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SIMULACIJA ADAMOVOG KOEFICIJENTA SA REALNIM PODACIMA U INDUSTRIJSKOJ ZONI NOVOG SADA

SIMULATION OF ADAM COEFFICIENT WITH REAL DATA ON INDUSTRIAL ZONE OF NOVI SAD

APSTRAKT

Model analize arhitektonskih odluka (eng. Architectural Decision Analysis Model – ADAM) je osmišljen kao koncept platforme za zaštitu životne sredine. ADAM je baziran na holističkom pristupu na tri osnovna kompartimenta životne sredine koji su eko funkcionalno kontaminaciono zavisni (zagađenje zemljišta, vazduha i vode). Primena ADAM-a na svaki kompartiment zasebno u radu fokusiranih na vodu i vazduh omogućava korektan naučni pristup. Na taj način su moguće procene i analize direktnog i realnog uticaja arhitektonskih odluka. Glavni zadatak ADAM-a je procena negativnih efekata arhitektonskih procesa konstrukcije i rušenja. ADAM je simuliran na postojeće industrijsko područje koje je prošlo kroz ozbiljne procese reizgradnje u desetogodišnjem periodu od 2008. do 2018. Izabrano područje je spoj dve gradske industrijske zone (Industrijska zona sever i Industrijska zona jug), između kojih protiče kanal Dunav-Tisa-Dunav. Vrhunac rekonstrukcije zone je bio je 2012., i od tada je primetan trend smanjenja arhitektonskih aktivnosti. Pretpostavke dobijene simulacijom ADAM-ovog koeficijenta su proverene analizom podataka monitoringa površinske vode kanala DTD. Izračunata vrednost K_{AT} predviđa i ukazuje da će arhitektonski procesi imati ozbiljan hazardni efekat na životnu sredinu. Analizom podataka fizičko-hemijskih karakteristika površinske vode dokazana je validnost ADAM-ove simulacione pretpostavke.

Ključne reči:

ABSTRACT

Architectural Decision Analysis Model - ADAM was created as a concept of an environmental protection platform. ADAM is based on the holistic approach on the three elementary compartments of environment which are physicochemical and eco-functionally dependant regarding pollutants and contamination (soil, water and air contamination). Application of ADAM on each compartment separately water and air provides scientifically correct approach, which enables the analyses of direct and real influences of architectural decisions onto environment. The main aim of ADAM is assessing negative effects of construction and demolition processes. ADAM was applied on the old industrial area that has severely changed in period from 2008 to 2018 Selected area is juncture of two city zones (Industrial zone North and Industrial zone South) with canal Danube-Tisa-Danube between them. Redevelopment has reached its peak in 2012 and since then shows trend of decrease in renewal. Assumption obtained by ADAM simulation was checked by analysing monitoring data of DTD surface water. Simulated value of K_{AT} gives the assumption that construction and demolition processes will have significant hazard effect on environment. Data analyse of physicochemical characteristics for surface water has proven validity of ADAMs assumption.

Keywords:

1. UVOD

Građevinski otpad tokom proizvodnje, skladištenja, transporta i odlaganja, posebno na gradilištima potencijalno može da izazove štetni uticaj na životnu sredinu. Izgradnja i operacije građenja imaju ogroman direktan i indirektan efekat na životno okruženje (Levin, 1997). Glavni uticaj na životnu sredinu je vidljiv kroz generisanje otpada, snažne buke i vibracija, prašine i hazardnih emisija koje mogu naneti ozbiljna oštećenja čoveku i ekosistemima (Chen et al., 2004). Ovaj problem je isprovocirao mnoge inženjere

1. INTRODUCTION

Construction and demolition waste on building sites have the potential to cause adverse negative environmental impacts during generation, storage, transport and disposal building materials. Building construction and operations have a massive direct and indirect effect on the environment (Levin, 1997). Main impact on the environment is represented through release of waste, noise, dust and hazardous emissions, which can cause serious damages to humans and ecosystems (Chen et al., 2004). This issue has provoked many construction

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da pokušaju da kontrolišu uticaj arhitektonskih aktivnosti primenom sistema menadžmenta životne sredine (Lam et al., 2011).

Sistemi upravljanja životnom sredinom mogu biti unapređeni identifikacijom glavnih komponenti koje utiču na životnu sredinu i razumevanjem efekata koje građevinski procesi imaju na životno okruženje. Mogućnost da se predvide povezani uticaji na životnu sredinu, pre faze rušenja ili građenja može direktno da utiče na poboljšanje performansi građevinskih projekata i smanjenje hazarda na životnu sredinu. Određivanje komponenti koje imaju najveći uticaj na životnu sredinu može ukazati na brojne procedure u cilju mitigacije zagađenja (Gangolells et al., 2011).

Građevinski procesi koji aktivno doprinose zagađenju vazduha uključuju čišćenje zemljišta, rad dizel motora, rušenje, paljenje i rad sa toksičnim materijalima. Sva gradilišta generišu visoke nivoe prašine (tipično od cementa, betona, drveta, kamena, silikata) koji se mogu transportovati na velike udaljenosti u dugom vremenskom periodu. Prašina nastala u građevinskim procesima se klasifikuje kao PM10 (IAQM, 2014).

Vodna zagađenja u građevinskim procesima potiče od dizela goriva, ulja, boje, suspendovanih čestica, rastvarača i drugih štetnih hemikalija, konstruktivnih otpadaka i prašine. Erozija prouzrokuje oticaj kontaminiranog mulja i spiranje kontaminanata u obližnje vodno telo. Mulj i kontaminanti u prirodnim vodim telima izazivaju mutnoću, koja sprečava prolazak sunčevih zraka i uništava akvatični bio sistem. Otpadni mulj nosi i ostale polutante sa gradilišta, kao što su gorivo, ulje, toksične hemikalije i građevinske materijale. Kada se supstance i materije unesu u vodna tela, kontaminiraju akvatične biosisteme i imaju hazardni efekat. Zagađujuće supstance sa gradilišta se mogu sorbovati i difundovati u zemljište i podzemne vode. Jednom zagađene podzemne vode izuzetno je teže tretirati nego površinske vode (UNAB, 2015).

Katjoni metala koji se spiraju sa gradilišta vode poreklo od izduvnih gasova vozila, industrijske čađi, sagorevanja goriva, prašine i korozije različitih metalnih komponenti. Najčešći konstituanti u spiranju katjona metala sa puteva su bakar, cink i olovo, i najčešće se nalaze u visokim koncentracijama. Direktiva o vodnim telima Evropske unije – 2000/60/EC označava katjone Fe, Mn, Zn, Cu, Ni, Cd, Pb, Cr i Hg kao potencijalno toksične za životnu sredinu. U odnosu na organske polutante, metali se ne razgrađuju u životnoj sredini a lako bio kumuluju i bio magnifikuju u ljudskom organizmu lancima ishrane.

2. EKSPERIMENTALNI DEO, MATERIJAL I METODE

Osnovni koncept rada je da se testira simulacionim procesom mogućnost primene ADAM-a na realnom

participants to attempt to control the impacts of their activities by adopting environmental management systems (Lam et al., 2011).

Environmental management systems can be improved by identification of the major environmental impacts and understanding the effects of construction and demolition processes on the whole environment. Possibility to simulate and predict eco negative impacts before the construction and demolition stage could directly affect the improvements in the environmental performance of construction projects and sites. The determination of major environmental impacts can be helpful for pointing variety on-site procedures in order to mitigate pollution (Gangolells et al., 2011). Construction and demolition processes that actively contribute to air pollution include land cleaning, operation of diesel engines, demolition, burning and working with toxic materials. All construction sites generate high levels of waste dust (typically from concrete, cement, wood, stone, silica) which can be transported large distances over a long period of time. Construction dust is classified as Particulate Matter - PM10 (IAQM, 2014).

Common water pollutants generated in building construction and demolition processes and discharged into the aquatic systems are diesel and oil, paint, solvents, cleaners and other harmful chemicals, construction debris and dirt. Erosion leads to silt-bearing run-off and sediment pollution. Silt and soil rinsed into the natural waterways increases the turbidity, thus restricting the amount of the sunlight which can have significant negative effect on the aquatic life. Run-off also carries other pollutants from the site, such as diesel and oil, toxic chemicals, and building materials like cement. When these materials and chemicals are inputted in waterways they contaminate aquatic life and all bio systems. Pollutants on construction sites can also filter and by horizontal and vertical diffusion processes penetrate soil and could contaminate groundwater. Once contaminated, groundwater is much more difficult to treat than surface water (UNAB, 2015).

Cations of metals in urban run-off are mainly from vehicle exhaust, industrial soot, fossil fuel burning, sandstorm dust and corrosion of various metal facilities, and cations of metals copper, zinc and lead are common constituents in highway runoff, usually at relatively high concentrations. European Union Water Framework Directive-2000/60/EC marks Fe, Mn, Zn, Cu, Ni, Cd, Pb, Cr and Hg as metals potentially highly toxic to the environment. Different from organic pollutants, the metal cations, $Me^{n+}_{(aq)}$ are non-degradable in environment and they easier bioaccumulate and bio magnify through food chain and other ways in human body.

2. EXPERIMENTAL MATERIALS AND METHODS

The basic concept of this paper is to test simulative possibility of ADAM application on the real area. The okruženju. Izabrano područje za testiranje ADAM-a je industrijska zona u procesu rekonstrukcije (veliki broj građevinskih radova) koja na odgovarajući način, simplificirana može biti posmatrana i analizirana. ADAM-ov koeficijent je simuliran za direktan uticaj građevinskih procesa na akvatična tela na primeru kanala Dunav-Tisa-Dunav. Provera koeficijenta je izvršena analizom podataka zvaničnog državnog monitoringa površinske vode kanala DTD.

2.1. ADAM-ov koeficijent

Da bi se olakšalo postizanje održivih i integralnih ciljeva razvoja i stvaranja sigurnijeg i zdravijeg okruženja, osmišljen je Model procene arhitektonskih odluka (Architectural Decision Analysis Model – ADAM) kao koncept platforme za zaštitu životne sredine. Prednost ADAM-a je aplikacija holističkog pristupa na tri elementarna kompartimenta životne sredine koji su eko funkcionalno kontaminaciono zavisni (zagađenje zemljišta, vazduha i vode). Identifikacija ključnih prostornih specifikuma u svakom posmatranom kompartimentu ponaosob omogućava metodološki korektan pristup. Glavni zadatak ADAM-a je procena negativnih posledica uticaja na životnu sredinu i identifikacija problematičnih delova procesa izgradnje. ADAM-ov koeficijent promptno determiniše realne uticaje arhitektonskih odluka na životnu sredinu. Unosom pouzdanih podataka ADAM može validirati odluke donete od strane projektanata i pomoći da se otkriju mane u dizajnu projekta koje mogu imati hazardni efekat po čoveka i životnu sredinu. Iako ADAM ima određene limite, ADAM je pouzdan model za relevantne analize arhitektonskih odluka (Sunjevic et al, 2018). U eksperimentalnom delu rada su izabrani za simulaciono praćenje i proveru efekti arhitektonskih procesa na hidrosferu i atmosferu. Za eksperimentalni simulacioni deo rada ADAM modela korišćeni su koncentracioni nivoi katjona metala površinske vode DTD za period 2011., 2012. i 2016. kao i fizičke karakteristike mutnoća i suspendovane čestice.

Tabela 1. Vrednosti ADAM-ovog koeficijenta

K_A vrednost	Efekat na životnu sredinu	Validnost odluke
$K_A \cong 0$	Maksimalni hazardni efekat	Odluka **nije validna** i mora biti revidirana
$K_A \leq 0.3$	Veoma veliki hazardni efekat	Odluka **nije validna** i mora biti revidirana
$0.3 < K_A \leq 0.5$	Veliki hazardni efekat	Odluka **nije validna** i mora biti revidirana
$0.5 < K_A \leq 0.7$	Mali štetni efekat	Odluka je **validna,** ali treba biti uzeta u razmatranje za reviziju
$0.7 < K_A \leq 0.9$	Minimalni štetni efekat	Odluka je **validna**
$0.9 < K_A \leq 1$	Nema značajnog efekta na životnu sredinu	Odluka je **validna**

selected area for ADAM testing is industrial zone in redevelopment (large amount of construction and demolition sites) that can be easily observed. ADAM coefficient is calculated for the direct effect on artificial aquatic system (canal Danube-Tisa-Danube). Coefficient is then checked with governmental surface water monitoring data of canal DTD.

2.1. ADAM coefficient

In order to facilitate achievement of sustainable and integral development goals, and to create a healthier and safer environment, Architectural Decision Analysis Model - ADAM was designed as a concept of environmental protection platform. The main advantage of Model is application of holistic approach on three elementary environmental compartments inter correlated by partition processes on the contact surfaces phases in the heterogenic system of environment. Identifying key spatial specifics provide application of ADAM on each compartment separately with methodically correct approach. The main aim of ADAM is assessing negative consequences of environmental impacts and highlighting the problematic areas. Simulation of ADAM coefficient promptly predicts real influence of architectural processes. With the correct input of data ADAM can provide validation of the decisions made by project designer and help to detect weaknesses in a project design that has hazardous effect on the environment and helps designers to remove or to mitigate them. Although ADAM possesses some limitations, it still can be considered as very reliable model for a relevant decision analyses (Sunjevic et al, 2018). In experimental part of ADAM model, simulation was based on the data of the concentrations of metal cations in surface water of channel Danube-Tisa-Danube, for the period 2011, 2012 and 2016. as well as physical characteristics of surface water (turbidity and suspended particles).

Table 1. ADAM coefficient values

K_A value	Effect on the environment	Decision validity
$K_A \cong 0$	Maximum hazardous effect on environment	The decision is **not valid** and need to be revised
$K_A \leq 0.3$	Very significant hazard effect on environment	The decision is **not valid** and need to be revised
$0.3 < K_A \leq 0.5$	Significant hazard effect on environment	The decision is **not valid** and need to be revised
$0.5 < K_A \leq 0.7$	Small effect harmful on the environment	The decision is **valid**, but should be taken into consideration for revision
$0.7 < K_A \leq 0.9$	Minimal harmful effect on environment	The decision is **valid**
$0.9 < K_A \leq 1$	No significant effect on environment	The decision is **valid**

2.2. Lokacija

U eksperimentalnom delu istraživanja izabrana je lokacija starog industrijskog područja u Novom Sadu, površine 5 km^2 (Slika 1.). Izabrano područje je spoj dve gradske zone (Industrijska zona sever i industrijska zona jug) koje je ušlo u proces obnove i razvoja nakon stagnacije sa početka 21-og veka.

Posmatrano područje je izabrano jer obe pripadajuće industrijske zone direktno naležu na kanal Dunav-Tisa-Dunav koji se relativno blizu spaja sa Dunavom. Na granici izabranog područja se nalazi zvanična lokacija uzorkovanja površinske vode (Slika 1. označeno crvenom strelicom). Pozicija lokacije uzorkovanja omogućava direktnu kontrolu polutanata koji se unose u Dunav, što dozvoljava mogućnost ispitivanja validnosti simulacije ADAM-ovog koeficijenta.

2.2. Location

In the experimental part of research the historical industrial zone (the area of 5 km^2) of Novi Sad has been selected (Figure 1.). Selected area is juncture of two city zones (Industrial zone north and Industrial zone South) which have started after stagnation on the beginning of 21st century to redevelop.

The examined area was selected as two zones lay directly on channel Danube-Tisa-Danube and confluence nearby sampling location into the river Danube. On the border of selected area official governmental surface water monitoring gauge is located (Figure 1. marked with red arrow). Position of sampling location allows direct control of pollutants transported into the Danube. This allows possibility of ADAM simulation coefficient examination.

Slika 1. Lokacija ispitivanog područja

Figure 1. Location of examined area

3. REZULTATI I DISKUSIJA

Razvoj izabrane zone pratio je veliki broj gradilišta. Nakon 2012. primetan je smanjeni intenzitet razvoja i građevinskih aktivnosti. Osim izgradnje na slobodnom građevinskom zemljištu primetan je i veliki broj gradilišta gde su postojeći objekti bili rušeni.

ADAM-ov koeficijent je izračunat odvojeno za dva kompartimenta životne sredine vodu i vazduh osnovnom ADAM-ovom jednačinom (jednačina 1.) (Sunjevic et al., 2018). Izračunati koeficijenti su spojeni u jedinstveni koeficijent sa transformacionom jednačinom (jednačina 2.).

$$K_A = \frac{FD}{L} * K_e * K_c K_s \quad (1)$$

3. RESULTS AND DISCUSION

The redevelopment of the selected industrial zone was followed by huge number of construction sites. Decrease in redevelopment intensity has been noticeable since 2012. Besides objects built on the available construction space, visible is also a large number of demolition sites.

ADAM coefficient has been simulated and calculated separately for two environmental compartments air and water with basic ADAM equation (equation 1.) (Sunjevic et al., 2018). Calculated coefficients are connected into single coefficient with transformational equation (equation 2.).

$$K_A = \frac{FD}{L} * K_e * K_c K_s \quad (1)$$

$$K_{AT} = \frac{(K_{AW} + K_{AA})}{2} \quad (2)$$

U proračunu koeficijenta zbog specifičnosti prostora ekonomskom, korelacionom i prostornom koeficijentu data je vrednost 1. Izračunate vrednosti K_{AW} i K_{AA} su 0.29 i 0.44 respektabilno, dok je ukupna vrednost ADAM-ovog koeficijenta 0.365. Simulaciona vrednost K_{AT} „predviđa“ i ukazuje na ozbiljan hazardni efekat po životnu sredinu, biote i čoveka.

Analizom podataka koncentracionih nivoa katjona metala, $Me^{n+}_{(aq)}$, i dva fizička parametra mutnoća i suspendovane čestice za 2011., 2012. i 2016. preuzeti su sa zvaničnog republičkog monitoringa površinske vode sa selektovane lokacije (Tabela 2. i 3.). Primetne su velike promene u fizičko-hemijskim karakteristikama, odnosno razlike u koncentracionim nivoima katjona metala i odgovarajućih fizičkih karakteristika. Fizičke karakteristike prikazuju da je zamućenost drastično porasla u toku samo godinu dana (2011-2012.), a da su vrednosti u 2016. i dalje visoke. Promene u količini suspendovanih čestica direktno prate zamućenost vode. Ove promene u fizičkim karakteristikama vode kanala DTD mogu biti povezane sa količinom aktivnih građevinskih procesa i radova u izabranoj godini. Hemijske karakteristike vode kanala DTD mogu takođe biti funkcionalno praćene i korelirane sa količinom aktivnih građevinskih procesa. I efekat spiranja polutanata sa gradilišta prepoznat je kroz trend rasta kvantitativnih koncentracionih vrednosti katjona metala u 2016. godini.

Tabela 2. Koncentracioni nivoi katjona metala

Godina $Me^{n+}_{(aq)}$	2011	2012	2016
Gvožđe	0.03	15.48	38.55
Mangan	0.005	6.40	9.12
Cink	11.4	23.67	38.55
Bakar	5.97	19.77	4.92
Hrom	0.25	0.39	0.25
Olovo	0.25	0.37	0.25
Kadmijum	0.01	0.01	0.01
Živa	0.07	0.07	0.05
Nikl	1.67	4.28	2.87
Aluminijum	7.77	7.88	23.67

Tabela 3. Fizičke karakteristike površinske u uzorcima površinske vode kanala DTD vode kanala DTD

Godina Fiz. parametar	2011	2012	2016
Mutnoća	7.03	7.943	7.840
Suspendovane čestice	13.41	15.830	14.364

*Vrednosti katjona date su u µg/l

$$K_{AT} = \frac{(K_{AW} + K_{AA})}{2} \quad (2)$$

In the coefficient simulation due to site specific for economical coefficient, correlation coefficient, site specific risk assessment coefficient has been nominated as 1. Calculated values for K_{AW} and K_{AA} are 0.29 and 0.44 respectively, while the total ADAM coefficient value is 0.365. K_{AT} value marks that the *significant hazard effect on environment* will be implemented.

Using and analysing data from the official governmental surface water monitoring at selected location (Table 2. and Table 3.) on DTD shows the distinctive differences in physicochemical characteristics. Physical characteristics shows that turbidity has drastically increased in just a year (peak 2012), and in 2016 the value is still equally high. The turbidity is directly correlated to the change of suspended particles concentration in water (Table 3.). The changes of physical characteristics of DTD surface water can be correlated with quantity of active construction and demolition processes in selected year. Chemical characteristics of DTD surface water can be also connected with amounts of construction and demolition active processes. Effects of construction run-off can be viewed by rising trend of concentration of metal cations in 2016 (Table 2.).

Table 2. Concentration of metal cations

Year $Me^{n+}_{(aq)}$	2011	2012	2016
Iron	0.03	15.48	38.55
Manganese	0.005	6.40	9.12
Zink	11.4	23.67	38.55
Copper	5.97	19.77	4.92
Chrome	0.25	0.39	0.25
Lead	0.25	0.37	0.25
Cadmium	0.01	0.01	0.01
Mercury	0.07	0.07	0.05
Nickel	1.67	4.28	2.87
Aluminium	7.77	7.88	23.67

Table 3. Physical characteristics in surface in surface water samples of channel DTD water samples of channel DTD

Year Phys. characteristics	2011	2012	2016
Turbidity	7.03	7.943	7.840
Suspended particles	13.41	15.830	14.364

*Cations values are given in µg/L

4. ZAKLJUČAK

Simulacioni proračun ADAM-ovog koeficijenta za dva selektovana kompartimenta životne sredine vodu i vazduh pretpostavio je da arhitektonski procesi imaju značajan negativni efekat po životnu sredinu. Jedinstveni koeficijent (K_{AT}) je dobijen transformacionom jednačinom. Vrednost ukupnog ADAM-ovog koeficijenta rangira arhitektonske odluke (građevinske procese) sa 0.365 i ukazuje na značajan hazardni efekat po životnu sredinu. Veoma mala vrednost K_{AW} upućuje da će najveći hazardni efekat biti po vodna tela. Iz tog razloga voda je izabrana kao uzorak za procenu simulacije aplikativnosti modela ADAM da proceni mogućnost pretnje. Analiza podataka koncentracionih nivoa katjona u uzorcima površinske vode ispitivanog vodnog tela - kanala DTD i fizičkih karakteristika može se korelirati sa intenzitetom arhitektonskih procesa i građevinskih radova. A time su validirane pretpostavke ADAM-ove simulacije.

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4. CONCLUSION

Calculation of ADAM simulation coefficient for two selected environmental compartments (water and air) has shown prediction that architectural activities will have very high hazard effect on the environment. The simulative value of total ADAM coefficient ranked architectural decision (construction and demolition processes) with 0.365 and assumed that there will be significant hazard threat on environment. Very small value of K_{AW} directed the highest hazard effect will be on water bodies. For that reason water as the one of environmental compartments was selected as the assessment for ADAM simulation possibility to predict the threat. Total ADAM coefficient value proposes the assumption that construction and demolition processes will have significant hazard effect on environment. Data analyse for surface water has shown increase of physicochemical characteristics and proven validity of simulative ADAM assumption.

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