higher land requirements compared to CWs. The open water surface should also be protected against free access. Besides, they present an opportunity for development of unwanted insects and unpleasant odour, especially during the summer months. This is also one of the reasons, why the development of CWs in Slovenia oriented into the subsurface water flow systems. The septic tanks with open outflow should continue with corresponding land percolation field or soil filtration to achieve sufficient final wastewater treatment. This is however not possible to assure in case of hydric soils, which do not support natural soil-column filtration or in case of karstic terrain with percolation and insufficient self-treatment capacity fast. Installation of impermeable CWs treatment beds is therefore an appropriate option.

Today, additional potentials of wetlands, like aesthetic, cultural and ecological benefits are widely acknowledged (Steer et al., 2003; Ogden, 2001). However, the presentation of costs of these systems mainly base on capital costs incurred during the construction and maintenance, while other potentials (aesthetic, ecological and cultural values) are not quantified in a cost-benefit sense (Steer et al., 2003). Steer et al. (2003) however, demonstrated that CW net present value (NPV) costs could be up to 3.000 US$ less than comparable sand filter systems, when considering also ecosystem values and possible aesthetic value of the CW. The NPV costs of the systems were calculated by taking into account the inflation adjusted capital costs (initial installation costs, annual maintenance and possible wetland replacement), which were lowered by considering the ecosystem value of the system and possible aesthetic value of wetlands. The aesthetic value of wetlands was evaluated by using costs associated with installing comparable ornamental gardens

(used just in case of planting ornamental plants into CWs by homeowners). The ecosystem value of wetlands was taken to be 14.785 US$/ha/yr, as calculated by Costanza et al. (1997) from wetland ecosystem services. It was assumed that wetlands can provide several ecosystem services, like gas regulation, disturbance regulation (like flood control), water regulation and water supply (like reuse for irrigation), wastewater treatment, habitat, food production, raw materials, as well as recreation and cultural services. The valuation of these services base mainly on different techniques of estimation of the "willing-to-pay" of individuals for ecosystem services.

Ogden (2001) exposed the atmospheric carbon reduction capacity of CWs which is achieved through energy savings and retention of carbon compounds in the system compared to conventional wastewater treatment systems. Large treatment systems, like sequencing batch reactors, activated sludge, or oxidation ditches, can operate at relatively low costs per amount of treated water, however, the energy consumption remains high and increases with increase of technology complexity (Ogden, 2001). By Ogden (2001) calculation, the activated sludge systems, which are the most common WWTPs, generate between 1 to 4 kg of atmospheric carbon for every kg of carbon removed due to need of energy supply. The CWs can, however, run without energy supply if gravitational flow of water can be achieved, providing therefore both, energy savings and consequently reduction of carbon release. In case that also all carbon, nitrogen and phosphorous from wastewater would be converted into the useful or aesthetically pleasing plants, an ideal carbon sequestering system would be achieved. This is yet, not the case even in wetland systems, since conversion of carbon from wastewater and the whole carbon cycle is very complex, including conversion to carbon dioxide, methane, microbial and plant biomass or preservation of long chain organic compounds in reduced conditions. Wetlands also vary considerably in their carbon cycling and emissions, depending on vegetation type, water table and climate (Brix et al., 2001). By some estimation, only about 2% of carbon from wastewater is sequestered in the wetlands (Ogden, 2001). Nevertheless, a 4 ha natural treatment wetland with an influent carbon of 160 mg/L would therefore sequester 3.4 tones of carbon per year or 0.8 t/ha/yr by this calculation (Ogden, 2001).

From the point of view of primary biomass production in *Phragmites* CWs, it has been found that *Phragmites* produce between 0.3 – 4.5 kg of aboveground dry biomass per square meter per year (Brix et al., 2001). For treatment wetlands in Slovenia, aboveground dry mass of up to 6.5 kg/m^2/yr has been found (pilot CW at Ajdovščina treating municipal wastewater). The ratio between belowground and aboveground biomass for *P. Australis* was evaluated to be ~ 2.5 (Brix et al., 2001). In terms of sequestered carbon this would be between 0.15 – 3.25 kg C/m^2/yr for aboveground biomass and between 0.5 and 11.38 kg C/m^2/yr for total reed biomass, if we assume that 1 g of dry biomass contains 0.5 g of carbon. Assuming that only aboveground biomass can be removed and reused before it enters into natural carbon cycling, as it is the case in the natural wetlands, we would remove between 1.5 – 325 t C/ha/yr from CWs. This are higher numbers compared to calculations performed by Ogden (2001) for natural treatment wetlands, however for a detailed comparison the loading rates of nutrients in wastewater should be taken into account, as well as other environmental data, wetland maintenance practice etc. The results therefore implies on a need for further development of formula for predicting carbon sequestration in such systems (above and belowground parts), based on nutrients in wastewater and complete carbon cycling mechanisms in wetlands.

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ECOREMEDIATION FOR NATURAL RESTORATION OF THE ENVIRONMENT

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Abstract

A concept of using natural processes and systems for environment protection and restoration on the ecosystem level is termed ecoremediation (ERM). Phytoremediation, bioremediation, mycoremedaiton etc. are functional parts of ERM. ERM systems enhance ecosystems services increase of the environment includingpollutant removal, water balance and creation of habitats for wildlife.ERM approaches are multi-purpose, long-term and have positive social effects since they integrate environmental, economic and social development. ERM presents mediation between interference in the environment and nature protection that enables a balance between human needs and preservation of ecosystem services.ERM is mostly used in the form of constructed wetlands (CW), ponds, drainage ditches with treatment beds, buffer zones, vegetation strips,watercourse revitalization etc. CW are used for treatment of different types of wastewater. With connatural rehabilitation of drainage ditches agricultural contaminants are mitigated, water quantities are balanced and new wetland habitats are developed. Buffer zones protect surface and groundwater against dispersed pollution like agriculture, traffic, and act as noise and dust barriers. The basic purpose of watercourse revitalization is the reestablishment of ecologic balance in water and riparian ecosystem. Other important fields where ERM have an important role are water protection, protection against floods and droughts, improvement of life quality in urban areas, sanitation of old burdens, landfill restoration and support to agriculture.

Key words:*ecoremediation, constructed wetlands, revitalization, drainage ditch, ecosystem services*

1 INTRODUCTION

Human activities cause different kinds of pressure on the environment from pollutants emission to physical degradation of habitats. In south-east Europe there are extensive karst areas, marked by expressive shortage of surface water and soil, and by scattered communities. The main pressure on the environment in these areas is absent wastewater treatment reflecting in pollution, which is a serious treat for the extremely sensible underground sources of drinking water. Similar problems are recognized also in the coastal region at the Adriatic Sea, where untreated wastewaters are discharged directly into the sea.In the inland there are often extensive agricultural areas characterized by a high contamination with pesticides and other agricultural contaminants.

The only way to reduce the negative changes in natural processes on local and global scale caused by human activities is the use of natural – ecosystem solutions. With the increasing need to implement sustainable development including environment protection and restoration, suitable technologies are to be developed. The technologies have to be efficient, sustainable, cost-effective and multi-functional and as such they should enhance ecosystem services. Ecosystem services are everything that we can get or benefit from natural ecosystems. They are defined in Millenium Development Goals (Millennium Ecosystem Assessment, 2011), document produced by UN. Ecosystem services are divided in four groups (Figure 1): supporting services (primary production, nutrient and water cycling, etc.), provisioning services (acquisition of food, energy, minerals, etc.), regulating services (pollutant elimination, regulation of water quantities, etc.) and cultural services (recreation, aesthetic appearance, etc.).

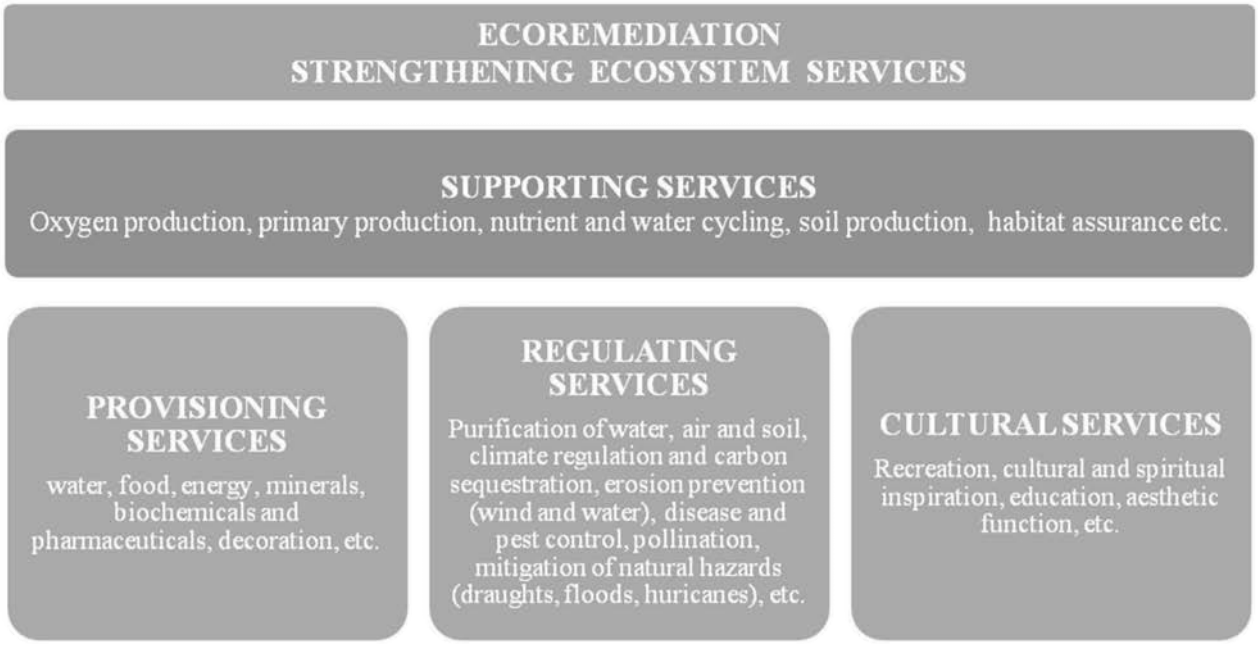

Figure 1: Ecosystem services

A concept of using natural processes and systems for environment protection and restoration on the ecosystem level is termed ecoremediation (ERM). Phytoremediation, bioremediation, mycoremedaiton etc. are functional parts of ERM. They can be used as an efficient tool in sustainable and integrated water resources management, preservation and restoration of ecosystems and habitats to protect biodiversity (Vrhovšek and Vovk Korže, 2007). One of the main aims of ERM concept is to integrate, exchange, combine, and use multi-functionality of different kind of green technologies to obtain innovative and sustainable solutions for environmental protection. With their multi-functionality ERM measures enhance ecosystem services from all four sections, while conventional restoration technologies usually focus on one specific service (e.g. biological wastewater treatment plant only enhance regulating service of water purification).

ERM are used to protect water resources, streams, rivers, lakes, groundwater, coastal areas, air and soil from pollution. Besides protection ERM are usedfor remediation of environmental contamination from point (wastewater discharge) and non-point sources (agriculture, traffic) and for restoration of degraded environment (landslides, erosion, eutrophication). They are also appropriate for protecting sensitive areas (e.g. Natura 2000) and for rational water management in dry areas. ERM systems bind CO_2 from the atmosphere and are therefore a suitable approach in the time of climate change. Besides this, biomass is produced in ERM systems presenting a sustainable energy source.

ERM aremostly used in the form of constructed wetlands (CW), waste stabilization ponds, stormwater ponds, vegetated drainage ditches, buffer zones, vegetation strips,watercourse revitalization etc. Due to complexity of the natural systems and processes, ERM offers a development of many new approaches to the environment protection and restoration. ERM systems are multifunctional: they increase the self-cleaning capacity of the environment, enable water retention (e.g. in a revitalized stream) and restore the habitats for wildlife.

2 EXAMPLES OF ECOREMEDIATION

2.1 Constructed wetlands

Constructed wetlands (CW) are used for treatment of different types of wastewater: municipal and industrial wastewater, pre-treated wastewater, landfill leachate, stormwater, agricultural runoff, polluted drinking water etc. Most spread areCWfor treatment of municipal wastewater. They are widely used for treatment of wastewater in dispersed settlements around Europe and US. Numerous scientific research show that CW enable efficient wastewater treatment in terms of removal of suspended solids, organic matter, nutrients, fecal and other bacteria, heavy metals

and even persistent organic pollutants (Kadlec and Wallace, 2009). Besides this, CWhave high buffering capacity and can quickly adapt to fluctuations in pollutant concentrations and hydraulic loadings. In practice the major advantages of CW are also that they operate without electric equipment and machinery; can be adjusted to available land, they are simple to enlarge and present a green area with additional functions like habitat creation and biomass production. CWare as well cost effective, easy to construct and maintain.

Each CW consists of pre-treatment step (septic tank or sedimentation basin) followed by one or more interconnected beds. Most of CW in Europe are subsurface vertical or horizontal flow wetlands. In those systemsbeds are fitten with impermeable foil and filled with media (most often gravel but also peat, and/or sand) and planted with marsh plants (Figure 2). Majority of CW are planted with common reed (*Phragmitesaustralis*), besides this *Carexgracilis, Typhalatifolia, Schoenoplectuslacustris, Juncuseffusus, Juncusinflexus, Iris pseudacorus* and other wetland plants are also in use depending on local climate characteristics and aesthetic demands of the site.

Besides CW with subsurface water flow, there are also open water wetlands (ponds) with floating, submerged or emergent wetland vegetation. They are cheaper to build and maintain compared to subsurface CW, however the exposure of open wastewater to the surroundingspresents the risk of contact with pathogenic bacteria and spreading of smells. Usually open water wetlands are used for treatment of less polluted wastewaters avoiding the above mentioned risks.

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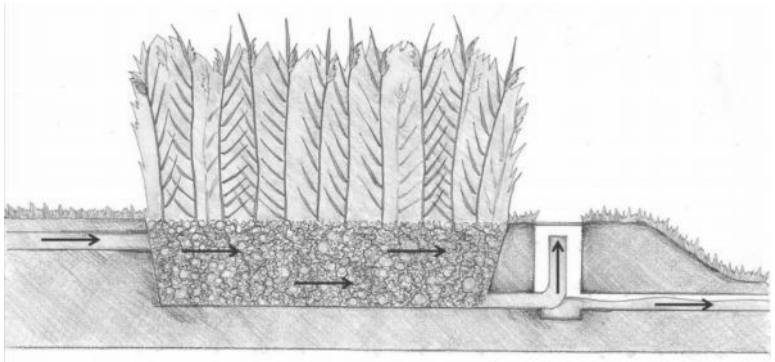

Figure 2: Constructed wetland with horizontal (left) and vertical (right) water flow

CWare also used for stormwater treatment. Most common pollutants in stormwater are biodegradable organic matter, nutrients, heavy metals, organic micropollutants, suspended solids and pathogenic microorganisms (Pitt et al. 1999, Bulc and Vrhovšek 2003). Besides the pollutants content stormwater present the challenge of hydraulic variability that implies higher loadings to the receiving water body. Stormwater treatment system should therefore enable also water detention, to minimize the hydraulic peaks on downstream facilities and/or receiving waters. Open water wetlands or ponds meet these demands. Wet ponds have permanent water pool and a temporary storage volume above it. They can include a silt trap and/or oil and grease trap. They are planted with different wetland plants.

In the last years experiments on treatment of polluted drinking water in CW are carrying out. Microorganisms, nitrates, pesticides and their metabolites and heavy metals from agriculture, traffic, wastewater etc. pollute drinking water and can cause health problems to humans and animals. Several pilot CW have been constructed in order to study the efficiency of CW in elimination of different pollutants from drinking water. The design of CW, used media and hydraulic operation are specific for different pollutants. CW for drinking water treatment also include polishing basins with certain special media (zeolites, peat, activated carbon) to increase the elimination of target pollutants. The main scope of the research is to find out to what extend we can eliminate problematic pollutants from drinking water, what are the possibilities of using CW for drinking water purification and their pros and cons according to classical purification techniques. The preliminary results have shown that CW enable efficient but not 100% elimination of coliform bacteria (Istenič et al., 2008) and high efficiency in elimination of most heavy metals (Vrhovšek, 2011); however the system could only

be used as a pretreatment stage before the discharge to the distribution system.

2.2 Ecoremediated drainage ditches

Typical drainage ditches enable drainage of agricultural land in the areas with high groundwater level. They are constructed as bare canals collecting the water from the fields usually loaded with nutrients and pesticides. The pollutants can freely enter the groundwater and watercourses causing numerous environmental problems. Ecoremediated drainage ditches contain treatment units for detention and transformation of pollutants. Treatment units can be positioned inside the existing canal, which usually has to be widened in order to maintain proper hydraulic conductivity; or the end of the ditch prior the discharge to the water recipient. Water treatment is enabled by filtration through sand media, sorption, uptake into plant biomass and microbial transformations. Besides treatment unit, ecoremediated drainage ditch also contains unit to balance water quantities and units to increase biodiversity.With ecoremediated drainage ditches draught threat is reduced, agricultural contaminants are mitigated and new wetland habitats are developed (Griessler Bulc et al., 2012).

2.3 Vegetation strips for mitigation of dispersed pollution

Different point- and non-point sources of pollution of water are resulting in eutrofication of fresh water environment. This has several consequences, which do not reflect only in low water quality, but also in decline of all other ecosystem services like prevalence of invasive species and reduction of species and habitat diversity in water and riparian ecosystems, reduced self-purification capacity and low aesthetic and cultural value. In extreme cases the pollution can lead as far as to the die-off of organisms due to the occurrence of toxicity.
The main sources of diffused pollution are traffic (exhaust gases, oils, heavy metals etc.), agriculture (excessive nutrients and pesticides), illegal landfills etc. There is no point source of dispersed pollution therefore mitigation measures should be applied in a wide region of pollution origin. There are different ERM measures suitable for mitigation of dispersed pollution, like vegetation strips or buffer zones, stormwater retention bodies and swales, vegetation covers for landfills and similar. Vegetation strips are lines or areas of tree, shrub and grass vegetation that have been used also in the past. Besides protection of surface and groundwater resources they have numerous other functions. Vegetation strips:

- enable retention and decomposition of pollutants,
- present habitat for birds and other animals (pest control),
- act as wind, noise, dust and smell barriers,
- improve aesthetical appearance of the landscape,
- mitigate temperature fluctuation,
- produce biomass that can be used for different purposes,
- enable water retention and mitigate droughts,
- prevent soil erosion etc.

Vegetation strips can be designed as hedges between fields for water protection and pest control, along watercourses to prevent pollution from fields and traffic, along roads for stormwater mitigation and noise reduction, in the catchment area of a drinking water well to prevent pollutant inflow etc.

2.4 Revitalization of watercourses

Numerous watercourses have been regulated in the past decades mostly due to agricultural demands and flood prevention. A canalized watercourse with no riparian areas has changed hydrology (increased drainage causes droughts upstream and severe floods downstream), no appropriate habitats for wild life and consequently reduced self-cleaning capacity. The quality of water deteriorates causing pollution of receiving water bodies and groundwater including drinking water sources. The basic purpose of watercourse revitalization is the reestablishment of ecological balance: to enable appropriate water retention, increase the diversity of habitats and thus self-cleaning capacity. The ecological balance can be established through appropriate water management activities. The activities in Slovenia are focused on small watercourses in which smaller measured can increase the ecosystem balance significantly:

- Weirs with small pools are constructed in the channels in order to improve habitat diversity, aerate and retain water. Weirs also provide a proper fish passages.

- For river bank stabilization willow knits are established. They are constructed from live willow branches which root into the bank and prevent erosion. The shade from willow canopies prevents algae growth and balances water temperature fluctuations. Willow knits also present a new habitat for wildlife.
- Flow deflectors direct and narrow water flow, which causes water to speed up and aerate. Flow deflectors are very efficient in water courses where there is not enough space to create meanders or where we want to diversify the water flow.
- Gulfs and widenings can also be constructed with the main purpose to increase a habitat diversity of a watercourse. They also increase water retention and slow down water flow enabling sedimentation of suspended particles and different treatment processes.
- Gravel beds increase self-purification capacity by filtration through the gravel media. Reeds planted in the gravel bed maintain the hydraulic conductivity of the bed and uptake nutrients.
- River revitalization also includes a vegetation of river/stream banks to provide a suitable shading of a watercourse and biodiversity.

Different revitalization measures are presented in Figure3.

Figure 3: Revitalization measures in a small stream: weir (left), willow knit (middle) and flow deflector (right)

3 CONCLUSIONS

In a last decade several ERM systems were installed in Slovenia:constructed wetlands, vegetated drainage ditches, vegetation strip, ERM for landfill restoration and revitalizations of numerous watercourses.ERM comprise methods of protection or restoration of the environment by means of natural processes existing in ecosystems. Our experiences show that highly efficient protection of water resources including streams, rivers, lakes, groundwater and the sea can be achieved at a relatively low cost. The basic functions of ERMare the high buffer and self-cleaning capacity and habitat creation. ERM technologies concerning water have a high retention capacity and can prevent droughts and flooding as well as instantaneous and specific physical, chemical and toxic pollution.

One of the most significant results of innovative ERM technologiesapplication is the water protection and the considerable saving in investment and management costs. The relevance of the concept is in developing and applying an innovative model for a deepen understanding of environmental and social sustainability to reduce the risk of natural disasters and human health, creating appropriate environmental-policy strategies and regulatory frameworks, reassuring community participation, protection of biodiversity, ecosystems, landscapes and local cultural specifics, and creating educational

opportunities to assure future environmentally stable society.

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EXPERIENCE IN LANDFILL GAS COLLECTION AT NOVI SAD LANDFILL

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ABSTRACT

Only lesser number of landfills in Serbia represent controlled dump sites, the rest of landfills are illegal dump sites. Having in mind that waste management practice is not properly applied in Serbia, there are some problems that occur with landfill gas (LFG) collection. Regular LFG analysis on gas extraction wells was conducted at Novi Sad landfill since 2003 and an idea of gas collection experiment formed. Landfill gas analysis results showed that methane concentrations at some landfill gas wells are in an acceptable range for gas usage, and an idea of gas collection formed. The main goal of this paper is to present results of landfill gas composition and gas flow analysis as well as problems that occur with landfill gas collection at non sanitary landfills in Serbia and possibilities of its utilization.

***Key words**: Landfill, gas, collection, problems, utilization*

INTRODUCTION

Landfill gas (LFG) is a flammable and potentially harmful gaseous mixture consisting mostly of CH_4 and CO_2 together with trace amounts of a number of volatile organic compounds (VOC).

Methane (CH_4) is an important green house gas, with a global warming potential of 21-25 times greater than carbon dioxide (Brasseur, 1998; He 1997, Wuebbles and Hayhoe, 2002). Methane emissions from landfills are estimated to account for 3-19% of anthropogenic CH_4 on a global scale (US EPA 1994). The Kyoto protocol defines the need to reduce imbalance between methane and carbon dioxide emissions, and the White book of the European Union defines the policy for utilizing renewable energy sources. Methane from landfills as an energy source became attractive partly in order to prevent atmospheric pollution, and partly due to energy potential of methane. The policy of increasing proportion of renewable energy sources in the overall energy production, as well as great dependence of energy imports in our country, have oriented re searches towards possibilities for utilizing LFG.

Landfill gas is produced by bacterial decomposition, which occurs when organic waste is decomposed by bacteria naturally present in the waste and in the soil used for landfill cover (Dunfield et al, 1993; Fornes, 2003; Hanson et. al, 1996; Higgins et. al, 1981; Wise et. al, 2001). When deposited in a landfill a proportion of biodegradable waste fraction will begin to degrade through biological and chemical reactions. Waste components that contain significant biodegradable fractions are food, garden waste, textiles, paper, and cardboard products. Bacteria decompose organic waste in four phases, and the composition of the gas changes during each phase (Cheremisinoff, 2003). Permanencies of methane generation rate and concentration level are crucial for determination of landfill gas energy potential. For achieving optimum energy utilization, composition, and constancy of land fill gas, the generation level represents the most important factors. However, there are many factors affecting the composition and generation of land fill gas. The most important factors are meteorological parameters (temperature, precipitation, atmospheric pressure, and air humidity), age and type of waste, as well as the site management practice (Akesson, 1998; Mata-Alvarez, 2003). Meteorological parameters have great influence on the generation, composition, and migration of landfill gas into landfill body. Decreases in atmospheric pressure are associated with increased emissions of LFG and hence methane from landfills. Precipitation, snow cover and ice sheets at the landfill surface may substantially influence on emission and

composition of landfill gas (Meres et. al, 2004, Christophersen et. al, 2001). However, increased precipitation may result in enhanced generation of CH_4. Seasonal changes also affect on landfill gas generation.

LANDFILL GAS GENERATION PROCESS

Methane production is an anaerobic biological process. It occurs naturally in the gut of living organisms, such as cows and humans, or on landfills in absence of oxygen. In MSW landfills organic components start to undergo biochemical reactions after disposal. In the presence of atmospheric air that is near the surface of the landfill, the natural organic compounds are oxidized aerobically, a reaction that is similar to combustion because the products are carbon dioxide and water vapor. However, the principal bioreaction in landfills is anaerobic digestion that takes place in three stages. In the first, fermentative bacteria hydrolyze the complex organic matter into soluble molecules. In the second, these molecules are converted by acid forming bacteria to simple organic acids, carbon dioxide and hydrogen; the principal acids produced are acetic acid, propionic acid, butyric acid and ethanol. Finally, in the third stage, methane is formed by methanogenic bacteria, either by breaking down the acids to methane and carbon dioxide, or by reducing carbon dioxide with hydrogen (Schwart R., et. al., 2005).
The process that produces methane is a naturally occurring process that can be managed, and is compatible with nutrient recycling, waste treatment, and odor control at landfill site. Both temperature and pH are critical to the production of methane. Methane only occurs in the absence of oxygen (anaerobic atmosphere), but can occur between 4° C and 60° C. Gas production increases with increasing temperature and anaerobic bacteria are most comfortable in a slightly alkaline environment (pH 7.5-8.5) (Schwart R., et. al., 2005).
Methane produced in an anaerobic landfill conditions is similar to natural gas emerging from a gas well. However, natural gas has a higher calorific value than pure methane because natural gas contains other high energy hydrocarbons. Methane in the presence of oxygen is a highly combustible gas and it can be burned in an internal combustion engine to turn an electricity generator or to heat water (Schwart R., et. al., 2005).
Part of the methane generated in landfills can be captured and used as a renewable energy source. In contrast, when methane is allowed to escape to the atmosphere, it has a global warming potential that IPPC estimates to be 23 times greater than that of the same volume of carbon dioxide (Themelis J.N., Ulloa A.P., 2006).
The simplest utilization of landfill gas is burning it with flare, which represents better solution to letting the gas go freely in the atmosphere.

NOVI SAD LANDFILL CHARACTERISTICS

The existing landfill is located 6 km north of the Novi Sad city centre. The distance from the nearest residential settlements is around 700 m (Vujic, et. al., 2010).
Total area of land fill covers 56 ha of which area covered by waste is approximately 22 ha, with fill depth of 2.5-15 m. Landfill has been operating almost 30 years and around 2.400.000 m^3 of municipal and building-demolition waste have been deposited until this day. Today landfill receives 360 tons of waste per day, while 3.6 tons of recyclables per day is extracted within the waste separation unit located at the landfill site. Remaining amount of waste is landfilled without any pretreatment. After closure of this site, waste will be deposited at the new landfill site which is located near operating landfill (Vujic, et. al., 2010).

Landfill exploitation started on Field IIIa (see figure1), and after closure of that field it continued on Field I, Field II, and Field IIIb. During closure of Field I, Field II, and Field IIIa in 2001, waste was covered with inert material. Also, leachate drainage and passive gas extraction system were installed and collection tanks for leachate were built. These improvements have contributed to elimination of odors, prevention of water courses pollution and reduced risk of explosion. During closure, installation of gas extraction wells was also performed in order to enable migration of landfill gas into the atmosphere and to prevent accumulation of methane in land fill body. The Field I has 29 gas extraction wells installed, Field II has 33, while Field III consists of two subfields IIIa and IIIb, with 43 gas extraction wells. The wells are distributed across entire landfill body but most of them were placed near land fill boundaries in

order to prevent horizontal migration of landfill gas outside the landfill body (Vujic, et. al., 2010).

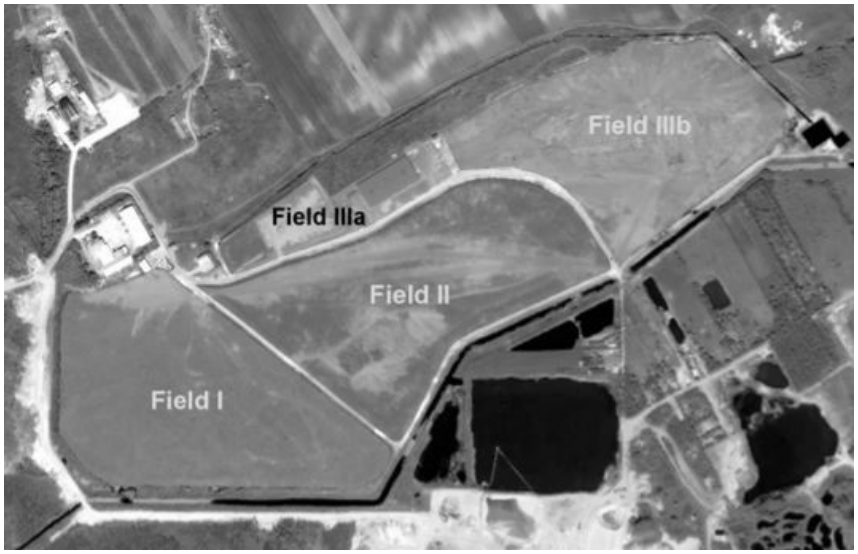

Figure 1: Position and view of Novi Sad landfill (Vujic, et. al., 2010)

Installed passive system for landfill gas extraction, passive gas wells, operates on pressure difference and gas diffusion from landfill body into the atmosphere (Gebert and Groengroeft, 2006). Adopted standards for passive systems are ventilation openings "wells" which are made from perforated plastic tubes wrapped with a layer of gravel (see also figure 2). Extraction well diameters are 0.5-1.0 m and their depth varies 50-90% of the waste depth (Vujic et. al., 2010).

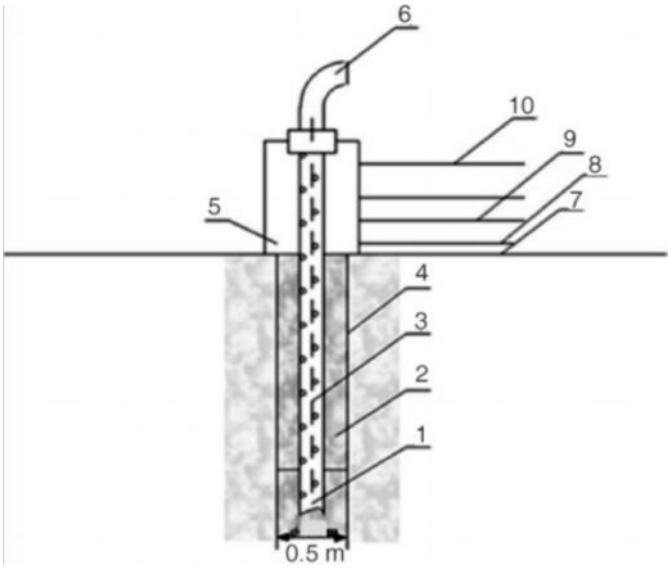

Figure 2: Gas extraction well scheme: (1) – existing garbage, (2) – gravel with granulation over 32mm, (3) – plastic perforated tube Ø160mm, (4) – protective insulation, (5) – concrete cover Ø700mm, (6) – exhoust pipe, (7) – final layer of waste, (8) – foil, (9) – inert cover, (10) - humus (Vujic, et. al., 2010)

EXPERIMENTAL LFG COLLECTION SYSTEM

Concentration of methane in LFG at gas extraction wells at Novi Sad landfill had been monitored for several years, but gas analysis was more frequent and more detailed particularly in last 3 years, when, whole landfill area had been covered with wells. The gas analysis was carried out four times per year (one analysis per season) and its results implied that there are 14 wells with concentration of methane higher than 25%vol, of which 10 are located at Field IIIb.

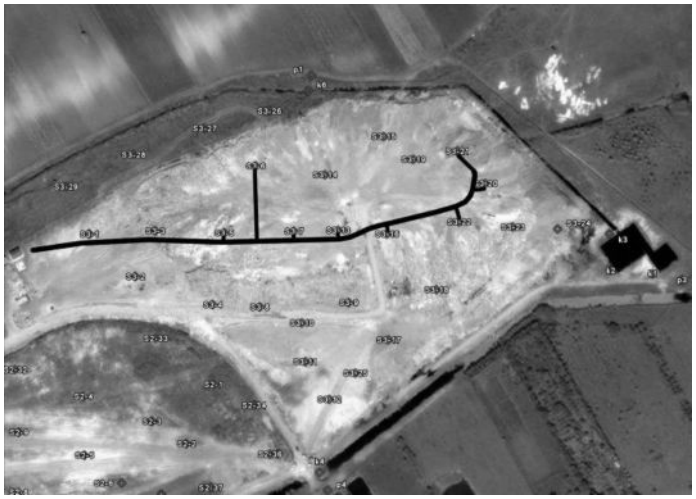

Figure 3: Connected gas extraction wells and main pipeline

This field is most appropriate for building experimental LFG extraction pipeline as it is closed for garbage disposal for 3 years and there are no machines working at it. Other than that, this field is the only one that was recently closed hence the methane production is at its beginning phase. Having all this in mind it was decided that Field IIIb is the best option for conducting research.

Based on perennial landfill gas analysis which showed constant high concentration of methane gas at several wells the decision was made to experiment with connecting these wells on a central pipeline, to investigate their behavior and possibilities of LFG usage and its benefits at non sanitary landfills. The idea behind this project is to learn how LFG collection would work on non sanitary landfills and to use the collected gas for operating an infra red heater or some other low cost and low demand technology for landfill gas utilization or for transformation of methane from landfill gas to carbon dioxide, thus reducing the amount of methane gas released to the atmosphere.

The main pipeline had been constructed with 8 gas extraction wells connected to it, these wells fulfilled certain criteria, (see figure 3) and then connected to the side channel blower with frequency regulator (figure 4). The criteria for well selection were the methane concentration and proximity to the pump station. Methane concentration at these wells ranges from 15–53%vol depending on the well and time of the year (see table 1).

Figure 4: Side channel blower

Table 1: Results of seasonal gas analysis at connected gas extraction wells

Well	Concentration [%vol]									
	August 2009.	November 2009.	December 2009.	April 2010.	July 2010.	November .2010.	February 2011.	July 2011.	September 2011.	December 2011.
S3-5	24,2	34,1	-	22,7	15,7	29,5	19,5	23,3	19,9	8,7
S3-6	50,5	30,4	30,2	28,6	25,5	47,1	29,3	25,6	21	16,2
S3-7	42,4	21,5	20,9	43,4	29,1	44,1	30,9	35	33,6	28,6
S3-13	46,3	34,1	33,1	59,6	21,1	59,8	42,5	34	33,6	26
S3-16	40,5	46	49,4	61,3	53,2	51,5	35,1	35,2	32,2	22,7
S3-20	40	58,7	59,8	60,9	52,7	58,1	53,8	47,8	39,8	32,2
S3-21	49,1	49,8	51,3	45,5	-	50,4	38,9	37,4	37	34,5
S3-22	46,5	-	62,9	59,5	25,7	39,9	27,8	24,2	44,4	36

Based on results from table 1, beside seasonal fluctuations, it is noticeable that there is a difference in methane production during the monitoring period of 3 years at these wells. This indicates that there are different stages of organic waste decomposition which depends on various time of disposal of organic waste at different parts of landfill.

When the pipeline was put into operation first measurements were taken and gas flow adjusted to avoid excessive gas drainage and with it oxygen infiltration through the landfill surface. Methane concentration at exhaust of the pump was measured at 35.5%vol with flow rate of 26m^3/h, but unusually high concentration of oxygen emerged (7.6%vol). Later inspection of pipeline showed that this was due to incorrectly built gas extraction wells (figure 5) and too high gas flow through the line.

Oxygen infiltration into the body of a landfill is not preferable, because its presence would replace the anaerobic conditions with aerobic and there would be no methane production during the organic waste decomposition. To prevent oxygen infiltration into the landfill body there are two possible solutions. First is to seal the landfill with bentonite cover or with PVC lining, and second solution is to extract the gas at its natural flow rate.

Because of inadequate cover, at Novi Sad landfill we are facing with oxygen infiltration through the landfill surface, and therefore, greater vacuum values and greater gas flows cannot be applied to this landfill gas collection system.

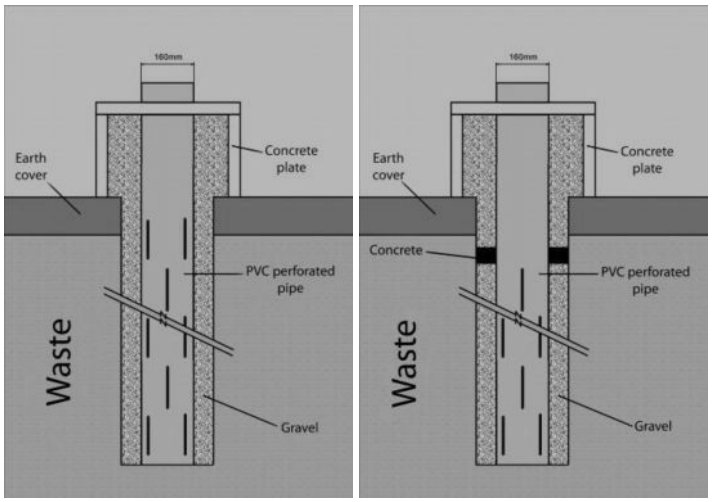

Figure 5: On the left – incorrectly built well, on the right – correctly built gas well

Modifications to the wells were needed to correct the flaws in their construction. The action consisted of putting a 110mm wide solid pipe, 3m long with two seal rings into the well. The diameters of the seal rings are 159mm and 170mm. The purpose of the smaller seal ring is to reduce the amount of oxygen pulled from the surface part of the perforated well pipe as it is placed 2.5m into the well and purpose of the larger ring is to hold the smaller solid pipe from falling into the well (figure 6). All the junctions at the wellheads were sealed with silicone to ensure there is no air infiltration at the pipeline itself. This action showed little effect because of absence of valve at the wellhead which regulates gas flow through the well and because there is no way of making a perfect seal at that depth.

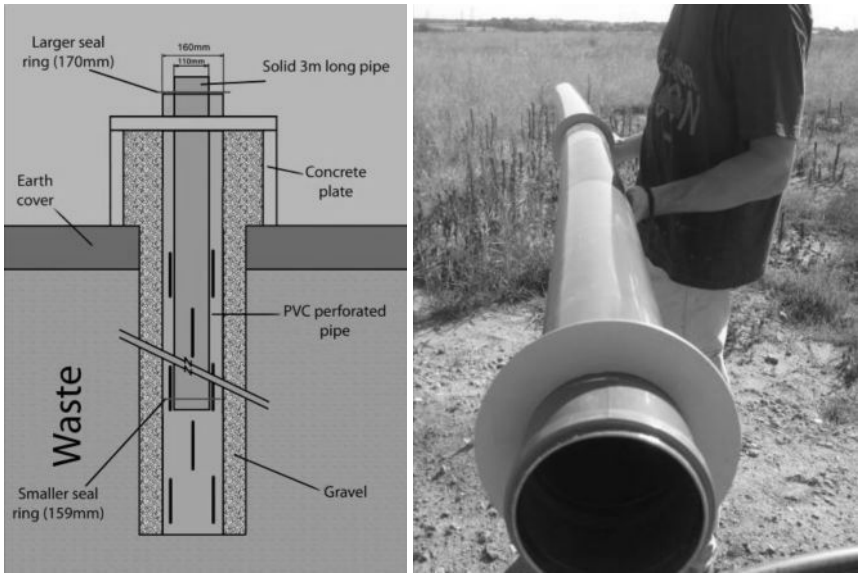

Figure 6: On the left – modifications done to the gas extraction wells; on the right – solid pipe drawn into the well

After the modifications to the wells mentioned above and adjustment of the gas flow another set of gas analysis were taken. As mentioned above the results of well modifications showed little effect, methane concentration was unchanged, which was not so unusual, but the oxygen concentration was unchanged also. Because of high oxygen concentration the only solution to remove its presence was to further reduce the gas flow rate through the pipeline. When gas flow was reduced from 26 to 13m^3/h, oxygen levels in the pipeline dropped to 3.4%vol which is an acceptable value for safe combustion and methane concentration rose to 47%vol (figure 7).

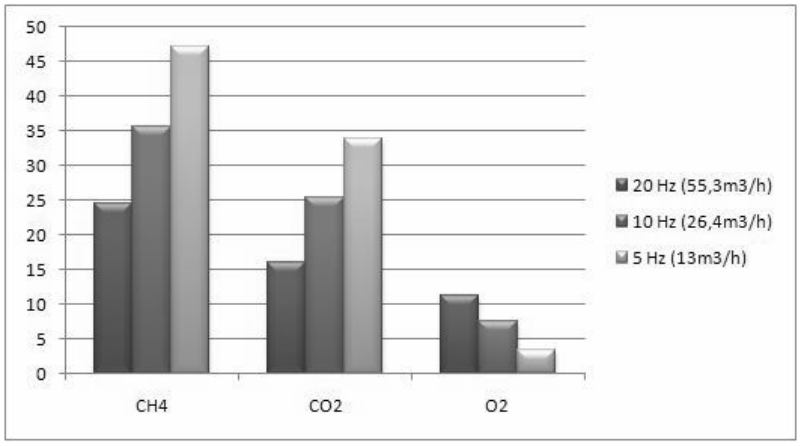

Figure 7: Methane, carbon dioxide and oxygen concentrations at different gas flow rates

CONCLUSIONS

This is the first project of this type in Republic of Serbia and this paper is representing operational and managing problems occurring during project development. There are some modifications to the pipeline that need to be done before the project is finished. To be more precise, a valve to each wellhead needs to be installed in order to reduce the oxygen infiltration into the landfill body and pipeline itself.

The most important part of collecting landfill gas which this project showed is careful gas extraction at non sanitary landfills. The landfill processes are giving off methane at their own rate and it can be collected at that rate only. Any excessive gas collection, especially at non sanitary landfills, will result in shutting down of methanogenic processes, and as a direct consequence, a drop in

methane production. This is the result of the oxygen infiltration from the surface through the landfill surface into the landfill body thus creating conditions for aerobic waste decomposition.

After the modifications are placed and gas flow adjusted at each well it will be time to install a flare or infra red heater that will use the collected landfill gas.

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VODA POSTAJE VRHUNSKI PRIORITET

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Rezime

Balans između potreba i raspoloživosti voda dostigao je kritični nivo u mnogim područjima svijeta, pa pitanje voda postaje i u Evropi centralno pitanje. Za osiguranje „mudrog i održivog rasta“, kao vrhunskog općeg cilja EU2020, Evropska komisija intenzivno radi na formulisanju i podsticanju uspostavljanja „Inovativnih platformi“ za efikasnije i održivo korištenje i zaštitu vodnih resursa. Evropska komisija priprema za 2012. godinu dokument „Plava knjiga“, u kome će se procijeniti dosadašnji i odrediti budući pravci EU vodne politike, s posebnim naglaskom na klimatske promjene i integralno upravljanje ekstremnim hidrološkim događajima, efikasno korištenje prirodnih resursa i međunarodnu saradnju, te integraciju vodne politike u ostale politike EU. Nakon razmatranja stanja u BiH, zaključuje se da je ona na dobrom putu, ali da ide veoma sporo, te da će dinamiziranje vodnih inicijativa u Evropskoj uniji, te brži napredak BiH susjeda Crne Gore, Hrvatske i Srbije, dovesti do dinamiziranja aktivnosti u sektoru voda i u BiH.

***Ključne riječi**: Voda, vodni stres, Okvirna direktiva o vodama, EU vodne inicijative, Plava knjiga, BiH vodna politika*

VODA KAO IZAZOV

Tu je oko nas, pored nas, ispod i iznad nas. Voda – osnova života i ekonomije, temelj poljoprivrede i industrije, resurs u proizvodnji svake energije i osnovni pokazatelj stanja našeg okoliša. Dok je ima, čiste i zdrave, u prirodi i u cijevima vodovoda, ili barem podnošljivog kvaliteta u rijekama i jezerima, ni premalo, ni previše, sve je u redu. Ali, u stvarnosti je sve manje u redu – sve je više redukcija u vodosnabdijevanju, pa čak i u Sarajevu, u njegovom centru. Miljacka često i sve više širi neugodne mirise i potencijalnu zarazu! Ni korita ostalih rijeka nisu prošlog ljeta bila mnogo bolja, dakle sve je manje vode, i sve je zagađenija, kada nam najviše treba, a sve je više vode kada je ima previše, pa su nam i poplave sve češće i sve veće. Prema tome, „vodni stres“ je već tu. Klimatske promjene ubrzavaju ove procese. Balans između potreba i raspoloživosti voda dostigao je kritični nivo u mnogim područjima, kako u Evropi, tako i kod nas, u BiH, Crnoj Gori i ostalim zemljama regije.

Zašto je to tako? Da li svježih voda stvarno nema dovoljno, ili se vodama ne upravljamo dovoljno dobro? Biće ovo drugo, jer voda u prirodi, a pogotovo kod nas, u jugoistočnoj Evropi, ima jako mnogo, čak preko 10.000 m^3/stanovniku godišnje (www.water.worldbank.org)! Vodama se u stvari ne upravlja dobro, vode se preko svake mjere razbacuju i zagađuju, a kada su nam najpotrebnije, onda ih nema dovoljno. Vodna infrastruktura nam je izrazito nedovoljna, zastarjela i dotrajala, često veoma neekonomična – a onda su i najambiciozniji i najsposobniji vodni menadžeri malo šta u stanju uraditi!

Da bi unaprijedili ili nastavili uživati u kvalitetu raznih usluga koje je našem društvu i privredi pružala i pruža voda, moramo osigurati dovoljnu snabdjevenost svih korisnika vodom zadovoljavajućeg kvaliteta, za njeno održivo i pravedno korištenje. Zato je već u Evropi, a moralo bi to hitno postati i kod nas, pitanje vode centralno pitanje veće od svih ostalih pitanja, čak bi se moglo reći da politika upravljanja vodama u Evropskoj uniji postaje politika svih politika (www.ec.europa.eu/environment/water).

VODA U EVROPSKOJ UNIJI

Godina 2011. je u EU bila godina resursne efikasnosti, razvoja nisko-karbonske ekonomije bazirane na znanju, te razvoja sposobnosti za održive odgovore na izazove, s kojima se EU suočava na svjetskom tržištu. Ova, 2012. je godina voda (www.water/blueprint).

Razumijevanje važnosti i ozbiljnosti vodnog stresa u EU, u posljednjih par godina proširilo se na sve njene institucije i politike povezane s vodom. Kao svjetski izazovi posebno relevantni za Evropu, iskristalisali su se:

- Globalizacija, sve više i praktično svega (neki će reći da se radi u stvari o globalnoj dominaciji Amerike, ali to za nas u BiH ili Crnoj Gori uopće nije bitno);
- Globalno zagrijavanje i klimatske promjene;
- Povećavanje međuzavisnosti snabdijevanja energijom, vodom i hranom;
- Starenja stanovništva;
- Javno zdravlje; te
- Sigurnost i zaštita ljudi i dobara.

Na bazi ovoga, i bazirajući se na svojoj poznatoj strategiji EU2020, u EU je u toku:

- Preispitivanje dosadašnje vodne politike, kao dijela razvoja resursne efikasnosti i zaštite evropskih vodnih resursa. Analizira se dosadašnja implementacija postojećih EU vodnih politika, posebno Okvirne direktive o vodama (WFD iz 2000.), te sve ostale legislative povezane s WFD, uključujući i Zajedničku poljoprivrednu politiku (CAP – podsticaje u poljoprivredi, jer se tu radi o najviše novca, kako na nivou EU, tako i u svakoj zemlji članici i potencijalnoj članici);
- Za osiguranje „mudrog i održivog rasta“, kao vrhunskog općeg cilja EU2020, Evropska komisija intenzivno radi na formulisanju i podsticanju uspostavljanja „Inovativnih platformi“ za mudrije, efikasnije i održivo korištenje i zaštitu vodnih resursa. Ovo je najnoviji proces optimizacije korištenja postojećih naučnih i istraživačkih instrumenata i potencijala, podsticanja prekogranične saradnje u oblasti voda i okoliša, te osiguranja sinergije među državama i sektorima neposredno povezanim sa okolišem i vodama. Osim poljoprivrede, težište je i na unapređenju upravljanja vodama u industriji, radi otklanjanja poteškoća u vodosnabdijevanju i tretmanu otpadnih voda, a sve radi povećanja konkurentske sposobnosti EU ekonomije na globalnoj sceni;
- Općeprihvaćeni principi „zagađivač plaća“ i „korisnik plaća“ povezuju se s pravom pristupa vodi i vodnim servisima svih kojima je voda potrebna - ljudima i ekosistemima, posebno naglašavajući princip tretiranja zagađenja na mjestu nastanka, integralno upravljanje vodnim resursima na nivou riječnih slivova, te opcije mjera mitigacije i adaptacije na klimatske promjene.

DOPRINOSI PREDSJEDAVAJUĆIH EU 2011-'12

Za vrijeme svog predsjedavanja EU, u prvoj polovici prošle godine, Mađarska je proširila kontekst u kome se razmatraju vode u EU, posebno podstičući integrisanje upravljanja vodama u sve relevantne EU politike (dr Sandor Fazekas, Ministar ruralnog razvoja, X/2011, www.eu2011.hu). Vode će imati specijalni status u aktuelnoj inicijativi o „Resursno efikasnoj Evropi do 2020“, zatim razvoju nove strategije za zaštitu EU biodiverziteta, budućoj elaboraciji evropske Strategije održivog razvoja te analizi Šestog okolišnog akcionog programa. Obnovljena „Koheziona politika“ i novi finansijski okvir za CAP će se iskoristiti za fokusiranje na vodnu politiku, posebno zbog toga što je poljoprivreda najveći potrošač i najveći zagađivač vodnih resursa u EU. Zato će tekuća reforma politike podsticaja u poljoprivredi sigurno imati veoma signifikantne reperkusije u budućoj vodnoj politici EU.

Poljska se u svom mandatu, u drugoj polovici prošle godine, između ostalog, posebno posvetila unaprjeđenju kvaliteta visokog obrazovanja i naučnih istraživanja, podsticanja mobilnosti istraživača i studenata, stavljajući tako intelektualni kapital u prvi plan. Okoliš i posebno upravljanje vodama su tu, jer su ovi prioriteti usko povezani sa promocijom „ozelenjavanja“

Evropske ekonomije, ciljevima u oblasti energetike i suočavanjem s klimatskim promjenama, te boljim regulisanjem upotrebe i zagađivanja hemikalijama. Ekonomska kriza je ozbiljna, jer je to ujedno i kriza upravljanja prirodnim i drugim resursima, uključujući vodama. Ekonomskog oporavka i novog zapošljavanja nigdje u Evropi nema bez unaprjeđenja konkurentnosti, a unaprjeđenja konkurentnosti nema bez substancijalnog unaprjeđenja resursne efikasnosti.

U prvoj polovici 2012. predsjedavajuća EU je Danska. Na nedavnom susretu u Evropskom parlamentu, danska ministrica okoliša, g-đa Ida Auken, naglasila je: „Unaprjeđenje resursne efikasnosti neće unaprijediti samo konkurentnost i profitabilnost Evropskog biznisa. Efikasno korištenje resursa je takođe put prema održivom upravljanju našim prirodnim resursima u širem smislu – energetske sirovine, zemljište, zrak, biodiverzitet i naravno voda. Ako želimo naš finansijski sistem održati, vjerujem da je zelena transformacija ekonomije ne samo pravi put naprijed, nego je to nužni izlaz iz krize“(www.epwatergroup.eu). I dalje, gospođa Ministrica naglašava:

- Vodna politika ima ključnu ulogu u zelenoj tranziciji Evropske ekonomije;
- Čista voda je vitalan preduslov za život uopšte; i
- Ako se nastavi kao da sada, voda će do 2030. postati vitalno ograničavajući faktor i u Evropi, jer će je u sušnim periodima nedostajati i preko 40%, upravo onda kada je najpotrebnija.

Suše i uopšte nedostatak vode su danas glavni razlog katastrofalne gladi u Istočnoj Africi. U 2030. se očekuje da 50% svjetske populacije živi u regionima s nedovoljno vode. Nedostatak vode je takođe jedno od glavnih ograničenja za dalji rast u Kini, pa je voda i tamo postala top prioritet u petogodišnjem razvojnom planu. Dakle, svugdje su neophodne velike investicije u vodnu infrastrukturu i štednju voda.

CILJEVI „PLAVE KNJIGE“

Evropska komisija priprema za 2012. godinu krucijalni dokument od dalekosežnog značaja, pod naslovom „Plava knjiga za zaštitu evropskih vodnih resursa (Blue-print, Plava knjiga)“. U njoj će se procijeniti dosadašnji i odrediti budući pravci EU vodne politike. Posebno se apostrofiraju sljedeće teme:

- Klimatske promjene i vodna politika;
- Integralno upravljanje ekstremnim hidrološkim događajima;
- Efikasno korištenje prirodnih resursa;
- Uloga usluga ekosistema, uključujući pošumljavanje;
- Važnost međunarodne saradnje; i
- Integracija vodne politike u ostale politike EU.

Pošto je u EU reafirmisano da je voda vitalni resurs za ljudsko zdravlje i osnovni input za mnoge sektore društva, uključujući poljoprivredu, turizam, industriju, transport i energiju, Plava knjiga za zaštitu evropskih vodnih resursa će imati opći cilj da se osigura dovoljna snabdjevenost vodom dobrog kvaliteta svima kojima je potrebna, za njeno održivo i pravedno korištenje. Generalni direktorat za okoliš i lično komisioner Janez Potočnik vode pripreme da se do kraja 2012. godine uradi ovaj, za vode u EU i budućim članicama EU, može se reći, epohalni dokument. Pripreme se baziraju na tri ključna stuba:

- Procjena Planova upravljanja riječnim bazenima, koje Evropskoj komisiji od prije nekoliko godina dostavljaju zemlje članice u okviru implementacije WFD;
- Preispitivanje politike EU u vezi nestašica vode i suša; te
- Procjena osjetljivosti vodnih resursa na klimatske promjene i druge ljudske pritiske.

Ispitaće se iskustva tekućih politika i legislative EU u oblasti voda i okoliša, te identificirati:

- Inicijative za osiguranje bolje implementacije okvirne legislative i politika;
- Bolja integracija vodne politike u druge okolišne politike i politike drugih sektora, kao što su poljoprivreda, transport i energija; te
- Inicijative za novu legislativu, gdje to bude odgovarajuće.

Uloga inovacija u unapređenju upravljanju vodama na svim nivoima može igrati ključnu ulogu, te će se podsticati partnerstvo u vodnoj efikasnosti. Generalni direktorat (DG) Okoliš je pokrenuo veliki broj studija o upravljanju

vodama, u saradnji sa mnogim EU institucijama, kao npr. DG JRC (Zajednički istraživački centar), DG Eurostat (Evropska statistika), DG Istraživanje i razvoj, Evropska agencija za okoliš i drugim. Analitički rezultati ovih studija predstavljaju solidnu bazu za formulisanje opcija buduće vodne politike, da bi se dostigli prioriteti EU2020, prije svega mnogo viša resursna efikasnost, zelenija i konkurentnija ekonomija, bazirana na znanju i inovacijama te, uz visok nivo zaposlenosti, ekonomska, socijalna i teritorijalna uravnoteženost.

„Zelena sedmica (Green Week)" – redovna godišnja proljetna manifestacija EU o okolišu, prošle godine je bila posvećena uopće resursnoj efikasnosti, pod geslom „Trošiti manje, živjeti bolje". Ove godine, sva će biti posvećena vodama, a paralelno s njom će se održati i Evropska konferencija ministara nadležnih za vode (www.greenweek2012). Poseban naglasak je na:

- Upravljanju potrebama za vodom;
- Unaprjeđenju vodne efikasnosti u urbanoj infrastrukturi, zgradama, industrijskim procesima, poljoprivredi, turističkoj infrastrukturi i proizvodima koji koriste vodu;
- Prostornom planiranju radi unaprjeđenja mogućnosti zadržavanja voda iz kišne u sušnu sezonu (retenzije i akumulacije), zaštiti od poplava i obezbjeđenju ekološki prihvatljivih proticaja; zatim
- Upravljanja hidrotehničkom infrastrukturom za pitku vodu, kanalizaciju, navodnjavanje, upravljanje poplavama i drugo; te
- Inovacijama u sektoru voda.

U svakoj od navedenih oblasti, predviđaju se pravne mjere i standardizacija, podsticaji i drugi ekonomski instrumenti, te kreiranje javnog mnijenja i odgovarajućih komunikacionih instrumenata. Već su u toku konsultacije s direktorima agencija za vode u zemljama članicama i grupama za zajedničke strategije implementacije WFD.

ŠTA SE RADI U BiH ?

Juna 2008. BiH je potpisala Sporazum o stabilizaciji i pridruživanju sa EU, kojim je potvrđen status BiH kao potencijalnog kandidata za članstvo u EU. Nakon usklađivanja legislative, od velikog značaja je njena implementacija, koja je u sektoru voda u BiH započeta usvajanjem entitetskih Zakona o vodama 2006. godine i početkom njihove implementacije 2008. Transponiranje zahtjeva WFD i drugih direktiva relevantnih za sektor voda u domaće zakonodavstvo, prema ocjeni EU (www.delbih.ec) je za sada:

- Okvirna direktiva o vodama, 90 % u FBiH i 100 % u RS (prema izvještaju RECa iz 2008);
- Direktiva o prečišćavanju komunalnih otpadnih voda, 35 % u FBiH i 41 % u RS;
- Direktiva o nitratima, 11 % u FBiH i 22 % u RS; te
- Direktiva o kvalitetu vode namijenjene za ljudsku upotrebu, 58 % u FBiH i 87 % u RS.

Politika upravljanja vodama određuje se Strategijom upravljanja vodama za period 2010-2022. Strategija je u formi nacrta u FBiH izrađena u aprilu 2008, ali je u Parlamentu konačno usvojena tek 20.12.2011 (www.fmpvs.gov.ba). Republika Srpska je izradila i usvojila Okvirnu vodoprivrednu osnovu još 2006. godine (www.voders.org). Za punu primjenu Zakona o vodama nedostaje još niz podzakonskih akata, od kojih su najvažniji oni koji određuju:

- Monitoring i sadržaj programa monitoringa;
- Referentne uvjete za klasifikaciju ekološkog stanja vodnih tijela površinskih voda i podzemnih voda;
- Postupak provođenja ekonomske analize korištenja voda;
- Metodologiju za određivanje ekološki prihvatljivog proticaja;
- Propis o uspostavljanju ciljeva zaštite okoliša; te
- Detaljni sadržaj i način donošenja planova upravljanja riječnim slivovima na vodnim područjima rijeke Save i Jadranskog mora.

Trenutno su u toku sljedeći značajniji projekti:

- Međunarodna saradnja u okviru priprema za izradu Plana upravljanja vodama sliva rijeke Save, te Konvencije o zaštiti vodnih resursa bazena rijeke Dunav;

- Izrada karakterizacijskih izvještaja za dijelove slivova Cetine i Krke na području FBiH, kao prve faze Plana upravljanja;
- GEF projekt upravljanja Neretvom i Trebišnjicom (oba BiH entiteta i Hrvatska);
- IPA projekt Podrška vodnoj politici u BiH, koji je upravo završen;
- DIKTAS – regionalni projekat unapređenja upravljanja podzemnim vodama Dinarskog krša;
- NATO – Nauka za mir, Program smanjenja rizika od okolišnog zagađenja rijeke Bosne;
- Nekoliko desetina projekata unapređenja komunalne infrastrukture vodovoda i kanalizacije u pojedinim općinama oba entiteta;
- Nekoliko projekata razvoja navodnjavanja u oba entiteta, te
- Smanjenja rizika od poplava i zaštita od poplava u FBiH i RS, te regionalno, s Crnom Gorom i Srbijom.

ZAKLJUČAK

Kao što se vidi, u BiH je trenutno u toku određen broj projekata iz oblasti upravljanja vodama i unaprjeđenja vodne infrastrukture, pa se može zaključiti da je BiH na dobrom putu, ali i da kasni i ide vrlo sporo.

Nadati se je da će dinamiziranje vodnih inicijativa u Evropskoj uniji, te brži napredak BiH susjeda, Crne Gore, Hrvatske i Srbije, dovesti do dinamiziranja aktivnosti u sektoru voda i u BiH.

WATER IS BECOMING A TOP PRIORITY

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Abstract

Balance between water needs and availability has reached the critical point in many world areas, and water is consequently also becoming a central issue in Europe. For achievement of "smart and sustainable growth", as overall goal of EU2020, the European Commission is intensively working on formulation of „Innovative Platform“ for more efficient and sustainable use and protection of water resources, taking the initiatives necessary for its establishment. For the 2012, the European Commission is preparing a "Blue Book", the purpose of which is the evaluation of previous and formulation of future EU Water Policy, with special emphasis on climate change and integrated management of extreme hydrological events, efficient use of natural resources and international cooperation, and integration of water policy into other EU policies. After analysis of the situation in B&H, it can be concluded that B&H is on the right path, but the progress is very slow. However, the dynamics of water initiatives in the EU and faster progress of B&H neighbors Montenegro, Croatia and Serbia will produce more dynamic activities in B&H water sector as well.

***Key words**: Water, Water Stress, Water Framework Directive, EU Water Initiatives, Blue Book, B&H Water Policy*

UDK 568.2:551.556.1(497.16)

PREGLED FAUNE PTICA BRDA MOŽURA KOD ULCINJA U SVIJETLU POTENCIJALNE IZGRADNJE VJETROELEKTRANA

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Uvod

Istraživanje ornitofaune brda Možura sprovedeno je u periodu od 2.jula 2010 do 25.juna 2011.a za potrebe procjene uticaja na životnu sredinu eventualne izgradnje vjetroparka od 23 turbine po grebenu brda. Na Možuri je realizovano 54 terenska dana sa metodama osmatranja: linijski transekt i cenzus u tački, a tokom kojih je na posmatranom području registrovano 73 vrste ptica. Poseban akcenat u istraživanju dat je migrantima s obzirom da se Možura nalazi na jadranskom koridoru i u blizini najznačajnih područja za ptice u državi (Skadarsko jezero i Ulcinjska solana).

Ključne riječi: *Možura, fauna ptica, gniježđenje*

Opis istraživanog područja

Brdo Možura se nalazi na oko 5 km vazdušne linije od grada Ulcinja, i na oko 3 km od Ulcinjske solane. Brdo se pruža pravcem jugoistok - sjeverozapad u dužini od oko 8,5 km, i njegova najvisočija kota je na 622 mnv. Možura je preko Zogajskog polja u kontaktu sa deltom Bojane a u zaleđu sa padinama Rumije.
Možuri pripada karstni teren sa mediteranskom vegetacijom koju karakterišu tri tipa staništa: makija, gariga i šumski pojas u podnožju brda i oko naselja. Brdo je na sjevernoj ekspoziciji obraslo neprohodnom makijom (43% površine brda) tj. vegetacijom gdje dominiraju zajednice termofilnih hrastova: *Quercus coccifera* i *Quercus pubescens*. Gariga je pojas nastao degradacijom makije većinom usljed požara i erozije i zahvata oko 29% njene površine. Karakteriše ga oskudnost vegetacije, kamenjar i zajednice kleke *Juniperus oxycedrus*, žukve *Spartium junceum*, vrijesa *Satureja montana* i pelima *Salvia officinalis*. Podnožje Možure sa južne_ekspozicije karakteriše puno veća pokrovnost, lišćarska listopadna šuma, maslinjaci, voćnjaci i kultivisane povšine (27%).

Metode rada

Za istraživanje ptica Možure korištene su metode cenzusa u tački i linijskog transekta.

Cenzus u tački

Cenzus u tački je rađen sa 3 lokacije: Sv.Ilija, Katolička crkva i zapadni vjetromjerač od čega se tokom istraživanja tačka Katoliča crkva pokazala kao optimalna. Tačka „zapadni mjerač vjetra“ pokazala se suboptimalnom i u kasnijim fazama istraživanja nije korištena.

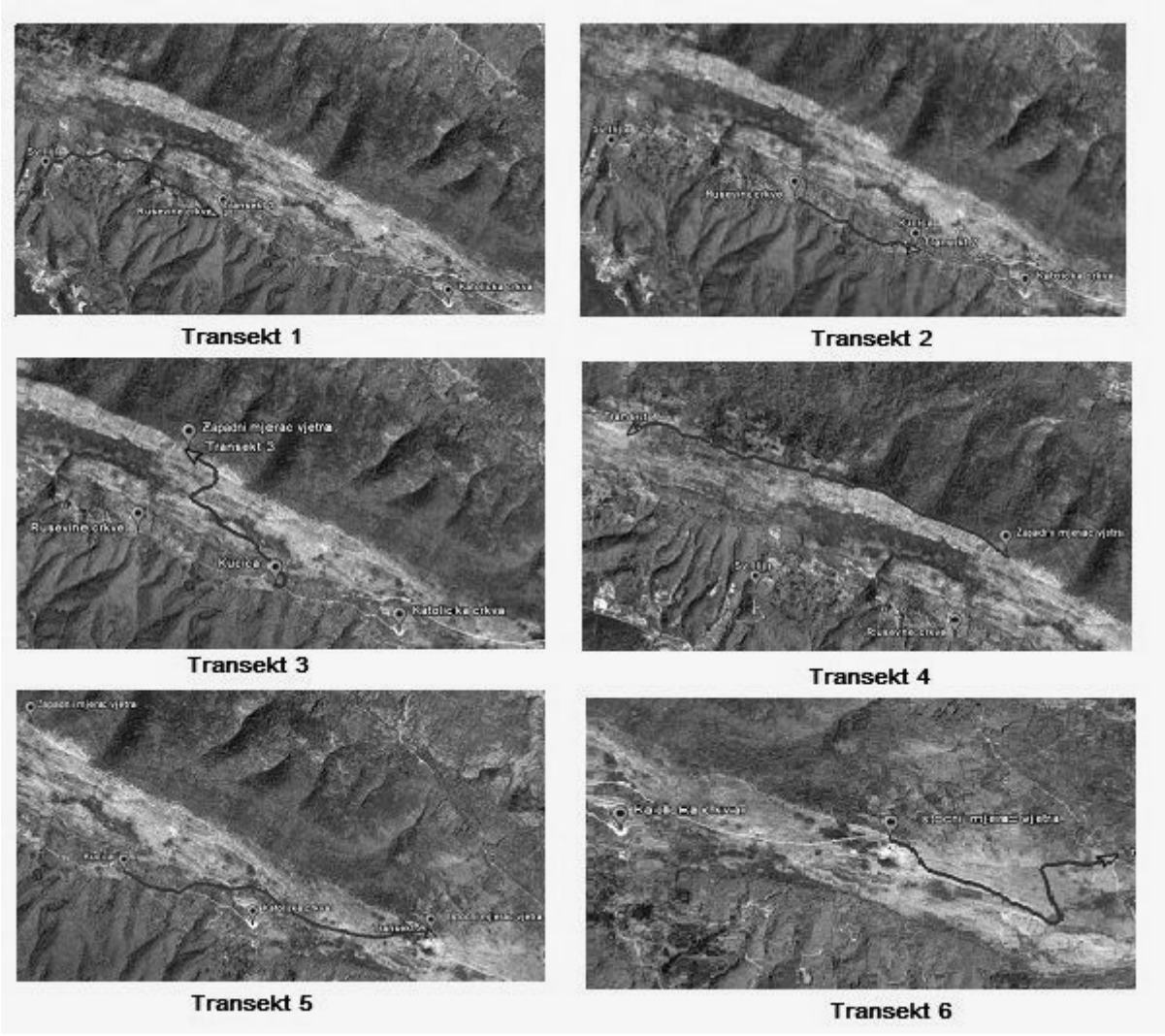
Slika 1: Tačke osmatranja i uglovi osmatranja pokriveni sa svake tačke.

Linijski transekti

Linijski transekti su realizovani na južnim ekspozicijama, po grebenu i sjeveroistočnoj ekspoziciji. Realizovano je 6 transekata u dužini 13.4km što je bilo dovoljno da se dobije jasna slika o gnjezdaricama, kako o njihovoj brojnost i zastupljenost, tako i distribuciji po staništima. Transektima su obuhvaćeni svi navendeni habitati

Tabela 1. – Transkekti realizovani na Možuri

Broj transekta	**Opis**	**Dužina transekta**
Transekt 1	Sv. Ilija – ruševine crkve	1.900 m
Transekt 2	Ruševine crkve – raskršće prema vrhu	1.600 m
Transekt 3	Raskršće 1 – Z vjetromjerač	2.500 m
Transekt 4	Središnji greben Možure	3.000 m
Transekt 5	Raskršće 1 – I vjetromjerač	2.400 m
Transekt 6	I vjetromjerač – raskršće 2	2.000 m
Ukupno		**13.400 m**



Slika 2. Linijski transekti na Možuri

Rezultati i diskusija

Na Možuri je u posmatranom period registoravano 73 vrste ptica.

Tabela 2: Spisak ornitofaune brda Možura sa ekološkim statusima vrsta, SPEC kategorijama, IUCN crvenoj listu, Ptičjoj direktivi, Bernskoj i Bonnskoj konvenciji, Emerald mreži i po CITESu. (skraćenice: B – gnjezdarica, M – selica, R – stanarica, W – zimovalica, LC – posljednja briga).

Broj	**Vrsta**	**Status**	**BiE2 SPEC kategor.**	**2008 Global IUCN Red List Category**	**Ptičja direktiva**	**Bernska konvencija**	**Emerald Network**	**Bonnska konvencija**	**CITES**
1.	*Pernis apivorus*	B?		LC	I	III	Yes	II	II
2.	*Circaetus gallicus*	B?	3	LC	I	II	Yes	II	II
3.	*Accipiter gentilis*	R	—	LC		II		II	II
4.	*Accipiter nisus*	B	—	LC		II		II	II
5.	*Accipiter brevipes*	B	2	LC	I	III	Yes	II	II
6.	*Circus cyaneus*	M	3	LC	I				II

7.	*Circus pygargus*	M	—[E]	LC	I				II
8.	*Circus aeruginosus*	M	—	LC	I				II
9.	*Buteo buteo*	R	—	LC		II		II	II
10.	*Aquila chrysaetos*	R	3	LC	I	II	Yes	II	II
11.	*Falco subbuteo*	B	—	LC					II
12.	*Falco tinnunculus*	B	3	LC		II		II	II
13.	*Grus grus*	M	2	LC	I				
14.	*Streptopelia turtur*	B	3	LC	II/2	III		II	
15.	*Cuculus canorus*	B?	—	LC		III			
16.	*Asio flammeus**	M	3	LC	I				II
17.	*Caprimulgus europaeus*	B	2	LC	I	II	Yes		
18.	*Tachymarptis melba*	B?	—	LC					
19.	*Apus apus*	B?	—	LC		III			
20.	*Upupa epops*	B	3	LC		II			
21.	*Dendrocopos syriacus*	R	—[E]	LC	I	II	Yes		
22.	*Jynx torquilla*								
23.	*Lullula arborea*	B	2	LC	I	III	Yes		
24.	*Alauda arvensis*	M	3	LC	II/2	III			
25.	*Ptyonoprogne rupestris*	B	—	LC		II			
26.	*Hirundo rustica*	B	3	LC		II			
27.	*Cecropis daurica*	B	—	LC		II			
28.	*Delichon urbica*	B	3	LC		II			
29.	*Antus campestris*	B	3	LC	I	III	Yes		
30.	*Anthus spinoletta*	M	—	LC					
31.	*Anthus pratensis*	M	—[E]	LC					
32.	*Motacilla cinerea*	M	—	LC		II			
33.	*Motacilla alba*	B	—	LC		II			
34.	*Troglodytes troglodytes*	W	—	LC		II			
35.	*Erithacus rubecula*	B	—[E]	LC		II		II	
36.	*Luscinia megarhynchos*	B	—[E]	LC		II		II	
37.	*Phoenicurus ochruros*	B	—	LC		II		II	
38.	*Saxicola rubetra*	M	—[E]	LC					
39.	*Oenanthe oenanthe*	M	3	LC		II		II	
40.	*Oenanthe hispanica*	B	2	LC		II		II	
41.	*Monticola saxatilis*	B	3	LC		II		II	
42.	*Turdus merula*	B	—[E]	LC	II/2	III		II	
43.	*Turdus philomelos*	B	—[E]	LC	II/2	III		II	
44.	*Turdus viscivorus*	B	—[E]	LC	II/2	III		II	
45.	*Sylvia cantillans*	B	—[E]	LC		II		II	
46.	*Sylvia crassirostris*	B	3	LC		II		II	
47.	*Sylvia melanocephala*								
48.	*Sylvia atricapilla*	B	—[E]	LC		II		II	
49.	*Phylloscopus sibilatrix*	M	2	LC					
50.	*Phylloscopus orientalis (P. bonelli)*	M	2	LC					
51.	*Phylloscopus collybita*	B	—	LC		II		II	
52.	*Muscicapa striata*	B	3	LC		II		II	
53.	*Parus palustris*	B	3	LC		II			
54.	*Regulus ignicapilla*	W	—[E]	LC					
55.	*Poecile lugubris*	B	—[E]	LC		II			
56.	*Cyanistes caeruleus*	B	—[E]	LC		II			
57.	*Parus major*	B	—	LC		II			

58.	*Aegithalos caudatus*	B	—	LC					
59.	*Sitta europaea*	B	—	LC		II			
60.	*Certhia brachydactyla*	B	—[E]	LC					
61.	*Oriolus oriolus*	B	—	LC		II			
62.	*Garrulus glandarius*	B	—	LC	II/2				
63.	*Pica pica*	B	—	LC	II/2				
64.	*Corvus corax*	B	—	LC		III			
65.	*Sturnus vulgaris*	R	3	LC	II/2				
66.	*Passer domesticus*	R	3	LC					
67.	*Fringilla coelebs*	R	—[E]	LC		III			
68.	*Chloris chloris*	R	—[E]	LC		II			
69.	*Carduelis carduelis*	R	—	LC		II			
70.	*Carduelis cannabina*	R	2	LC					
71.	*Coccothraustes coccothraustes*	R	—	LC		II			
72.	*Emberiza cirlus*	R	—[E]	LC		II			
73.	*Emberiza cia*	R	3	LC		II			

Od 73 registrovane vrste, 58 pripadaju gnjezdaricama ili stanaricama, 13 je selica i 2 zimovalice. Iznenađenje je da se na posmatranom području nijesu registrovale vrste iz roda *Lanius sp*, *Hippolais* sp, jarebica kamenjarka *Alectoris graeca*, a čije je Možura tipično stanište.

Na području Možure nisu registrovane vrste ugrožene na globalnom nivou (SPEC 1) iako je satelitksi praćen Falco cherrug 2009. preletio brdo na putu ka Italiji. (http://www.sakerlife.mme.hu/en/gmap). Tokom istraživanja za potrebe izrade ovog izvještaja, nijedan pripadnik ove vrste nije registrovan kako na Možuri, tako i u drugim djelovima Crne Gore na kojima je rađen monitoring ptica.

Tabela 3: Broj parova gnjezdarica na transektima 1, 2 i 5 unutar stanišnog tipa šuma i naselja, te izračunata gustina parova na hektar (d) i ukupnu površinu tog tipa staništa (359 ha) na Možuri. Italic slovima su označene vrste koje su bile registrovane tokom cenzusa gnjezdarica ali se na Možuri ne gnijezde. Skraćenice: l - dužina, UP - unutrašnji pojas, VP - vanjski pojas (maximumi iz tri brojanja), N – ukupni broj na ukupnoj dužini transekata, p - proporcija ukupnog broja i broja unutar unutrašnjeg pojasa transekata, k – preračunata konstanta detektibilnosti određene vrste, w – širina unutrašnjeg pojasa). Proračun se temelji na klasičnom izračunavanju gustine na transektu sa dva pojasa po Bibby et al. (gledaj literaturu): p = kw(2 – kw); k = (1 – SQRT(1 – p))/w; d = 10Nk/l

Transekti							
T1+T2+T5							
l=5.900 m	Max						
VRSTA	UP (N1)	VP	N	p (N1/N)	k	D	d=(D*d1)
Anthus campestris	**1**		1	1,00	0,01	0,02	6
Buteo buteo	**1**	**2**	3	0,33	0,00	0,01	3
Caprimulgus europaeus	**1**	**1**	2	0,50	0,00	0,01	4
Carduelis carduelis	**1**		1	1,00	0,01	0,02	6
Carduelis chloris	**4**		4	1,00	0,01	0,07	24
Dendrocopos syriacus	**1**		1	1,00	0,01	0,02	6
Emberiza cia	**4**		4	1,00	0,01	0,07	24
Emberiza cirlus	**7**	**3**	10	0,70	0,00	0,08	28
Erithacus rubecula	**4**	**2**	6	0,67	0,00	0,04	15
Falco subbuteo	**1**		1	1,00	0,01	0,02	6
Fringilla coelebs	**3**	**5**	8	0,38	0,00	0,03	10
Garrulus glandarius	**2**	**10**	12	0,17	0,00	0,02	6
Hirundo rustica	**1**		1	1,00	0,01	0,02	6

Luscinia megarhyncha		**5**	5	0,00	0,00	0,00	0
Oenanthe hispanica	**2**	**1**	3	0,67	0,00	0,02	8
Oriolus oriolus	**2**	**3**	5	0,40	0,00	0,02	7
Parus caeruleus	**7**	**7**	14	0,50	0,00	0,07	25
Parus lugubris	**1**	**1**	2	0,50	0,00	0,01	4
Parus major	**4**	**16**	20	0,20	0,00	0,04	**13**
Phylloscopus collybita	**1**	**6**	7	0,14	0,00	0,01	3
Phylloscopus sibilatrix	***3***	**3**	6	0,50	0,00	0,03	11
Regulus ignicapillus	***1***		1	1,00	0,01	0,02	6
Sitta europaea	**1**		1	1,00	0,01	0,02	6
Sylvia atricapilla	**2**	**4**	6	0,33	0,00	0,02	7
Sylvia cantillans	**23**	**21**	44	0,52	0,00	0,23	**83**
Sylvia crassirostris	**1**		1	1,00	0,01	0,02	6
Sylvia melanocephala	**9**	**8**	17	0,53	0,00	0,09	32
Troglodytes troglodytes	***4***		4	1,00	0,01	0,07	24
Turdus merula	**8**	**13**	21	0,38	0,00	0,08	**27**
Turdus philomelos		**1**	1	0,00	0,00	0,00	0

Tabela 4: Broj parova gnjezdarica na transektima 3 i 6 unutar stanišnog tipa gariga te izračunata gustina parova na hektar (d) i ukupnu površinu tog tipa staništa (369 ha) na Možuri. Italic slovima su označene vrste koje su bile registrovane tokom cenzusa gnjezdarica ali se na Možuri ne gnijezde. Skračenice: l - dužina, UP - unutrašnji pojas, VP - vanjski pojas (maximumi iz tri brojanja), N – ukupni broj na ukupnoj dužini transekata, p - proporcija ukupnog broja i broja unutar unutrašnjeg pojasa transekata, k – preračunata konstanta detektibilnosti određene vrste, w – širina unutrašnjeg pojasa). Proračun se temelji na klasičnom preračunavanju gustine na transektu sa dva pojasa po Bibby et al. (gledaj literaturu): p = kw(2 – kw); k = (1 – SQRT(1 – p))/w; d = 10Nk/l

Transekti							
T3+T6							
l=4.500 m	Max						
VRSTA	UP (N1)	VP	N	p (N1/N)	k	D	d=(D*d1)
Aegithalos caudatus	**1**		1	1,00	0,01	0,02	8
Alauda arvensis	***2***		2	1,00	0,01	0,04	16
Anthus campestris	**1**	**2**	3	0,33	0,00	0,01	5
Anthus pratensis	***1***	***1***	2	0,50	0,00	0,01	5
Anthus spinoletta	***1***		1	1,00	0,01	0,02	8
Asio flammeus	***1***		1	1,00	0,01	0,02	8
Carduelis carduelis	**2**		2	1,00	0,01	0,04	16
Carduelis chloris	**1**		1	1,00	0,01	0,02	8
Cuculus canorus	***3***		3	1,00	0,01	0,07	25
Emberiza cirlus	**1**		1	1,00	0,01	0,02	8
Fringilla coelebs	**1**		1	1,00	0,01	0,02	8
Garrulus glandarius		**1**	1	0,00	0,00	0,00	0
Luscinia megarhyncha		**4**	4	0,00	0,00	0,00	0
Monticola saxatilis		**1**	1	0,00	0,00	0,00	0
Oenanthe hispanica	**1**	**2**	3	0,33	0,00	0,01	5
Parus major	**3**		3	1,00	0,01	0,07	25
Phylloscopus collybita	**1**	**4**	5	0,20	0,00	0,01	4

Phylloscopus sibilatrix	***1***	***1***	2	0,50	0,00	0,01	5
Sylvia atricapilla	**1**	**2**	3	0,33	0,00	0,01	5
Sylvia cantillans	**14**	**7**	21	0,67	0,00	0,20	**73**
Sylvia melanocephala	**1**	**2**	3	0,33	0,00	0,01	5
Troglodytes troglodytes	***6***	***1***	7	0,86	0,01	0,10	36
Turdus merula		**1**	1	0,00	0,00	0,00	0
Turdus viscivorus		**1**	1	0,00	0,00	0,00	0

Tabela 5: Broj parova gnjezdarica na transektu 4 unutar stanišnog tipa makija te proračunata gustina parova na hektar (d) i ukupnu površinu tog tipa staništa (369 ha) na Možuri. Italic slovima su označene vrste koje su bile registrovane tokom cenzusa gnjezdarica ali se na Možuri ne gnijezde. Skraćenice: l - dužina, UP - unutrašnji pojas, VP - vanjski pojas (maximumi iz tri brojanja), N – ukupni broj na ukupnoj dužini transekata, p - proporcija ukupnog broja i broja unutar unutrašnjeg pojasa transekata, k – preračunata konstanta detektibilnosti određene vrste, w – širina unutrašnjeg pojasa). Proračun se temelji na klasičnom preračunavanju gustine na transektu sa dva pojasa po Bibby et al. (gledaj literaturu): p = kw(2 – kw); k = (1 – SQRT(1 – p))/w; d = 10Nk/l

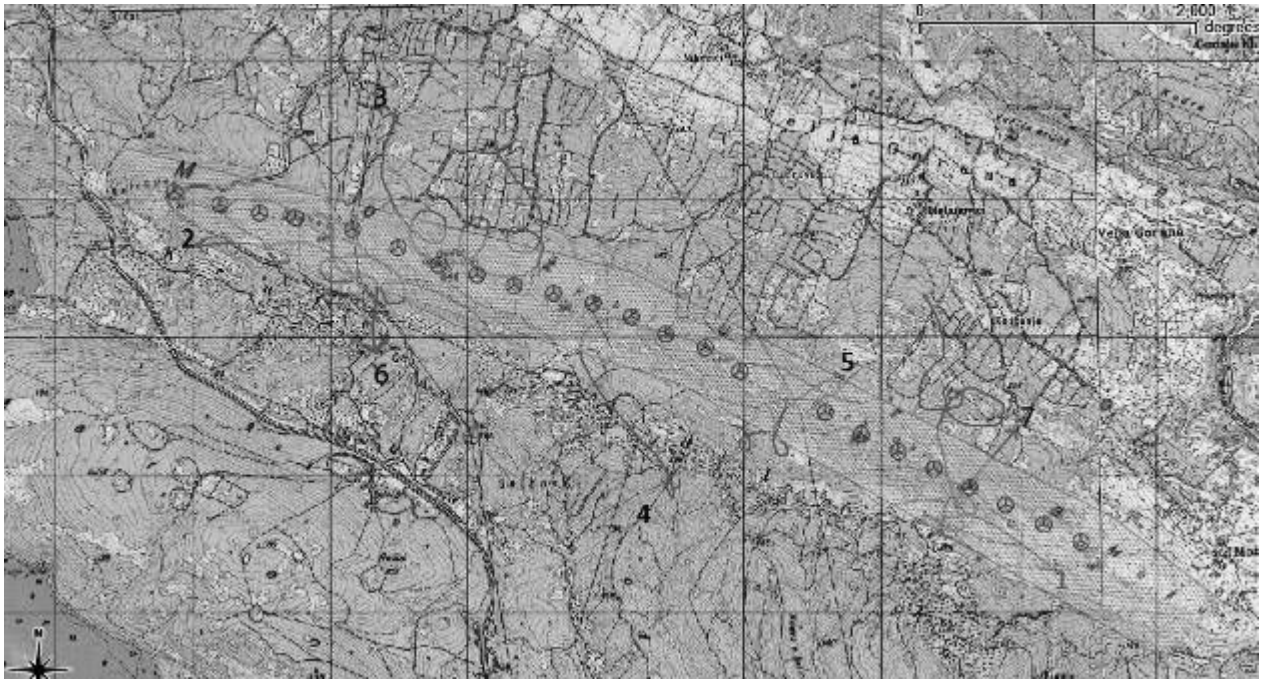
Transekt							
T4							
l=3.000 m	Max						
VRSTA	UP (N1)	VP	N	p (N1/N)	k	D	d=(D*d1)
Anthus pratensis	**4**		4	1,00	0,01	0,13	74
Tachymarptys melba	**10**		10	1,00	0,01	0,33	186
Buteo buteo		**2**	2	0,00	0,00	0,00	0
Carduelis chloris	**8**		8	1,00	0,01	0,27	149
Delichon urbica	**5**		5	1,00	0,01	0,17	93
Emberiza cia	**1**		1	1,00	0,01	0,03	19
Falco subbuteo	**1**		1	1,00	0,01	0,03	19
Falco tinnunculus		**1**	1	0,00	0,00	0,00	0
Fringilla coelebs	**2**	**2**	4	0,50	0,00	0,04	22
Oenanthe hispanica	**1**	**1**	2	0,50	0,00	0,02	11
Oenanthe oenanthe	**2**		2	1,00	0,01	0,07	37
Oriolus oriolus	**1**	**1**	2	0,50	0,00	0,02	11
Parus lugubris		**1**	1	0,00	0,00	0,00	0
Parus major	**3**	**3**	6	0,50	0,00	0,06	33
Phoenicurus ochruros	**2**		2	1,00	0,01	0,07	37
Phylloscopus collybita		**1**	1	0,00	0,00	0,00	0
Saxicola rubetra	**1**		1	1,00	0,01	0,03	19
Sturnus vulgaris		**1**	1	0,00	0,00	0,00	0
Sylvia cantillans	**9**	**4**	13	0,69	0,00	0,19	108
Troglodytes troglodytes	**1**		1	1,00	0,01	0,03	19
Turdus merula	**3**	**4**	7	0,43	0,00	0,06	32

Tokom istraživanja posebna pažnja je posvećena jesenjoj u proljećnoj migracji ptica s obzirom na potencijalni opasnost od kolizije.

Podaci tokom jesenje migracije su pokazali da na Možuri nije zabilježena ni jedna jedinka bilo koje vrste seleće grabljivice. Što se samih grabljivica tiče, tokom ovog perioda registrovani su samo jedinke mišara *Buteo buteo*, koje pripisujemo malobrojnoj rezidentnoj populaciji, koja je ujedno i najbrojnija grabljivica ovog lokaliteta.

Tokom proljećne migracije, kada je na terenu organizovano 10 terenskih dana jedine osmatrane vrste bile su eja livadarka, *Circus pygargus*, ždral *Grus grus*, velika čiopa *Apus melba*, te osičar

Pernis apivorus. Ostale vrste grabljivica na proučavanom području su stanarice ili ljetnji posjetioci. Takve su vrste suri orao, mišar, orao
Na osnovu izvedenih istraživanja procjena je da je potencialna ugroženost migrirajućih grabljivica usljed rada vjetroparka mala. Tokom proljećne seobe jedino je eja livadarka preletjela greben u visini zahvata rotora (ca. 50 m iznad grebena, pravac 20° (SSI). Osmatrane dvije jedinke osičara su greben preletjele na visini od oko 400 m, dakle iznad zahvata vjetroturbina, tako da se može tvrditi da je opasnost od direktnog sudara grabljivica sa rotorima turbina na Možuri veoma mala.
Jedina vrsta osjetljiva na vjetroelektrane koja bi mogla doći u koliziju sa rotorima, a koja je zmijar, vjetruška *Falco tinnunculus*, soko lastavičar *F.subbuteo*, te kratkoprsti kobac *Accipiter brevipes.*
registrovana na Možuri je suri orao i to u skitnji, van sezone gniježđenja, mlade jedinke. On je u 54 terenska dana registrovan 7 puta sa 5 minuta prosječnog osmatranja i od čega je 4 puta proletio kroz rotore turbina. Na osnovu proračuna po modelu koji je korišten u Slovenij (slučaj Volovja rebar) procijenjeno je da bi uz nepromjenjeni broj preleta surih orlova kroz područje planiranog vjetroparka na Možuri jedan suri orao stradao svakih dvije do tri godine. Uz pretpostavku da se u Crnoj Gori gnijezdi oko 30 parova surih orlova, znači da Možura na godišnjem nivou utiče na mortalitet 0,27% do 0,45% populacije ove vrste.



Slika 4: Linije leta osmatranih surih orlova Aquila chrysaetos preko grebena brda Možura i planiranog vjetroparka

Zaključak

Tokom jdnogodišnjeg israživanja u ukupnom periodu od 54 terenska dana na Možuri je registrovano 73 vrste ptica od čega 58 gnjezdarica i/ili stanarica, 13 selica, 2 zimovalice. U usporedbi sa sličnim staništima u okruženju, može se reći da stanje orntiofaune na Možuri, kako kvalitativno tako i kvantitativno, značjano odstupa od prosjeka. Mnoge vrste očekivane na Možuri a koje su karakteristične za mediteranska staništa nijesu registrovane a pojedine koje su na drugim staništima brojne na Možuri imaju zanemarljivo male populacije. Na osnovu izvedenih istraživanja, tokom jesenje i proljećne seobe, zaključuje se da brdo Možura, iako se nalazi u neposrednoj blizini jednog od najznačajnijih evropskih koridora za ptice (Skadarsko jezero, Delta Bojane, Jadransko more) ne prestavlja dio tog koridora.

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AN OVERVIEW OF BIRD FAUNA OF THE HILL MOŽURA NEAR ULCINJ CONSIDERING THE POTENTIAL CONSTRUCTION OF WIND FARMS

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Abstract

Between 2nd of July 2010. and 25th of June 2011., during 54 field work days, bird fauna of Možura hill (located on southeast of Montenegro near Ulcinj) was survayed. The size of the area is 1286 ha and it covers mediterranean scrubland, agriculture land and edges of some villages around it. On Možura have been registered 73 bird species. The survay has been done for the purpose of developing Environmental Impact Assessment (EIA) study of windfarms on birds.

***Key words**: Možura, birdfauna, breeding*

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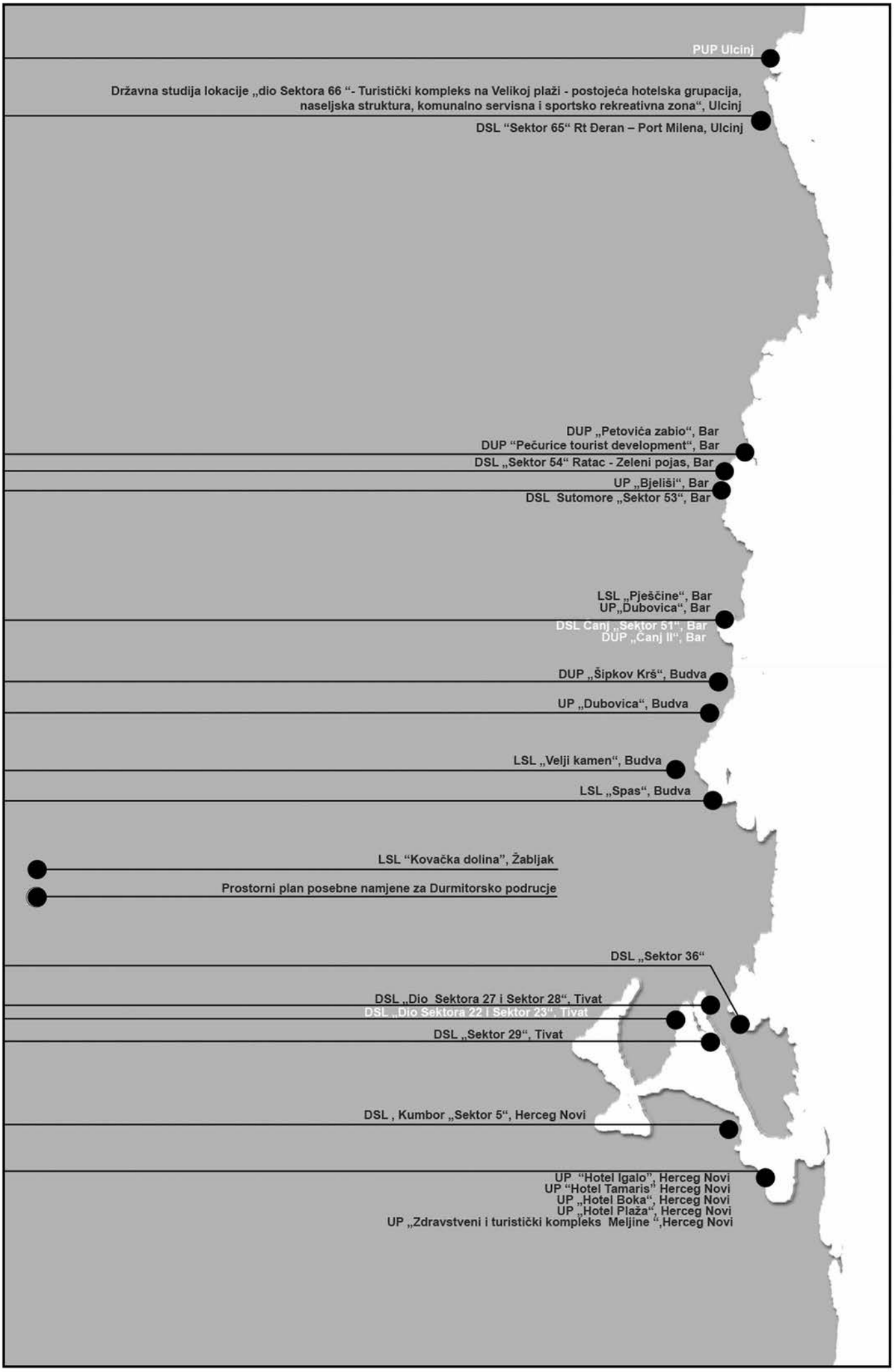
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Centar za arhitekturu i urbanizam - CAU je nastao kroz proces intenzivne, međunarodne, intelektualne i profesionalne saradnje na razmjeni ideja između pojedinaca koji su okupljeni oko zajedničkih ciljeva.Pokazalo se da u uslovima globalizacijena i vrijednosti informacije, timski rad umreženih pojedinaca sa raznih krajeva svijeta postaje trend u ozbiljnim projektima.U sveukupnoj klimi prostornog planiranja u Crnoj Gori danas, regionalna i međunarodna saradnja,multidisciplinarnost, nesmetan protok znanja i kapitala, studiozan pristup, zaštita životnog okruženja, održivi razvoj, obnovljiva energija i sl. samo su neke od 'ključnih riječi` za definisanje ispravnog pristupa ovoj ozbiljnoj disciplini. CAU posjeduje licence za izradu prostorno-planske dokumentacije.

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Osnovna djelatnost koju obavlja Industrija mesa Goranović DOO Nikšić je proizvodnja finalnih proizvoda od mesa - suvomesnati proizvodi i prerađevine od mesa. U proizvodnom asortimanu kompanije ima više od 120 različitih proizvoda, koji su, prema tehnološkom postupku proizvodnje, podijeljeni u 7 grupa:

- Dimljeni proizvodi
- Fermentisane kobasice
- Suvomesnati proizvodi
- Kuvane kobasice i paštete
- Konzerve od mesa u komadima
- Fino usitnjene barene kobasice
- Barene kobasice sa komadima mesa

Sve najbolje, Goranović

Goranovic, taste only the best

The main activity of the Meat industry Goranovic is final meat production. The assortment counts more than 120 different meat products, which, according to the process of production, can be divided in 7 groups:

1. Smoked products
2. Fermented sausages
3.Cured meat products
4. Boiled sausages and pate
5.Canned meat pieces
6. Finely chopped boiled sausages
7.Boiled sausages with meat pieces

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- ***O preduzeću***

Preduzeće „MEDIX“ d.o.o. Podgorica osnovano je u oktobru 1998. godine. Zapošljava 4 radnika koji su u stalnom radnom odnosu, a u honorarnom odnosu ima 15-tak radnika.

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Osnovna djelatnost preduzeća je izrada Elaborata procjene uticaja na životnu sredinu, Strateških procjena uticaja, Studija izvodljivosti i Projekata iz oblasti životne sredine.

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Preduzeće okuplja veliki broj stručnjaka iz različitih oblasti koji za pojedine poslove čine multidisciplinarni tim. Svi angažovani stručnjaci imaju veliko iskustvo u izvršavanju poslova iz oblasti životne sredine, tako da je ovo preduzeće jedno od vodećih u pružanju usluga koje se odnose na sferu njegove djelatnosti.

Osim saradnje sa domaćim institucijama i preduzećima, jedan dio aktivnosti preduzeća je vezan i za saradnju sa inostranim partnerima koji se bave problemima životne sredine.

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Izgrađen kao fabrika namjenske industrije za potrebe Vojske AD “POLIEX“ je počeo sa radom 1985. godine.

Prvobitna proizvodnja minsko-eksplozivnih sredstava je 1991. godine dopunjena proizvodnjom inicijalnih sredstava, a tri godine kasnije usvojena je i proizvodnja eksploziva za civilnu upotrebu.

Fabrika upošljava 50 radnika,VSS 10 i SS 40.

Proizvodni program fabrike čine:

1. Praškasti eksplozivi- Beranit 1,2 i 3
2. Vodootporni eksplozivi- Beranit 35
3. Anfo eksplozivi- Beranex A
4. Eksplozivni metak 200 gr
5. Elektrodetonatori br. od 0 do 6
6. Konektor
7. DK-8
8. Polinel
9. PP Pojačnik

*NOVO - EGK

Fabrici je uveden ISO 9001 standard- Sertifikovani sistem menadžmenta i svi proizvodi su usklađeni sa evropskim standardima tj. posjeduju CE znak po tipu Modula B i Modula D.

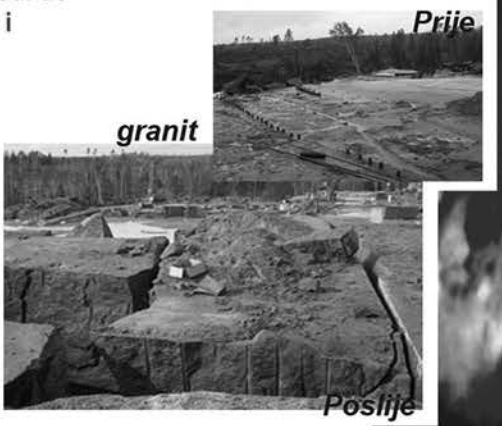
Fabrika se takođe bavi uslugom minerskog servisa, kao i delaboracijom minsko-eksplozivnih sredstava i ima obučeni kadar i mogućnost da ovu oblast dodatno usavršava.

Menadžment fabrike je usvojio i usvaja još niz proizvodnih programa koji će uskoro biti prezentovani, a jedan od njih je i proizvod jedinstven na evropskom tržištu,

Ekološki gasni klin- EGK

EGK kao novi proizvod AD»Poliex» Berane po svojim karakteristikama, osobinama i načinu primjene predstavlja napredak u odnosu na sva dosad poznata sredstva korištena za razbijanje, rezanje i cijepanje građevinskih materijala (betoni, armirano-betonske konstrukcije, graniti, mermeri,kameni blokovi).Za razliku od klasičnih eksploziva EGK u zatvorenom prostoru stvara kvazistatički pritisak gasova što dovodi do cijepanja homogenih struktura stijena bez eksplozije i rasipanja materijala.

Prednosti EGK su pouzdanost, sigurnost pri radu i transportu, te da u procesu rada nema za nus produkte štetne materije koje direktno utiču na životnu i radnu sredinu budući da pri sagorijevanjuoslobađa vodu-vodenu paru i ugljen-dioksid.



YU BRIV Kotor, Montenegro

Preduzeće YU BRIV je nastalo spajanjem dvije porodične firme. Do danas smo prerasli u efikasnu kompaniju sa 120 stalno zaposlenih. Pored inžinjeringa i gradjevinske djelatnosti, obavljamo poslove projektovanja, ugostiteljstva, unutrasnje i spoljne trgovine, unutrasnjeg i medjunarodnog transporta, turizma. Usmjerili smo se na djelatnosti i konačne rezultate naših napora – izvedene objekte. Velika je odgovornost gledati u budućnost i nastojati opravdati ukazano povjerenje, ali je veliko zadovoljstvo pogledati unazad i vidjeti kako su se ostvarile naše poslovne želje, zahvaljujući vjerovanju da se uvijek može postići više.

Spoj tradicije i novih dostignuća i iskustva, tehničko-tehnološke i stručne osposobljenosti, omogućio nam je da u periodu koji je iza nas izgradimo veliki broj objekata visokogradnje, hidrogradnje, niskogradnje i specijalizovanih građevinskih radova.

Sa posebnim zadovoljstvom ističemo radove na:

- II fazi Sanacije i rekultivaciji jalovišta rudnika olova i cinka čime smo dali značajan doprinos saniranju jedne od najvećh crnih ekoloških tačaka u našoj državi.
- Hidrotehnički radovi na izgradnji marine „Porto Montenegro“
  Sistemi za vezivanje mega jahti
  Izgradnja Gata III, IV i kejskog zida
- veliki broj stambenih objekata, drugih objekata visokogradnje, niskogradnje i hidrogradnje

U izvođenju dosta zahtjevnih i složenih građevinskih objekata, posebnu pažnju posvećujemo primjeni i korišćenju najnovijih tehničkih dostignuća nanošenja premaza otpornih na visoko temperature, zaštita građevinskih objekata, uticaja morske vode na izgrađene objekte, ugradnja uređaja i njihova zaštita u sistemima vodosnabdjevanja, uz praćenje stanja i procesa u životnoj sredini.

Veliki broj uspješno realizovanih projekata, dugogodišnje iskustvo omogućili su da postanemo respektabilna firma, razvijana i građena samo sa prijateljima . Graditeljska tradicija je i naša tradicija.Prateći nova tehnološka rješenja posebnu pažnju u realizaciji projekata posvećujemo kvalitetu naših usluga.

U Kompaniji je uveden sistem kvaliteta ISO 9001:2008, i sistema ISO 14001:2008 što je dokaz naše privrženosti uspostavljanja međunarodnih standarda za sisteme upravljanja kvalitetom i zaštitom životne sredine i potvrđuje da je uspostavljen i da se primjenjuje sistem upravljanja zaštitom životne sredine.

LUKA KOTOR

PORT OF KOTOR

Kotor, odnosno Luka Kotor se nalazi neposredno uz Jadransku magistralu i njom je povezana sa mjestima uz obalu, kao i sa gradovima u unutrašnjosti.

Dužina operativne obale kojom raspolaže Luka Kotor u luci iznosi 665 m, od čega se 512 m nalazi na zapadnom djelu dok je 153 m okrenuto prema rijeci Škurdi. Operativna obala se može funkcionalno podjeliti na 5 vezova i to:

- Riva I, vez u dužini od oko 150 m. Operativna obala na ovom vezu je opremljena sa 11 bitava.
- Riva II, vez u dužini od 100 m. Uz ovu operativnu obalu postoji samo uska traka širine od 6 do 9 m koju brodovi mogu koristiti.
- Riva III, obuhvata južni dio rive u dužini od oko 250 m.
- Rijeka I je vez na sjevernom djelu prema rijeci Škurdi u dužini od oko 80 m.
- Rijeka II je vez u dužini od oko 70 m.

LUKA KOTOR
PORT OF KOTOR

Luka Kotor je morskim putem od važnijih luka udaljena kao je prikazano:

	Nm
Kotor-Bar	42
Kotor-Bari	125
Kotor-Otrant	151
Kotor-Trst	334
Kotor-Ankona	254
Kotor-Pirej	715
Kotor-Dubrovnik	40

Operativna obala Rijeka I i Rijeka II su opremljeni sa 10 bitava. Operativna obala je ukupno opremljena sa 61 gumena bokobrana.

Na južnom djelu obale prema moru postoje priključci za vodu, telefon i električnu energiju koji su na raspolaganju plovilima.

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