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Acta hydrotechnica 17/26 (1999)

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ZBORNIK REFERATOV 18.GOLJEVŠČKOVEGA SPOMINSKEGA DNE 12.MAREC 1999

PROCEEDINGS OF THE 18th GOLJEVŠČEK MEMORIAL DAY

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V S E B I N A - C O N T E N T S

UVODNIK

Pred vami je nova številka Acta hydrotechnica. V tej posebni številki je objavljen izbor člankov, predstavljenih na 18. Goljevščkovem spominskem dnevu, ki je bil 12. marca 1999 v prostorih Hidrotehnične smeri Fakultete za gradbeništvo in geodezijo na Hajdrihovi 28 v Ljubljani. Na tem znanstvenem posvetovanju slovenskih hidrotehnikov in vodarjev je bilo prikazanih 13 raziskovalnih in strokovnih dosežkov sodelavcev Hidrotehnične smeri FGG Univerze v Ljubljani in sodelavcev Inštituta za hidravlične raziskave v Ljubljani, ki skupaj organizirata to že tradicionalno posvetovanje. Poleg običajnega postopka recenziranja vsakega prispevka s strani dveh kolegov je bilo vodilo pri izboru objavljenih člankov tudi ocena zaključenosti raziskovalnega ali strokovnega dela.

Pri recenziranju prispevkov so sodelovali: mag. Dušan Blagajne (Ministrstvo za okolje in prostor RS, Ljubljana), prof.dr. Mitja Brilly (FGG), doc.dr. Metka Gorišek (Ministrstvo za okolje in prostor RS, Ljubljana), doc.dr. Boris Kompare (FGG), doc.dr. Uroš Krajnc (Inštitut za ekološki inženiring, Maribor), doc.dr. Eugen Petrešin (Univerza v Mariboru), prof.dr. Andrej Pogačnik (FGG) - za njihovo sodelovanje se vsem iskreno zahvaljujem.

Kot lahko vidite, postaja oblika revije drugačna. Opuščamo objavljanje samo v slovenskem jeziku z izvlečkom v angleškem jeziku in prehajamo na popolnoma dvojezično periodično objavljanje prispevkov v slovenskem in angleškem jeziku enakovredno. Tej usmeritvi dodajamo željo, da revija preraste v znanstveno-strokovno periodično publikacijo, namenjeno objavam prispevkov strokovnjakov in raziskovalcev s področja vodarstva in hidrotehnike, katere izdajatelj in založnik je Univerza v Ljubljani, Hidrotehnična smer Fakultete za gradbeništvo in geodezijo (FGG), ki jo sestavljajo Katedra za mehaniko tekočin z laboratorijem (LMTe), Katedra za splošno hidrotehniko (KSH) in Inštitut za zdravstveno hidrotehniko (IZH). Predstavniki omenjenih enot tudi sestavljajo izdajateljski odbor revije. V prihodnosti bomo poskušali povabiti k sodelovanju tudi druge strokovnjake s tega področja.

Acta hydrotechnica bo v letu 2000 začela izhajati dvakrat na leto. V njej bomo objavljali prispevke s področja vodarstva in hidrotehnike v obliki izvirnih in preglednih znanstvenih člankov, preliminarnih objav in strokovnih člankov. Podrobnejša navodila za oblikovanje prispevkov lahko poiščete na zadnjih straneh revije.

Ljubljana, september 1999 — Glavni urednik

EDITORIAL

In front of you there is a new issue of the Acta hydrotechnica. Reviewed papers are published in this special issue. These were selected from short presentations at the 18th Goljevšček Memorial Day, held on March 12, 1999 at the Faculty of Civil and Geodetic Engineering, Hajdrihova 28, Ljubljana. Thirteen scientific and professional contributions were presented by colleagues of the Hydraulics Division of the FGG and the Hydraulic Institute in Ljubljana at this scientific conference of Slovenian hydraulic and water resources engineers. These two institutions jointly organise this now already traditional conference. All papers were peer-reviewed by two reviewers and selected on the basis of their scientific or professional completeness.

The following colleagues helped review the papers: Dušan Blagajne (Ministry of Environment and Physical Planning, Ljubljana), Mitja Brilly (FGG), Metka Gorišek (Ministry of Environment and Physical Planning, Ljubljana), Boris Kompare (FGG), Uroš Krajnc (Institute for Ecological Engineering, Maribor), Eugen Petrešin (University of Maribor), and Andrej Pogačnik (FGG) - I would like to sincerely thank them all for their co-operation.

As you might notice, the outlook of the journal has changed. We are abandoning the possibility of publishing papers basically only in Slovenian with an abstract in English, and are going to publish only fully bilingual papers in Slovenian and English, in two columns. We are adding to this commitment our wish for Acta hydrotechnica to become the scientific-professional journal open to professionals and researchers in fields of water resources management, hydraulic engineering and research. The publisher of the journal remains the Hydraulic Division of the FGG, which has the following three chairs: Chair of Fluid Mechanics with a Lab (LMTe), Chair of Hydrology and Hydraulic Engineering (KSH), and Institute of Sanitary Engineering (IZH). The Publishing Board of the journal is selected from these three chairs, and will, we hope, soon be strengthened by other researchers from this field.

In 2000, the Acta hydrotechnica will be issued twice. We will publish contributions from the fields of water resources management, hydraulic engineering and research in the form of original and overview scientific papers, technical papers, and professional papers in the Journal. More information about the technical preparation of the manuscript is to be found at the end of each copy of the journal.

Ljubljana, September, 1999 — Editor-in-Chief

Zbornik referatov 18. Goljevščkovega spominskega dne - Proceedings of 18th Goljevšček Memorial Day
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MONITORING ODPADNIH VODA IN ZAHTEVANE STOPNJE ČIŠČENJA NA KOMUNALNIH ČISTILNIH NAPRAVAH
MONITORING OF WASTEWATER AND THE REQUIRED DEGREES OF TREATMENT FOR MUNICIPAL WASTEWATER TREATMENT PLANTS

Jože PANJAN

V prispevku so prikazane zahteve po monitoringu komunalnih in nekaterih industrijskih odpadnih voda za plačevanje ekološke takse v državi. V Sloveniji je bilo v letu 1996 in 1998 sprejetih več uredb, ki urejajo to področje. Podane so zahteve iz teh uredb in naše izkušnje pri spremljanju tehnološkega delovanja čistilnih naprav (ČN). Povzete so nekatere maksimalne dovoljene koncentracije onesnažil, ki se izpuščajo v vodotok ali v kanalizacijo. Prikazane so zahtevane stopnje čiščenja na komunalnih ČN. Podali smo primerjavo med zahtevami naše zakonodaje za kakovost iztokov iz komunalnih ČN z zakonodajo ZRN in EZ.
Ključne besede: *monitoring, komunalne odpadne vode, čistilne naprave, zakonodaja*

Requirements on the monitoring of urban and some industrial wastewaters for the payment of the discharge tax to the State are presented in this contribution. Several decrees that regulate this field were adopted in the years 1996 and 1998. Requirements from these decrees and our experience from the monitoring of the technical operation of wastewater treatment plants (WWTPs) are explained. Some data on the maximal permitted concentration of pollutants discharged in a watercourse and collecting system are reviewed. Requirements on the degrees of treatment in municipal WWTPs are discussed. A comparison between the requirements of our legislation and that of Germany and the EU for the quality of the discharges from municipal WWTPs is also presented.
Key words: *monitoring, urban wastewater, wastewater treatment plants, legislation*

1. UVOD

Po svetu in pri nas že vrsto let spremljamo kakovost vodotokov, jezer in morja (pri nas to izvaja Hidrometeorološki zavod pri MOP). Nadzor nad onesnaževalci pa je bil bolj ali manj stihijski. V Sloveniji je bilo v letu 1996 na podlagi *Zakona o varstvu okolja* [1] sprejetih več uredb, ki urejajo to področje.

Emisijski monitoring ali monitoring odpadnih vod je postopek, ki ga izvaja pooblaščena oseba. Metodologijo vzorčenja in merjenja parametrov in količin odpadnih vod, vsebino poročila o emisijskem monitoringu ter način sporočanja podatkov ministrstvu, ki je pristojno za varstvo okolja, opravlja v skladu s *Pravilnikom o prvih meritvah in obratovalnem monitoringu odpadnih vod ter o pogojih za njegovo izvajanje* [2]. Obliko poročila

1. INTRODUCTION

The quality of watercourses, lakes and seas has been monitored all over the world, as well as in our country (provided by the Hydrometeorological Institute of the MEPP), for many years. The control of causers of pollution has been more or less unplanned. Several decrees that regulate this field were adopted in Slovenia in 1996 on the basis of the *Environmental Protection Act* [1].

Emission monitoring or operational monitoring of wastewater is a procedure provided by a competent authority. This authority implements the methodology of sampling, the measurement of parameters and the amount of wastewater, the content of the report on emission monitoring and the method and form of notifying data to the MEPP, who is competent in environmental protection, in accordance with the *Regulation on the initial measurements and operational monitoring of waste water and the conditions for its* predpisuje *Uredba o obliki poročila o občasnih in trajnih meritvah v okviru obratovalnega monitoringa odpadnih vod* [3].

Izvedba emisijskega monitoringa obsega:

– merjenje količine odpadne vode med vzorčenjem,
– vzorčenje odpadne vode,
– merjenje parametrov odpadne vode: merjenje temperature in pH vrednosti odpadne vode med vzorčenjem in analiza vzorca odpadne vode,
– vrednotenje emisije snovi, emisijskega deleža oddane toplote ter izračun letne količine odpadne vode in letne količine nevarnih snovi,
– izračun emisijskega faktorja ali učinka čiščenja odpadne vode, če je s predpisi o emisiji snovi za posamezni vir onesnaženja ali komunalno oziroma skupno čistilno napravo za te veličine določena mejna vrednost,
– izdelavo poročila o opravljenih meritvah.

Emisijski monitoring zahteva od vsakega onesnaževalca, da dokaže količino onesnaženja. V Sloveniji mora po podatkih MOP-a opravljati emisijski monitoring približno 800 onesnaževalcev.

V Sloveniji se je emisijski monitoring prvič izvajal v letu 1996 samo na KPK. Že za leto 1997 pa so bili zahtevani parametri naslednjih težkih kovin: živo srebro, kadmij, krom, nikelj, svinec, in baker ter njihove spojine, izražene kot kovine. Z navedenimi uredbami so kemijski postopki in analize zelo natančno in kakovostno definirani. Ker so analize, izražene kot koncentracije, le prvi del za določitev letne mase onesnaženja, menimo, da je za drugi del, to je za meritve pretokov in njihov nadzor slabo ali neprofesionalno poskrbljeno (neurejenost merskih mest, nekvalificiranost za odčitavanje ali meritev pretokov brez nadzora idr.).

Poleg emisijskega monitoringa je pomemben imisijski monitoring, ki obravnava varstvo voda celovito, in sicer tako, da za onesnaževalce ugotovimo in določimo

implementation [2]. The form of the report is prescribed by the *Decree on the form of the report of periodical and continuous measurements in the scope of the operational monitoring of waste waters* [3].

Implementation of emission monitoring includes:

– measurement of the amount of wastewater during sampling,
– sampling of wastewater,
– measurement of the parameters of wastewater: measurement of temperature and the pH value of wastewater during sampling and analysis of the sample of wastewater,
– evaluation of the emission of substances, the emission fraction of discharged heat and calculation of the annual amount of waste water and annual amounts of dangerous substances,
– calculation of the emission fraction and the effect of wastewater treatment when the limit value of these parameters is set by regulations on the emission of substances for an individual source of pollution or a municipal, respectively, mixed wastewater treatment plant,
– elaboration of the report on the accomplished measurements.

Emission monitoring requires that causer of pollution prove the amount of pollution it causes. There are approximately 800 causers of pollution in Slovenia which must provide emission monitoring.

Emission monitoring for COD only was implemented in Slovenia for the first time in 1996. Then in 1997, the parameters of the following heavy metals were required: mercury, cadmium, chromium, nickel, lead and copper and their compounds expressed as metal. Chemical procedures and analyses are defined very precisely and according to the high quality standards by the decrees mentioned. While analytical results, expressed as concentrations, are only the first factor in the determination of the annual amount of a pollutant, it is, in our opinion, very poorly and unprofessionally provided for in the second portion, which is for the measurements of flows and their control. Some examples are: disorganised measuring sites, unprofessional reading of results or flow measurements without control etc.

Besides emission monitoring, immission monitoring, which deals comprehensively with water protection, is also important, so that the necessary degree of treatment and the hierarchy of construction of municipal potrebno stopnjo čiščenja in hierarhijo graditve komunalnih čistilnih naprav v posameznih porečjih. Trenutno se imisijski monitoring, ki upošteva tudi samočistilno sposobnost odvodnikov, pri nas ne izvaja.

WWTPs in an individual river basin is stated and determined for each causer pollution. Currently, the immission monitoring that also takes into account the self-purification capability of a recipient, has not yet been implemented in Slovenia.

2. IZVEDBA EMISIJSKEGA MONITORINGA

V okviru emisijskega monitoringa mora obravnavano podjetje zagotavljati izvedbo trajnih meritev količin odpadne vode, če so za vir onesnaženja določene s predpisi o emisiji snovi in toplote pri odvajanju odpadnih voda iz virov onesnaženja in občasnih meritev temeljnih in dodatnih parametrov ter količin odpadne vode med vzorčenjem.

Občasne meritve se izvajajo med obratovanjem ali uporabo vira onesnaženja ali komunalne ali skupne čistilne naprave v enakomernih časovnih presledkih v koledarskem letu oziroma v obdobju obratovanja ali uporabe, kadar ne obratuje ali se ne uporablja skozi celo koledarsko leto.

Letna pogostost občasnih meritev in čas vzorčenja reprezentativnega vzorca odpadne vode za komunalne ali skupne čistilne naprave [2] sta podana v preglednici 1.

2. IMPLEMENTATION OF IMMISION MONITORING

Regulations regarding the emission of substances and heat in the drainage of wastewater from pollution sources require that the responsible enterprise must ensure the implementation of permanent measurements of the amount of wastewater or periodical measurements of the basic and additional parameters and the amount of wastewater during sampling within the scope of emission monitoring.

Periodical measurements are implemented during the operation or use of a pollution source or a municipal or mixed WWTP in regular time intervals in a calendar year or within the time of operation or use, when it does not operate for the entire calendar year.

The annual frequency of periodical measurements and the sampling time of the representative sample of wastewater for a municipal or mixed WWTP [2] are given in Table 1.

Preglednica 1. Pogostost občasnih meritev in čas vzorčenja reprezentativnega vzorca odpadne vode za komunalne ali skupne čistilne naprave [2].
Table 1. Frequency of the periodical measurements and the sampling time of the representative sample of wastewater for a municipal or mixed WWTP [2].

Zmogljivost komunalne ali skupne čistilne naprave [PE] *Capacity of a municipal or mixed waste water treatment plant [PE]*	Letna pogostost meritev [-] *Annual frequency of measurement [-]*	Čas vzorčenja reprezentativnega vzorca [ure] *Sampling time of the representative sample [hour]*
≤ 50	1	2
51-200	2	2
201- 2000	2	6
2001- 10000	4	24
10001- 50000	8	24
> 50000	12	24

Letna pogostost občasnih meritev in čas vzorčenja reprezentativnega vzorca odpadne vode za vir onesnaženja [2] pa sta določena v preglednici 2.

Annual frequency of the periodical measurements and sampling time of the representative sample of wastewater for a pollution source [2] are determined in Table 2.

Preglednica 2. Pogostost občasnih meritev in čas vzorčenja za vir onesnaženja [2].
Table 2. Frequency of periodical measurements and the sampling time for a pollution source [2].

Letna količina tehnološke odpadne vode [1000 m^3/leto]	Letna pogostost meritev [-]	Čas vzorčenja reprezentativnega vzorca [ure]
Annual amount of industrial waste water [1000 m^3/year]	Annual frequency of measurements [-]	Sampling time of the representative sample [hour]
< 4	1	6
4 - 10	2	6
10 - 50	3	6
50 - 200	4	24
200 - 500	6	24
> 500	12	24

Če ima vir onesnaženja, ki odvaja tehnološke odpadne vode, več iztokov v kanalizacijo ali neposredno v vode, se pri določitvi letne pogostosti občasnih meritev in časa vzorčenja upošteva vsota letnih količin tehnološke odpadne vode iz vseh iztokov.

Trajne meritve količine odpadnih vod mora povzročitelj zagotoviti, če je letna količina tehnološke odpadne vode iz vira onesnaževanja na posameznem iztoku večja od 100000 m^3/leto. Če ima vir onesnaževanja več iztokov in v nobenem letna količina tehnoloških odpadnih vod ne presega 100000 m^3/leto, letna količina tehnoloških odpadnih vod vseh iztokov skupaj pa presega 100000 m^3/leto, mora povzročitelj zagotoviti trajne meritve količine odpadnih vod na iztoku, ki ima največjo letno količino tehnoloških odpadnih vod. Izvajalec javne službe mora zagotoviti trajne meritve količine odpadnih vod na iztoku komunalne ali skupne čistilne naprave, če je zmogljivost čiščenja več kot 10 000 PE.

Emisija snovi in toplote se določa na iztoku odpadne vode iz vira onesnaževanja ali čistilne naprave v kanalizacijo ali neposredno v odvodnik brez predhodnega razredčevanja odpadne vode.

When a pollution source from which industrial wastewater is discharged, has several outlets in the collecting system or discharges directly into a body of water, the sum of the annual amounts of industrial wastewater from all outlets must be considered for the determination of the annual frequency of periodical measurements and the sampling time.

Permanent measurements of the amount of wastewater must be ensured by the causer of pollution when the annual amount of industrial wastewater from a pollution source on a separate outlet is higher than 100.000 m^3/year. When a pollution source has several outflows and the annual amount of industrial wastewater in none exceeds 100.000 m^3/year, but the annual amount of industrial wastewater from all outlets together exceeds 100.000 m^3/year, the originator of the pollution must ensure continuous measurements of the amount of wastewater on the outlet that has the highest annual amount of industrial wastewater. A public service manager must ensure permanent measurements of the amount of wastewater on the outflow of a municipal or mixed wastewater treatment plant when the treatment capacity is higher than 10.000 PE.

The emission of substances and heat is determined by the outflow of wastewater from the pollution source or a wastewater treatment plant into the sewage system or directly into a body of water without preliminary dilution.

3. MEJNE VREDNOSTI PARAMETROV ODPADNE VODE

Emisija snovi ali toplote v posamezni meritvi presega predpisane mejne vrednosti odpadnih vod, če so izmerjene ali izračunane vrednosti večje od predpisanih mejnih vrednosti.

Mejne vrednosti parametrov odpadne vode za iztok v vodotok ali iztok v kanalizacijo so podane v Prilogi 1 *Uredbe o emisiji snovi in toplote pri odvajanju odpadnih voda iz virov onesnaženja* [4]. Preglednica 3 pa nam podaja po en parameter kot primer.

3. LIMIT VALUES OF THE PARAMETERS OF WASTEWATER

The emission of substances or heat of the particular measurement exceeds the regulated limit values for wastewater when the measured or calculated values are higher than the regulated limit values.

Limit values of the parameters of wastewater for the discharge into a watercourse or sewage system are given in Appendix 1 of the *Decree on the emission of substances and heat in the drainage of wastewater from pollution sources* [4]. Some parameters are given in Table 3 as an example.

Preglednica 3. Prikaz opisa mejnih vrednosti za izpust v vodotok ali v kanalizacijo [4].
Table 3. Presentation of some limit values for discharge into a watercourse or discharge into the sewage system [4].

Parameter	Izražen kot *Expressed as*	Enota *Unit*	Mejne vrednosti *Limit values*	
			Iztok v vode *Discharge into a watercourse*	Iztok v kanalizacijo *Discharge into the sewage system*
I. SPLOŠNI PARAMETRI *I. GENERAL PARAMETERS*				
4. Usedljive snovi *4. Settleable substances*		mg/l	0,5	10
II. BIOLOŠKI PARAMETRI *II. BIOLOGICAL PARAMETERS*				
7. Biološka razgradljivost *7. Biodegradability*		%	-	(c)
III. ANORGANSKI PARAMETRI *III. INORGANIC PARAMETERS*				
18. Krom šestvalentni *18. Chromium(VI)*	Cr	mg/l	0,1	0,1
IV. ORGANSKI PARAMETRI *IV. ORGANIC PARAMETERS*				
38. KPK *38. COD*	O_2	mgO_2/l	120	-

Količine v vode izpuščenih nevarnih snovi so podane v Prilogi 2 [4]. Preglednica 4 pa nam podaja dva parametra kot primer.

The amounts of dangerous substances released into a recipient are given in Appendix 2 [4]. Two parameters are given as an example in Table 4.

Preglednica 4. Prikaz zapisa količin v vode izpuščenih nevarnih snovi v enem letu [4].
Table 4. Presentation of the amounts of dangerous substances released in one year [4]

Parameter	Izražen kot *Expressed as*	Enota *Unit*	Količina izpuščene nevarne snovi *Amount of dangerous substance released*
III. ANORGANSKI PARAMETRI *III. INORGANIC PARAMETERS*			
18. Krom šestvalentni *18. Chromium(VI)*	Cr	g/leto *g/year*	100
IV. ORGANSKI PARAMETRI *IV. ORGANIC PARAMETERS*			
46. Fenoli *46. Phenols*	C_6H_5OH	g/leto *g/year*	100

Za obrate, ki proizvajajo kovinske izdelke, *Uredba o emisiji snovi pri odvajanju odpadnih vod iz objektov in naprav za proizvodnjo kovinskih izdelkov* [5] določa posebne zahteve v zvezi z emisijo snovi pri odvajanju tehnoloških odpadnih vod iz objektov in naprav. Posebne mejne vrednosti parametrov za odvajanje v kanalizacijo:

The *Decree on the emission of substances in the discharge of wastewater from plants and facilities for the production of metal products* [5] regulates special requirements concerning the emission of substances in the discharge of industrial wastewater from plants and facilities producing metal products. There are special limit values of the parameters for the drainage into a sewage system:

14. Kadmij *14. Cadmium*	Cd	mg/l	0.2	0.2

Za obrate, ki proizvajajo, predelujejo in obdelujejo tekstilna vlakna, Uredba o emisiji snovi pri odvajanju odpadnih vod iz objektov in naprav za proizvodnjo, predelavo in obdelavo tekstilnih vlaken [6] določa posebne zahteve v zvezi z emisijo snovi pri odvajanju tehnoloških odpadnih vod iz objektov in naprav. Posebne mejne vrednosti parametrov za odvajanje v kanalizacijo:

The Decree on the emission of substances in the discharge of wastewater from plants and facilities for the production, processing and treatment of textile fibre [6] regulates special requirements concerning the emission of substances in the drainage of industrial wastewater from industrial plants and facilities producing, processing and treating textile fibres. Special limit values of parameters for the drainage into a sewage system follow:

13. Cink *13. Zinc*	Zn	mg/l	3.0	3.0

Uredba o emisiji snovi pri odvajanju odpadnih voda iz komunalnih čistilnih naprav [7] določa posebne zahteve v zvezi z emisijo snovi pri odvajanju odpadnih vod iz komunalnih čistilnih naprav:
– mejne vrednosti parametrov odpadne vode,
– mejne vrednosti učinka čiščenja odpadne

The *Decree on the emission of substances in the discharge of wastewater from municipal wastewater treatment plants* [7] regulates the emission of substances in the drainage of urban wastewater from municipal wastewater treatment plants:
– limit values of the parameters of wastewater
– limit values of the effect of treatment of

vode,
- posebne ukrepe v zvezi z načrtovanjem in obratovanjem komunalnih čistilnih naprav.

Mejne vrednosti parametrov odpadnih voda za **obstoječe komunalne čistilne naprave** [7] ne glede na njihovo zmogljivost so podane v preglednici 5.

wastewater
- special measures concerning the planning and operation of municipal wastewater treatment plants

The limit values of the parameters of wastewater for **existing municipal waste water treatment plants** [7] without respect to their capabilities are given in Table 5.

Preglednica 5. Mejne vrednosti parametrov odpadnih voda za **obstoječe komunalne čistilne naprave** [7].
*Table 5. Limit values of the parameters of wastewater for **existing municipal wastewater treatment plants** [7].*

Parameter	Izražen kot *Expressed as*	Enota *Unit*	Mejne vrednosti za obstoječe KČN *Limit values for existing WWTPs*
BPK_5 *BOD_5*	O_2	mg/l	30
KPK *COD*	O_2	mg/l	160
Amonijev dušik *Ammonium nitrogen*	N	mg/l	15
Celotni fosfor *Total phosphorous*	P	mg/l	10

Mejne vrednosti parametrov odpadnih voda za **nove komunalne čistilne naprave in za komunalne čistilne naprave v rekonstrukciji** [7] so glede na njihovo zmogljivost čiščenja, podane v preglednici 6.

Limit values of the parameters of wastewater for **new municipal wastewater treatment plants and municipal wastewater treatment plants in reconstruction** [7] with respect to their treatment capacities are given in Table 6.

Preglednica 6. Mejne vrednosti parametrov odpadnih voda za **nove komunalne čistilne naprave in za komunalne čistilne naprave v rekonstrukciji** [7].
Table 6. Limit values of the parameters of wastewater for new municipal wastewater treatment plants and municipal wastewater treatment plants in reconstruction [7].

			Zmogljivost KČN izražena v [PE] *Capacity of a municipal WWTP in [PE]*			
Parameter	Izražen kot *Expressed as*	Enota *Unit*	< 2000	2001 - 10000	10001-100000	> 100000
Neraztopljene snovi *Suspended solids*		mg/l	-	60	35	35
Amonijev dušik *Ammonium nitrogen*	N	mg/l	-	10	10	10
KPK *COD*	O_2	mg/l	150	125	110	100
BPK_5 *BOD_5*	O_2	mg/l	30	25	20	20

Mejna vrednost za učinek čiščenja komunalne čistilne naprave, ki ne sme biti manjši od 80 odstotkov, velja namesto mejne vrednosti za KPK iz preglednice 6 v primeru, če v mesečnem povprečju iz analize 24-urnega vzorca izhaja, da je vrednost KPK v surovi odpadni vodi na iztoku iz mehanske stopnje čiščenja večja od:

- 625 mg/l za KČN s kapaciteto čiščenja več kot 2 000 PE
- 550 mg/l za KČN s kapaciteto čiščenja več kot 10 000 PE ali
- 500 mg/l za KČN s kapaciteto čiščenja več kot 100 000 PE.

Mejna vrednost za učinek čiščenja komunalne čistilne naprave, ki ne sme biti manjši od 90 odstotkov, velja namesto mejne vrednosti za BPK_5 iz preglednice 6 v primeru, če v mesečnem povprečju iz analize 24-urnega vzorca izhaja, da je vrednost BPK_5 v surovi odpadni vodi na iztoku iz mehanske stopnje čiščenja večja od:

- 250 mg/l za KČN s kapaciteto čiščenja več kot 2 000 PE ali
- 200 mg/l za KČN s kapaciteto čiščenja več kot 10 000 PE.

Mejne vrednosti za koncentracijo in učinek čiščenja celotnega dušika in celotnega fosforja, če se odpadne vode iz novih KČN ali KČN v rekonstrukciji iztekajo v:

- zajezene površinske vode, ki se skladno z določbami [4] štejejo za vodotok,
- ustja rek, ki se izlivajo v obalno morje,
- druge površinske vode, kjer je mogoče ugotoviti ali pričakovati evtrofikacijo

ter skladno z dopolnilom [8] k uredbi [7] tudi v:

- površinske vode, ki so namenjene za pripravo pitne vode in presegajo mejne imisijske vrednosti nitratov, določene s predpisi o kakovosti površinskih voda,
- vode na območjih, kjer je skladno s predpisi s področja voda in varstva narave obvezno terciarno čiščenje odpadne vode,

so podane v preglednici 7.

Limit values that cannot be less than 80 % for the efficiency of treatment of a municipal wastewater treatment plant are valid instead of the limit value for COD from Table 6 in the case when it comes out of the monthly average of the 24-hour sample analysis that the COD value in raw wastewater in the outflow from the mechanical (primary) phase of the treatment is higher than:

- 625 mg/l for a municipal WWTP with a treatment capacity higher than 2 000 PE
- 550 mg/l for a municipal WWTP with a treatment capacity higher than 10 000 PE
- 500 mg/l for a municipal WWTP with a treatment capacity higher than 100 000 PE

Limit values for the efficiency of treatment of a municipal wastewater treatment plant that cannot be less than 90 % are valid instead of the limit value for BOD_5 from Table 6 in the case when it comes out of the monthly average of the 24-hour sample analysis that the BOD_5 value in raw wastewater in the outflow from the mechanical (primary) phase of treatment is higher than:

- 250 mg/l for a municipal WWTP with a treatment capacity higher than 2 000 PE or
- 200 mg/l for a municipal WWTP with a treatment capacity higher than 10 000 PE

Limit values for concentration and the efficiency of treatment of total nitrogen and total phosphorous when waste water from a new municipal WWTP or municipal WWTP in reconstruction is discharged into:

- stemmed water bodies which are considered in agreement with the regulations [4] as watercourses,
- estuaries draining into coastal seas,
- other surface waters in which it is possible to state or expect eutrophication,

and according to Amendment [8] to Decree [7] also into:

- surface waters intended for the preparation of drinking water and exceeding the limit immission values of nitrates determined by regulations on the quality of surface waters,
- water bodies in the areas where the tertiary treatment of wastewater is obligatory according to the regulations concerning waters and the protection of nature,

are given in Table 7.

Preglednica 7. Minimalne zahteve za izpust komunalnih odpadnih vod v Sloveniji v občutljiva območja [7].
Table 7. Minimal requirements for the discharge of urban wastewater in Slovenia [7].

			Zmogljivost KČN izražena v [PE] *Capacity of a municipal WWTP in [PE]*			
Parameter	Izražen kot *Expressed as*	Enota *Unit*	< 2000	2001 - 10000	10001- 100000	> 100000
Celotni dušik *Total nitrogen*	N	mg/l	-	18	15	10
Učinek čiščenja celotnega dušika *Effect of treatment of total nitrogen*		%	-	65	70	80
Celotni fosfor *Total phosphorus*	P	mg/l	-	3	2	2
Učinek čiščenja celotnega fosforja *Effect of treatment of total phosporus*		%	-	70	80	80

4. IZPUSTI IZ KOMUNALNIH ČN IN PRIMERJAVA Z DRUGIMI

Kontrola izpustov iz KČN je zelo pomembna, saj z njo na eni strani ugotavljamo obremenitve ostalih onesnaževalcev, ki so priključeni na kanalizacijski sistem, po drugi strani pa nam zahtevane stopnje varujejo odvodnike. Kakovost izpustov iz KČN nam v fazi projektiranja tudi neposredno določa stopnjo čiščenja in s tem investicijsko vrednost ČN.

V preglednici 8 so podane minimalne zahteve za izpust komunalnih odpadnih vod v ZRN [9].

Pri tem so posamezni razredi opredeljeni z:

1. velikostni razred: do 60 kg BPK_5/dan ali približno 1 000 PE
2. velikostni razred: od 60 do 300 kg BPK_5/dan ali 1 000 – 5 000 PE
3. velikostni razred: od 300 do 1200 kg BPK_5/dan ali 5 000 – 20 000 PE
4. velikostni razred: od 1200 do 6000 kg BPK_5/dan ali 20 000 – 100 000 PE
5. velikostni razred: nad 6000 kg BPK_5/dan ali nad 100 000 PE

4. DISCHARGES FROM MUNICIPAL WWTPS AND COMPARISON WITH OTHERS

The monitoring of effluents from a municipal WWTP is very important on one side because the loads of other sources of pollution which are connected to the collecting system are discovered with its aid, and on the other side, because recipients are protected by the required degrees. The quality of discharges from a municipal WWTP also directly determines the degree of treatment in the planning stage, and consequently, the investment costs.

Minimal requirements for the discharge of urban wastewater in Germany are given in Table 8 [9].

Particular dimension classes are determined as follows:

1. Dimension class: to 60 kg BPK_5/day or approximately 1 000 PE
2. Dimension class: from 60 to 300 kg BPK_5/day or 1 000 – 5 000 PE
3. Dimension class: from 300 to 1200 kg BPK_5/day or 5 000 – 20 000 PE
4. Dimension class: from 1 200 to 6 000 kg BPK_5/day or 20 000 – 100 000 PE
5. Dimension class: over 6 000 kg BPK_5/day or over 100 000 PE

V preglednici 9 so podane zahteve Smernic EZ [10] za izpuste iz KČN.

Requirements of EU Directives for the discharges from a municipal WWTP [10] are given in Table 9.

Preglednica 8. Minimalne zahteve za izpust komunalnih odpadnih vod v ZRN [9].
Table 8. Minimal requirements for the discharge of municipal wastewater in Germany [9].

			Velikostni razred KČN Dimension class of a municipal WWTP				
Parameter	Izražen kot *Expresed as*	Enota *Unit*	1.raz. *1.cl.*	2.raz. *2.cl.*	3.raz. *3.cl.*	4.raz. *4.cl.*	5.raz. *5.cl.*
KPK *COD*		mg/l	150	110	90	90	75
BPK_5 *BOD_5*		mg/l	40	25	20	20	15
Amonijev dušik *Ammonium nitrogen*		mg/l	-	-	10	10	10
Celotni fosfor *Total phosphorous*		mg/l	-	-	-	2	1

Preglednica 9. Zahteve Smernic EZ [10] za izpuste iz KČN.
Table 9. Requirements of EU Directives for the discharges from municipal WWTPs [10].

Parameter	Izražen kot *Expressed as*	Enota *Unit*	Koncentracija *Concentration*	Učinek čiščenja *Effect of treatment*
BPK_5 *BOD_5*	O_2	mg/l	25	70-90 %
KPK *COD*	O_2	mg/l	125	75 %
Celotne netopne snovi *Total suspended solids*		mg/l	35 [a)]	90 % [b)]
Celotni fosfor *Total phosphorous*	P	mg/l	2 [c)]	80 %
Celotni dušik *Total nitrogen*	N	mg/l	15 [d)]	70-80 %

Legenda:

a) za KČN od 2000 do 10000 PE pod 60 mg/l in pod 35 za KČN, večje od 10000 PE
b) za KČN od 2000 do 10000 PE pod 70% in pod 90% za KČN, večje od 10000 PE
c) 1 mg/l za KČN večje od 10000 PE
d) 10 mg/l za KČN večje od 10000 PE

Legend:

a) for municipal WWTPs from 2 000 to 10 000 PE under 60 mg/l and under 35 for municipal WWTPs larger than 10 000 PE
b) for municipal WWTPs from 2 000 to 10 000 PE 70% and under 90% for municipal WWTPs larger than 10 000 PE
c) 1 mg/l for municipal WWTPs larger than 10 000 PE
d) 10 mg/l for municipal WWTPs larger than 10 000 PE

Iz primerjav preglednic 7, 8 in 9, čeprav niso čisto kompatibilne, vidimo, da so naše zahteve za KČN nad 100000 PE za celotni

From a comparison of Tables 7, 8 and 9, though they are not quite compatible, it is fosfor nekoliko nižje (2 mg/l celotnega fosforja) kot v ZRN in EZ pa (1 mg/l), za celotni dušik pa so zahteve enake.

V preglednici 10 so prikazani roki za program ureditve in sanacijski program odvajanja komunalne odpadne vode po kanalizaciji ter roki za sekundarno, terciarno in ustrezno čiščenje odpadne vode, kot je določeno v *Uredbi o spremembah in dopolnitvah uredbe o emisiji snovi pri odvajanju odpadnih vod iz komunalnih čistilnih naprav* [8] za različne velikosti in občutljivosti območja poselitve.

evident that the requirements for total phosphorous in municipal WWTPs over 100000 PE are less stringent (2 mg/l) in Slovenia than in Germany and the EU (1 mg/l), while the requirements on nitrogen are the same.

Deadtimes for the regulation and sanitation program for the discharging of urban wastewater into a collecting system, and the secondary, tertiary and appropriate treatment of wastewater as it its regulated by the *Decree on the changes and the amendments of the decree on the emission of substances in the drainage of wastewater from municipal wastewater treatment plants* [8] for different sizes and sensitivities of agglomeration areas is presented in Table 10.

Preglednica 10. Roki za program ureditve in sanacijski program odvajanja komunalne odpadne vode po kanalizaciji ter roki za sekundarno, terciarno in ustrezno čiščenje odpadne vode kot je določeno v uredbi [8].

Table 10. Deadtimes for the regulation and sanitation program for the discharging of urban wastewater into a collecting system, and the secondary, tertiary and appropriate treatment of waste water [8].

	PROGRAM UREDITVE (do konca leta) *REGULATION PROGRAM (to the end of the year)*				SANACIJSKI PROGRAM (do konca leta) *SANITATION PROGRAM (to the end of the year)*			
Velikost območja poselitve [PE] *Agglomer. area in [PE]*	Odvajanje odpadne vode po kanalizaciji *Collect. System*	Sekund. čiščenje *Second. Treatment*	Terciarno čiščenje *Tertiary Treatment*	Ustrezno čiščenje *Appropr. Treatment*	Odvajanje odpadne vode po kanalizaciji *Collect. system*	Sekund. čiščenje *Second. treatment*	Terciarno čiščenje *Tertiary Treatment*	Ustrezno čiščenje *Appropr. treatment*
< 2000				2005*				2015*
2000 - 10000		2010 2005*				2015* 2017		
2000 - 15000	2005				2015			
10000 - 15000		2005				2015		
> 10000	1998*		1998*		2008*		2008*	
> 15000	2000	2000			2010	2010		
> 100000					2005	2005		

* zahteve za občutljiva območja

** requirements for sensitive areas*

5. ZAKLJUČEK

V članku smo prikazali, kakšna je kontrola onesnaževalcev z odpadnimi vodami odvodnikov v Sloveniji. Podane so zahteve iz ustreznih uredb in nekatere naše izkušnje pri spremljanju tehnološkega delovanja ČN. Pogrešamo predvsem imisijski pristop k obravnavi onesnaževanja naših rek, jezer in morja. Povzete so nekatere maksimalne dovoljene koncentracije snovi, ki se izpuščajo v vodotok ali v kanalizacijo. Prikazane so zahtevane stopnje čiščenja na komunalnih čistilnih napravah (ČN). Podali smo primerjavo zahtev naše zakonodaje z zakonodajo v ZRN in EZ ter roke za izvedbo kanalizacij in čistilnih naprav v Sloveniji.

5. CONCLUSION

The situation of the control of the causers of pollution and the discharging of wastewater into recipients in Slovenia was presented. Some requirements from the regulations and our experiences regarding the control of the technical operation of wastewater treatment plants (WWTPs) are provided. Slovenia is especially missing the immission approach to the treatment of the pollution of our rivers, lakes and sea. Some maximal allowed concentrations of pollutants discharged into a watercourse or in a collecting system are reviewed. The required degrees of treatment in municipal wastewater treatment plants (WWTPs) are shown. A comparison of the requirements of Slovene legislation with legislation in Germany and the EU and deadtimes for the construction of collecting systems and wastewater treatment plants in Slovenia is presented.

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ZASNOVA VODNOGOSPODARSKIH STROKOVNIH PODLAG ZA POTREBE USKLAJEVANJA PROSTORSKEGA RAZVOJA
THE CONCEPT OF WATER MANAGEMENT STUDIES AND PLANS TO BE USED IN THE HARMONIZATION PROCESS IN SPATIAL PLANNING

Marta VAHTAR

Postopek prostorskega planiranja in načrtovanja je eden najpomembnejših segmentov operativnega izvajanja politike varstva voda ter vodnega in obvodnega prostora, kakor tudi zagotavljanja uveljavljanja načel trajnostno uravnoteženega gospodarjenja z vodami. Zato so za potrebe prostorskega planiranja ustrezno pripravljene vodnogospodarske strokovne podlage nujna naloga vodarske stroke. V prispevku je podana zasnova vodnogospodarskih strokovnih podlag za potrebe usklajevanja prostorskega razvoja tako na nivoju države kot lokalne skupnosti. Pri tem je podana navezava teh strokovnih podlag na sam postopek usklajevanja prostorskega razvoja, saj namreč ni vseeno, kako, kdaj in s kakšno težo posamezne vodnogospodarske vsebine vstopajo v sistem prostorskega usklajevanja. Podana je tudi navezava teh strokovnih podlag na sistem vodnogospodarskega planiranja in načrtovanja. Vodnogospodarske strokovne podlage za potrebe usklajevanja prostorskega razvoja naj bi namreč ne bile posebne vodnogospodarske strokovne podlage, temveč sestavni del načrta upravljanja povodja (NUP). To pa pomeni, da mora biti NUP zasnovan tako, da bo, kot temeljni vodnogospodarski akcijski načrt, lahko tudi strokovna podlaga za medsektorsko usklajevanje in prostorsko planiranje tako na lokalni kot na državni ravni.
Ključne besede: *gospodarjenje z vodami, prostorsko planiranje.*

The process of spatial planning and design is one of the most important elements for the implementation of water policy (protection of water and aquatic environment), as well as for asserting the principles of sustainable water management into the every day praxis. Therefore, water management studies and plans, prepared in a way that is understood by regional planners and developers, is currently one of the most important tasks for those in the water profession. The paper gives the basic scheme of those water management studies and plans which have been developed to be used in the harmonization process in spatial planning on state and/or local levels. Besides that, the paper focuses on the process of decision making in spatial planning, and on the role various water related issues play in such a process. In other words, the issues related to water conservation should be included as a restrictive criteria very early in the process of spatial planning. The paper also gives the basic idea of how these water management studies and plans should be included into the system of water management planning and design. Nevertheless, water management studies and plans, which are developed to serve in the harmonization process in spatial planning, should be the integral part of River Basin Management Plans. A River Basin Management Plan, however, should be designed in a way that can serve as a basic water management action plan, as well as a basis for adjustment of stand-points among various users of the physical environment in the process of spatial planning on a local, as well as on a state level.
Key words: *water resources management, physical planning.*

1. UVOD

V Sloveniji se trenutno pripravlja več, za gospodarjenje z vodo ter vodnim in obvodnim prostorom, ključnih zakonov (Zakon o vodah, Zakon o urejanju prostora itd.). Hkrati z zakonom se vzpostavlja nov sistem gospodarjenja z vodami, ki temelji na izhodiščih najnovejših spoznanj stroke, ki jih uokvirja nova evropska zakonodaja v "Direktivi o okvirni politiki za področje voda Evropske zveze". Vzporedno z zasnovo novih vodnogospodarskih dokumentov se pripravlja tudi nov prostorski plan RS. To je ključni medsektorski dokument, ki določa politiko rabe prostora in gospodarjenja z naravnimi viri.

Treba se je zavedati, da je postopek prostorskega planiranja in načrtovanja verjetno najbolj pomemben segment operativnega izvajanja politike varstva voda ter vodnega in obvodnega prostora, kakor tudi zagotavljanja uveljavljanja načel trajnostno uravnoteženega gospodarjenja z vodami. Zato so za potrebe prostorskega planiranja ustrezno pripravljene vodnogospodarske strokovne podlage nujna naloga stroke. Še bolj pomembno kot same strokovne podlage pa je način, kako te vsebine vstopajo v proces medsektorskega usklajevanja pri pripravi prostorskega plana države.

1. INTRODUCTION

Slovenia is currently preparing several important documents that are relevant for management of water and aquatic environments (Water Act, Spatial Planning Act, etc.). At the same time, Slovenia is trying to implement a new system of water management that is based on the latest findings in the field of water management, which are incorporated into a new EU legislation in the proposed Water Policy Framework Directive. Parallel to new water management documents, Slovenia is preparing a new Spatial Master Plan of Slovenia, which is a key document that defines the policy of land use and the management of natural resources.

The process of spatial planning and design is probably the most important element for the implementation of water policy (water conservation and the conservation of aquatic environments), as well as for asserting the principles of sustainable water management into the every day praxis. Therefore, preparing water management studies and plans in a way that is understood by regional planners and developers, is currently one of the most important tasks for those in the water profession. More important than water management studies and plans themselves, is the way topics related to water management enter the harmonization process in preparing the State Spatial Master Plan.

2. OBSTOJEČE VODNOGOSPODARSKE STROKOVNE PODLAGE ZA PRIPRAVO PROSTORSKIH DOKUMENTOV

2.1 VODNOGOSPODARSKE OSNOVE SLOVENIJE

Strokovno navodilo za izdelavo vodnogospodarskih osnov (Ur. list SRS, št. 27/1984) navaja, da vodnogospodarske osnove, na podlagi prikaza danosti vodnega režima in kakovosti vode v povodju, dajejo izhodišča in možnosti prihodnjega vodnogospodarskega razvoja. Hkrati pa so

2. CURRENT WATER MANAGEMENT STUDIES AND PLANS THAT SERVE AS A BASIS FOR THE PREPARATION OF SPATIAL PLANNING DOCUMENTS

2.1 WATER MANAGEMENT MASTER PLAN OF SLOVENIA

The Expert Guideline for the Preparation of the Water Management Master Plan (UL SRS, 1984) says that a Water Management Master Plan (WMMP) gives the basic information about the possibilities of future development of water management on the basis of the water regime and water quality in a river basin. At vodnogospodarske osnove strokovna osnova za pripravo prostorskih planskih aktov.

V tem strokovnem navodilu je bilo tudi opredeljeno, do kdaj morajo biti izdelane posamezne vodnogospodarske osnove. Vodnogospodarske osnove vodnih območij v M - 1:25.000 bi morale biti izdelane do konca leta 1991, Vodnogospodarske osnove RS v M - 1:250.000 pa leto dni kasneje. Delno so se nove Vodnogospodarske osnove Slovenije izdelale, do njihove popolne realizacije pa ni prišlo zaradi dveh glavnih razlogov. Prvič, zaradi pomanjkanja sredstev in drugič, zaradi razveljavitve planiranja v vodnem gospodarstvu s črtanjem poglavja “Planiranje” iz Zakona o vodah (Uradni list SRS, št. 29/86). Tako so zadnje uradne Vodnogospodarske osnove Slovenije v M - 1:400.000 še iz leta 1978. Žal so te Vodnogospodarske osnove Slovenije predvsem v tistih segmentih, ki obravnavajo razvojno planska izhodišča, že povsem zastarele: (1) doktrina v vodnem gospodarstvu se je v zadnjih 20 letih močno spremenila; (2) podatkovne baze, na katerih temeljijo veljavne vodnogospodarske osnove so v marsičem zastarele; (3) merilo 1:400.000 ni operativno.

2.2 VODNOGOSPODARSKE SESTAVINE PROSTORSKEGA PLANA RS

Leta 1986 je bil, v skladu s takratno novo prostorsko zakonodajo (Zakon o urejanju prostora itd., Uradni list SRS, št. 18/84) in v skladu s takratno doktrino ter vlogo vodnega gospodarstva v sistemu družbenega planiranja, pripravljen Dolgoročni plan vodnega gospodarstva Slovenije za obdobje 1986 - 2000. Sektorski dokument je bil hkrati strokovna podlaga za pripravo prostorskega dela republiškega dolgoročnega plana, kjer so te vsebine prikazane na treh kartah: (I.4) Zasnova vodnih virov in oskrbe z vodo, (I.5) Zasnova vodnogospodarskih ureditev in (V.14) Zasnova sanacije naravnih virov ter razmestitve čistilnih naprav. Karte so bile izdelane v merilu 1:250.000 in leta 1989 dopolnjene.

Doktrina v vodnem gospodarstvu se je v

the same time, WMMP represents the basic analytical studies for preparation of spatial planning documents.

The expert guideline also defined the date by when the WMMP should be prepared. WMMP for river basins in the scale of 1:25.000 would have had to be prepared by the end of the year 1991, while the WMMP of Slovenia would have to be prepared a year later. The new WMMP of Slovenia was partly realized, but it was never completed because of two main reasons. The first reason was the lack of funds, and the second was the invalidation of planning in the field of water management with the abolishment of the chapter “Planning” from the Water Act in 1986 (UL SRS, 1986). Therefore, the last official WMMP of Slovenia in the scale of 1:400.000 is still from the year 1978. Unfortunately, the official WMMP of Slovenia is, in the segments that relate to developmental planning guidelines, already completely out of date: (1) the doctrine of water management has changed dramatically in the last 20 years; (2) the data base, on which the official WMMP is based, has become obsolete; (3) the scale 1:400.000 is not operative.

2.2 WATER MANAGEMENT COMPONENTS OF THE LONG-TERM PLAN OF SLOVENIA

In 1986, a long-term Water Management Plan of Slovenia for the period of 1986-2000 was prepared, in accordance with (at that time the new) spatial planning legislation (Spatial Planing Act and others, UL SRS, 1984) and in accordance with the current doctrine in water management. The branch document also served as a basis for the preparation of the spatial segment of the Long-Term Plan of Slovenia (LTPS). The water management elements are included in three maps entitled: (I.4) The Concept of Water Resources and Water Supply, (I.5) The Concept of Water Resources Development Projects, and (V.14) The Concept of Sanitation of Natural Resources and Placement of Water Purifying Plants. The maps were made on a scale of 1:250.000, and were supplemented in the year 1989.

The doctrine in water management has

zadnjih 15 letih močno spremenila. V 80-tih letih je vodno gospodarstvo služilo predvsem potrebam drugih sektorjev, kot so kmetijstvo, poselitev in drugi. V zadnjem obdobju pa postaja varovanje okolja in naravnih virov ena najpomembnejših nalog tudi za vodno gospodarstvo (Direktiva o okvirni politiki za področje voda EZ). Nov način razmišljanja je našel svojo pot tudi v Dolgoročnem planu Slovenije. Z zadnjo spremembo in dopolnitvijo Dolgoročnega plana RS (Ur. list RS, št.11/1999) zapisane v besedilu novega člena pod točko 3.1.39., je poudarek na varovanju vodnega sistema in trajnostno uravnoteženi rabi vode in vodnih ter obvodnih ekosistemov.

2.3 TEŽAVE OBSTOJEČIH VODNOGOSPODARSKIH STROKOVNIH PODLAG ZA POTREBE PROSTORSKEGA USKLAJEVANJA

Težave obstoječih vodnogospodarskih strokovnih podlag za potrebe prostorskega usklajevanja so dvojne. Prvič gre za težave plansko razvojnih vsebin in nosilca priprave teh vsebin, drugič pa za težave pri ustrezni, predvsem pa jasni in drugim strokam kot uporabnicam teh strokovnih podlag razumljivi predstavitvi vodnogospodarskih vsebin, pomembnih za prostorsko planiranje in načrtovanje.

Medtem ko je bilo poglavje "Planiranje" leta 1986 črtano iz Zakona o vodah (Ur. list SRS, št.29/86), pa Zakon o urejanju prostora (Ur. list SRS št. 18/94, 15/89 in Ur. list RS št. 71/93) zahteva, da so v prostorskih vsebinah opredeljene temeljne usmeritve in globalna zasnova dejavnosti v prostoru, ki se med drugim nanašajo na pomembnejše vodne vire ter pomembnejša omrežja in naprave za vodooskrbo s pitno in tehnološko vodo ter za odvajanje in čiščenje odplak. Kot sta zelo dobro izpostavila avtorja članka "Trenutna institucionalna ureditev gospodarjenja z vodami v RS in trendi nadaljnega razvoja" (Umek & Banovec, 1998), se postavlja vprašanje "kako naj se vodno gospodarstvo vključi v proces prostorskega načrtovanja, če

changed a lot in the last 15 years in Slovenia. In the 1980's, water management predominately served the needs of other branches, such as agriculture, urbanization and others. In the last years, the protection of the environment and natural resources in general has also become one of the most important tasks for water management (EU Water Policy Framework Directive). The new way of thinking has also found its way into the Long-Term Plan of Slovenia (LTPS). With the last change and supplementation of the spatial segment of the LTPS (Ur. list RS, No.11, 1999) presented in the new article 3.1.39, the main emphasis is given to water system conservation and to the sustainable use of waters and aquatic environments.

2.3 THE PROBLEMS OF CURRENT WATER MANAGEMENT PLANS AND THE STUDIES USED IN THE HARMONIZATION PROCESS IN SPATIAL PLANNING

The problems of the current water management plans and studies used in the harmonization process in spatial planning are of two different origins. Firstly, the official holder responsible for the preparation of developmental planning documents has not been defined. Secondly, there is the problem of the proper graphical presentation of all water management related topics that are important in the process of harmonization in spatial planning. Users from other professions should easily understand them.

While the chapter "Planning" was abolished from the Water Act (UL SRS, 1986), the Spatial Planning Act (UL SRS 1984; 1989; 1993; 1994) requires that spatial planning components of Long- Term Plans define the basic guidelines and the concept of land use, which includes important water resources, water supply, and wastewater treatment. As has been well pointed out by others (Umek & Banovec, 1998), the question is "how can water management be included in the process of spatial planning, if the chapter *Planning* is abolished from the basic act that defines the roles of water management?" Because of the discontinuation of planning in water so temeljnemu zakonu, ki določa pogoje za gospodarjenje z vodami, črtali zelo pomembno poglavje?" Zaradi diskontinuitete planiranja v vodnem gospodarstvu so tudi strokovne podlage s tega področja dostikrat zastarele, predvsem pa nesistematične, kljub številnim poizkusom preseči nastalo zakonsko in s tem tudi institucionalno praznino.

Vodnogospodarske strokovne podlage, kot so Vodnogospodarske osnove Slovenije (1978) in vodnogospodarske sestavine prostorskega dela Dolgoročnega plana RS (grafične priloge so iz leta 1989), niso najustreznejša strokovna podlaga za uresničevanje varstva hidrosfere, ki je ena izmed temeljnih nalog vodarske stroke in s tem tudi vodnega gospodarstva. Prostorski planer si namreč z nekaterimi, za prostorsko planiranje pomembnimi vodnogospodarskimi podatki, težko pomaga, saj niso predstavljeni na način, da bi jih nevodarske stroke lahko preprosto uporabile in pravilno razlagale. Zato smo si postavili cilj, da bi zasnovali takšno grafično predstavitev vodnogospodarskih strokovnih podlag (Načrt upravljanja s povodji...) za potrebe prostorskega usklajevanja, ki bo jasna, transparentna in jo bodo lahko neposredno uporabili kot podlago za sprejemanje odločitev v prostoru (Steinman & Vahtar, 1996; Kompare et al., 1997; Vahtar et al., 1998).

3. ZASNOVA VODNOGOSPODARSKIH STROKOVNIH PODLAG ZA POTREBE USKLAJEVANJA PROSTORSKEGA RAZVOJA

3.1. KONCEPT VODNEGA SISTEMA

Pri zasnovi vodnogospodarskih strokovnih podlag za potrebe vključevanja v procese medsektorskega usklajevanja smo izhajali iz upoštevanja dvojnosti vodnega sistema in iz tega izhajajoče dvojne vloge vodnega gospodarstva (Kompare et al., 1997; Vahtar et al., 1998).

V prvi vlogi vodno gospodarstvo skrbi za varstvo stabilnosti in dinamike naravnih sistemov. Gre torej za **ekosistemski pristop**,

management, water management plans and studies are often out of date, or non-systematic, regardless of many attempts to bridge the resulted legal and also institutional gaps.

The current water management plans, such as the Water Management Master Plan of Slovenia (1978) and the water management section of the spatial components of the Long-Term Plan of Slovenia (the graphical part is from 1989), are not the best guidelines for the implementation of the protection of the hydrosphere, which is one of the basic tasks of water management. It is very difficult for spatial planners to use some of the important water management data in the process of spatial planning, if they are not presented in a way that can be easily used and properly interpreted by non-water professionals. Therefore, we have set a goal to develop such a graphic presentation of Water Management and River Basin Management Plans, that will be clear and easy to understand for non-water professionals. At the same time, the presentation should be prepared in such a way that it can directly serve as a basis for making decisions in the process of harmonization in spatial planning (Steinman & Vahtar, 1996; Kompare et al., 1997; Vahtar et al., 1998).

3. THE CONCEPT OF WATER MANAGEMENT EXPERT GUIDELINES USED IN THE HARMONIZATION PROCESS IN SPATIAL DEVELOPMENT

3.1. THE CONCEPT OF THE WATER SYSTEM IN THE HARMONIZATION PROCESS OF SPATIAL PLANNING

The concept of water management expert guidelines used in the harmonization process in spatial development is based on taking into consideration the double nature of the water system and from that, proceed to the double role of water management (Kompare et al., 1997; Vahtar et al., 1998).

The first role is the protection of the stability and dynamics of natural systems - the ki smo ga imenovali sistem "okolje". To vključuje ohranjanje zdravega vodnega okolja oziroma vse tisto, kar vpliva na funkcijske povezave znotraj vodnega sistema in nanj vezanih ekosistemov. Gre torej za najnujnejše robne pogoje, ki jih je treba upoštevati, da še ohranimo stabilnost naravnega sistema. To pa so tako pomembni pogoji, da jih je kot omejitvene razvojne dejavnike potrebno že zelo zgodaj vključiti v proces prostorskega usklajevanja interesov različnih sektorjev.

V drugi vlogi gre za načrtovanje gospodarske rabe vode ter vodnega in obvodnega prostora**,** kjer je vodno gospodarstvo, razen vodooskrbe in odvoda odpadnih voda, predvsem v službi drugih sektorjev, kot so energetika, turizem, kmetijstvo, urbanizacija in drugi. **Antropocentrični pristop**, ki smo ga poimenovali sistem "raba", skuša zadovoljiti človekove potrebe po vodi. Pri tem pa, v skladu z novo doktrino v stroki (Direktiva EZ), to ni več klasičen koncept rabe oziroma izkoriščanja. Gre namreč za zadovoljitev človekovih potreb po vodi v najširšem pomenu, kar predstavlja integralen in holističen pristop rabe v smislu trajnostno uravnoteženega razvoja (sustainable development). Stanje voda in vodnega okolja opredeljeno v sistemu "okolje" torej podaja omejitve razvojnih možnosti sistemu "raba".

ecosystematic approach, which we call a system "environment". It includes the protection of healthy water environments, together with everything that has an impact upon vital functional connections within the water system and connected ecosystems. These are, actually, the minimum requirements that one has to take into consideration in order to protect the stability of natural systems. These requirements, however, are so important, that one has to use them as restrictive developmental criteria very early on in the process of the harmonization of developmental goals among various users.

The second role is the economic use of waters and aquatic environments. In this context, other branches of the economy, such as energy, tourism, agriculture, urbanization and others, employ water management, with the exception of water supply and wastewater treatment (the basic tasks of water mamanement). The anthropocentric approach, that we call a system "use", tries to satisfy human needs for water. In accordance with the new doctrine in the water profession (EU Directive) this, however, is no longer a classical concept of use. It means the satisfaction of human needs for water in a broad sense, which represents the integral and holistic approach to use in the sense of sustainable development. The conditions of water environments as defined in the system "environment" represent the restrictions of developmental possibilities to the system "use".

OKOLJE	**RABA**	
URESNIČEVANJE CILJEV VARSTVA OKOLJA **varstvo stabilnosti in dinamičnosti naravnega sistema** (direktive EZ, nac. program varstva okolja, nac. program gospodarjenja z vodami...)	**URESNIČEVANJE PLANSKIH RAZVOJNIH CILJEV SEKTORJA** **varstvo potencialov prostora za rabo / protection of potentials for use** **srednjeročne in kratkoročne naložbe / long-term and short-term investments** (nac. program gospodarjenja z vodami)	**URESNIČEVANJE PLANSKIH RAZVOJNIH CILJEV DRUGIH SEKTORJEV** **varstvo potencialov za rabo** **srednjeročne in kratkoročne naložbe** (nac. programi drugih sektorjev)
ODTOČNI REŽIM EROZIJA KAKOVOST površinskih in podzemnih voda KOLIČINE površinskih in piodzemnih voda VODNO OKOLJE IN VODNI EKOSISTEMI	PRESKRBA Z VODO (pitna in tehnološka voda) ODVOD IN ČIŠČENJE ODPADNIH VODA (VARSTVO PRED POPLAVAMI)	HIDROMELIORACIJE KMETIJSKIH ZEMLJIŠČ (osuševanje in namakanje) GRADNJA ZADRŽEVALNIKOV za potrebe energetike, namakanja, in varstva pred poplavami VODNOGOSPODARSKE UREDITVE ZA POTREBE VARSTVA PRED VODO IN EROZIJO (urbaniziranih in intenzivnih kmetijskih površin ter infrastrukturnih objektov) DRUGE VODNOGOSPODARSKE UREDITVE (turizem, ribištvo...)

Slika 1. Delitev vodnogospodarskih vsebin za potrebe prostorskega usklajevanja na sistem "okolje" in sistem "raba".

ENVIRONMENT	**USE**	
REALIZATION OF ENVIRONMENTAL PROTECTION GOALS: **Protection of stability and dynamics of the natural system** (EU directive, national program of environmental protection, nat. program of water management...)	**REALIZATION OF PLANNED DEVELOPMENTAL GOALS IN THE FIELD OF WATER MANAGEMENT:** **protection of potentials for use** **long-term and short-term investments** (national program of water management)	**REALIZATION OF PLANNED DEVELOPMENTAL GOALS IN OTHER ECONOMIC FIELDS:** **protection of potentials for use** **long-term and short-term investments** (national programs of other economic fields)
RUN-OFF REGIME SOIL EROSION QUALITY of surface and ground waters QUANTITY of surface and ground waters AQUATIC ENVIRONMENTS	WATER SUPPLY (drinking and technological waters) WASTEWATER DISPOSAL AND TREATMENT FLOOD PREVENTION	LAND RECLAMATION AND IRRIGATION in agriculture CONSTRUCTION OF WATER RESERVOIRS to use in energy, flood prevention and irrigation WATER RESOURCES DEVELOPMENT PROJECTS FOR FLOOD AND EROSION PREVENTION (of urbanized and intensive agricultural areas, and infrastructural objects) OTHER WATER RESOURCES DEVELOPMENT PROJECTS (tourism, fishing...)

Figure 1. The division of water management topics used in the harmonization process in spatial planning on the system "environment" and the system "use".

3.2 KONCEPT GRAFIČNE PREDSTAVITVE VODNO-GOSPODARSKIH VSEBIN

Novi prostorski plan države (2000-2020) bo opredeljeval predvsem politiko prostorskega razvoja. Z opredelitvijo pogojev prostorskega razvoja bo predvsem usmerjevalne narave. Izhodišča za urejanje prostora tako predstavljajo: (1) zavarovana območja s pravno zagotovljenim varstvom (varstvena območja vodnih virov itd.); (2) varovana območja kot rezervacije prostora za izvedbo pomembnih gospodarskih naložb (državna infrastruktura itd.); in (3) prostorski redi, to so prostorski standardi in normativi, s katerimi država varuje javni interes (varovanje okolja, varovanje kakovosti kulturnih krajin itd.).

Da bi dosegli kar najučinkovitejši in najbolj razumljiv prenos informacije s področja vodnega gospodarstva na področje prostorskega planiranja, je potreben ustrezen način grafične predstavitve vsebine. Tako je vsaka vsebina predstavljena na dva načina. Prvi način oziroma prva plast so inventarizacijske karte, ki celostno in zelo jasno opišejo pojav oziroma težavo. Druga plast pa je nadgradnja inventarizacijskih kart v obliki opozorilnih in usmerjevalnih kart za potrebe prostorskega planiranja in načrtovanja, s katerimi se bo varovala kakovost naravnih danosti, izraženih v okviru javnega interesa.

V sklopu zakonodaje, ki ureja področje normativov in drugih regulativnih mehanizmov, ki so podlaga za izdajanje

3.2 THE CONCEPT OF THE PRESENTATION OF WATER MANAGEMENT TOPICS TO BE USED IN THE HARMONIZATION PROCESS IN SPATIAL PLANNING

The new Spatial Plan of Slovenia (2000-2020) will define the policy of spatial development. With determination of restrictions for spatial development, it will predominately serve as a directive. The bases for spatial development are: (1) protected areas with legal acts of protection (protection of drinking water resources etc.); (2) protected areas as reservations for important state investments (state infrastructure etc.); and (3) spatial orders, which are spatial standards and regulations, which are used to protect the public interest (protection of the environment, protection of the qualities of cultural landscapes etc.).

To achieve an effective and easily understandable system of transferring information from the field of water management into the field of spatial planning, we need a suitable method for graphic presentation. Therefore, each topic is presented in two layers. The first layer consists of basic analytical maps that, in an integral and very clear way, present the natural phenomena and/or problem. The second layer is an upgrade of the analytical maps in the form of warning maps and guidelines for spatial planning and design. Through implementing dovoljenj za različne posege v prostor, je prostorski plan še posebej pomemben. S prostorskim planom je namreč moč uveljaviti vrsto imisijskih okoljskih normativov (kakovost okolja), ki jih s še tako dobrim uveljavljanjem emisijskih normativov ne moremo doseči. Prostorski plan je namreč tisti instrument, ki lahko uveljavi vrsto okoljskih kriterijev tako, da opredeljuje območja s posebnimi varstvenimi režimi.

Vodnogospodarske strokovne podlage morajo tako z vidika varstva okolja, poleg opisa stanja okolja, vsebovati predvsem opozorilne karte z režimi varovanja vodnega sistema. Ti režimi varovanja morajo biti usklajeni z zahtevami po doseganju ciljnega stanja voda ter vodnega in obvodnega prostora, kot jih določajo mednarodni sporazumi in nacionalna politika varstva okolja.

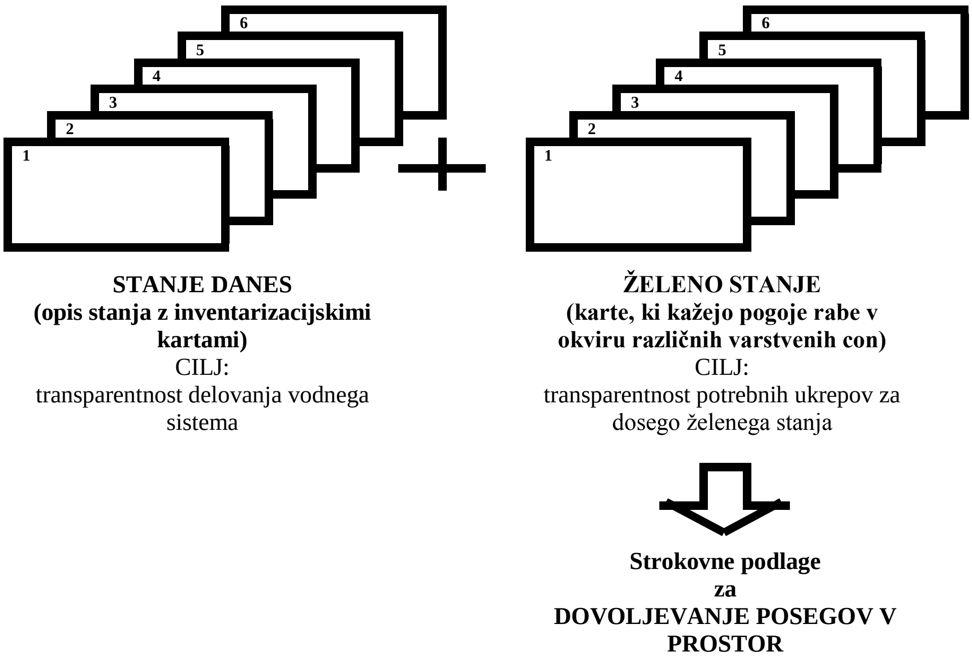
Z vidika rabe pa morajo vodnogospodarske strokovne podlage na podlagi opisa obstoječega stanja in identifikacije razvojnih smernic posameznih sektorjev pripraviti prostorsko zasnovo vodnogospodarskih aktivnosti. Za zagotavljanje varstva razvojnih potencialov bo treba tudi za nekatere teh vsebin izdelati opozorilne karte z režimi varovanja.

these guidelines, one can protect the qualities of the natural elements expressed through the general public interest.

In the context of legislation that discusses the area of regulations, which are the basis for legal permission for various spatial operations, spatial plans are very important. With a spatial plan, it is possible to enforce many of those environmental quality objectives that are hard to achive even with very strict implementation of the emmission controls. The spatial plan is one of the key instruments that can enforce environmental quality objectives through definition of the areas with special protection.

In the context of the environmental protection, the water management guidelines have to define the areas with special protection in accordance to various international environmental agreements and the national environmental policy.

From the point of view of economic use, the water management guidelines have to define the spatial organization of water management activities that follow developmental trends in other branches of the economy. In some cases, the areas with special protection will have to be defined, to protect some key environmental potentials for possible future use.



Slika 2. Delitev vodnogospodarskih strokovnih podlag
za potrebe prostorskega usklajevanja na: (1) temeljne inventarizacijske karte (stanje danes) in
(2) karte želenega stanja, izražene skozi prizmo ukrepov (pogoji rabe).

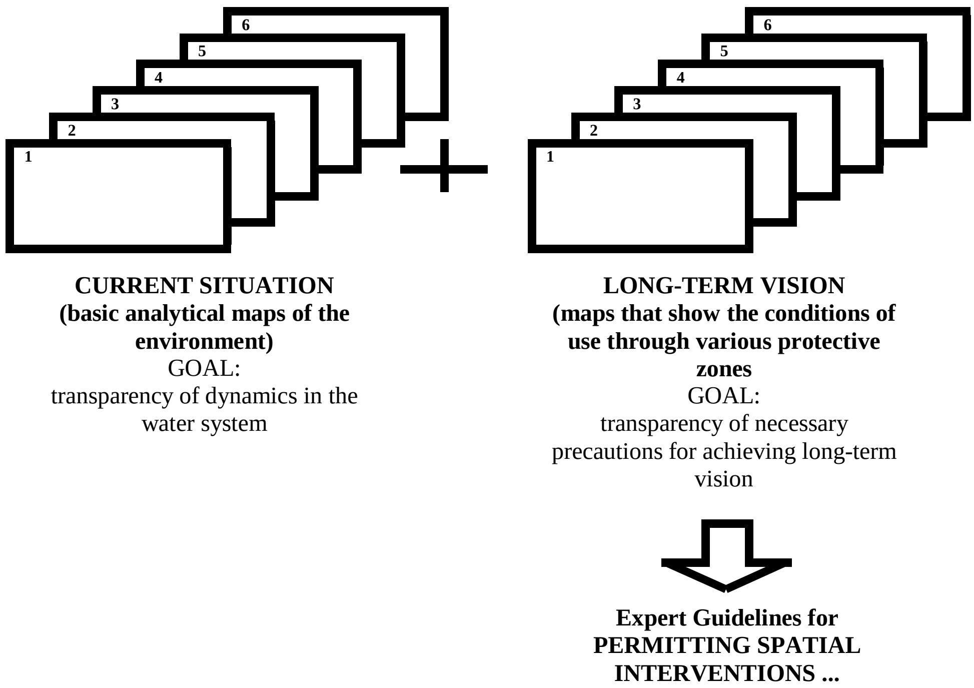


Figure 2. The division of water management guidelines (used in the harmonization process in spatial planning) on: (1) basic analytical maps of the environment (current situation) and (2) maps that show the conditions of use expressed through the necessary precautions for achieving long-term vision.

4. KONCEPT VKLJUČEVANJA VODNOGOSPODARSKIH VSEBIN V SISTEM PROSTORSKEGA PLANIRANJA

Zaradi narave vode in njene splošne prisotnosti v prostoru je gospodarjenje z vodami v interesu številnih sektorjev, kot so energetika, turizem, kmetijstvo, industrija in drugi. Pri tem se dostikrat pojavlja velika neusklajenost sektorskih interesov s prostorskimi danostmi. Zaradi nerazumevanja dinamike vodnega sistema se interesi drugih sektorjev pogosto kažejo kot enostranske zahteve do vodnega gospodarstva v obliki ustreznega varstva pred vodo, zadostnih količin vode idr.. Na srečo imamo v Sloveniji sorazmerno dovolj vode, vendar se vse premalo zavedamo, da je zdrava pitna voda omejen naravni vir. Zato je zelo pomembno, da vodnogospodarski pogoji in omejitve rabe prostora (ki izhajajo iz varovanja vode, vodnega ciklusa in vodnega ekosistema) že zelo zgodaj in z zadostno težo v obliki omejitev in pogojev rabe vstopijo v proces usklajevanja prostorskega razvoja. To je

4. THE CONCEPT OF THE INCORPORATION OF WATER MANAGEMENT TOPICS INTO THE SYSTEM OF PHYSICAL PLANNING

Because of the nature of water and its general presence in the environment, water management is in the interest of many economic branches, such as energy, tourism, agriculture, industry and others. Often, we can notice an enormous disagreement between the interests of various branches and spatial possibilities. Because of the non-understanding of the dynamics of the water system, the interests of the other branches are often expressed as one-sided demands toward water management in the form of proper flood prevention, assuring enough good quality water and other demands. In Slovenia we are quite rich in water resources; however, we are not conscious yet of the fact that healthy drinking water represents a limited natural resource. Therefore, it is very important that water management conditions and limitations of land use (deriving from water conservation, water dynamics and aquatic environments) are included in the harmonization process in spatial planning very early on, and that they verjetno najpomembnejši način, kako preprečiti takšno rabo prostora, ki vodno gospodarstvo sili v izvajanje vodnogospodarskih posegov, ki niso v skladu z načeli trajnostnega gospodarjenja z vodami.

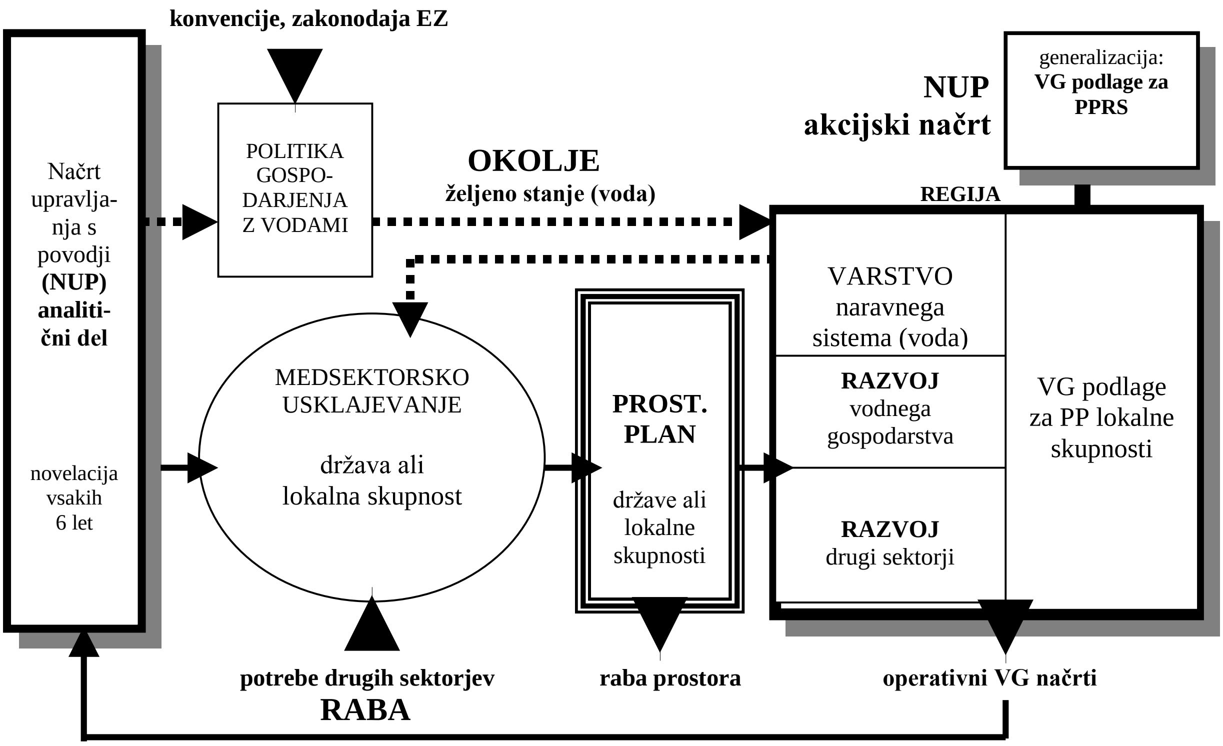
Strokovne podlage, ki jih razvijamo za potrebe prostorskega planiranja, naj ne bi bile posebne strokovne podlage, temveč sestavni del načrta upravljanja povodja (NUP). Ta se v Sloveniji pripravlja na regionalni ravni v merilu M - 1:25.000. NUP naj bi bil v svoji končni obliki medsektorsko usklajen in verificiran akcijski plan za področje gospodarjenja in upravljanja s povodji.

Slika 3 podaja temeljni koncept umestitve NUP v širši kontekst prostorskega planiranja in načrtovanja. Shema hkrati podaja jasno sliko načina, kako se vsebine, ki smo jih opredelili znotraj sistema "okoljske", neposredno vključujejo kot omejitve in pogoji rabe v NUP in tudi v sam postopek prostorskega usklajevanja, medtem ko se vsebine, ki smo jih opredelili znotraj sistema "raba", v NUP vključujejo po dolgotrajnem postopku preverjanja in medsektorskih usklajevanj znotraj procesa prostorskega planiranja.

are really considered as limitations. This is probably the most important possibility to prevent land use which forces water management into building structures that are not in accordance with the principles of the sustainable management of waters.

The expert studies and maps that are to be developed for the needs of the harmonization process in spatial planning are not supposed to be special studies. They should be an integral part of the River Basin Management Plan (RBMP) that is, in Slovenia, prepared on a regional level at a scale of 1:25.000. The RBMP will, in its final form, be a cross-branch harmonized and officially ratified plan of action for the management of waters in the river basins.

Figure 3 gives the basic concept of incorporation of the RBMP into the wider context of spatial planning. The scheme also gives a clear picture of how the contents that we defined inside the system "environment" are directly included as limitations and conditions of use into the RBMP and also into the harmonization process within spatial planning, while the contents that we defined as system "use" are included into the RBMP after a long process of verification and harmonization inside the process of spatial planning.



Slika 3. Koncept zasnove vključevanja vodnogospodarskih vsebin, ki smo jih definirali kor sistem "okolje" in sistem "raba", v procese usklajevanja interesov v prostoru.

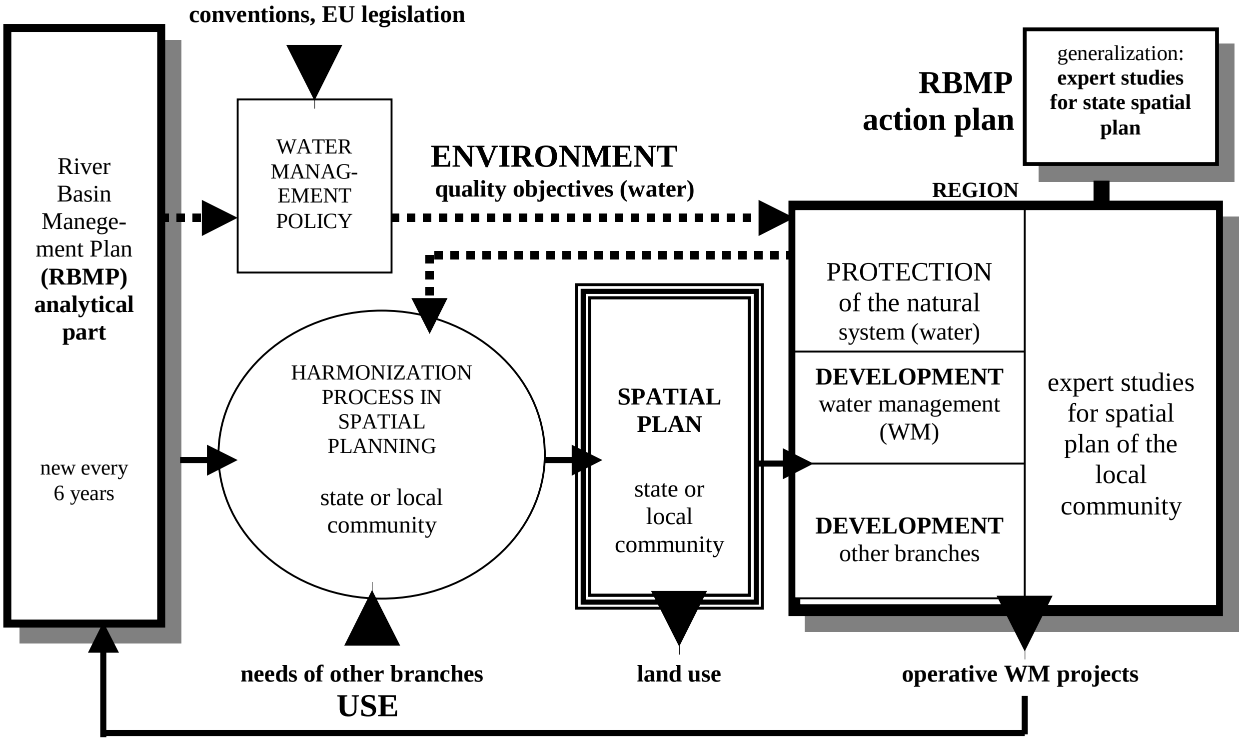


Figure 3. The concept of incorporation of water management topics that we defined as the system "environment" and the system "use" into the harmonization process within spatial planning.

5. ZAKLJUČEK

Da bi se politika varstva voda ter vodnega in obvodnega prostora lahko učinkovito izvajala, mora vodarska stroka pripraviti ustrezne strokovne podlage. Te morajo biti razumljive vsem, ki se vključujejo v procese odločanja, ki zadevajo okolje. Hkrati moramo zagotovit, da bodo vodnogospodarske vsebine, ki smo jih definirali kot sistem "okolje", že zelo zgodaj vključene v procese usklajevanja prostorskega razvoja kot omejitveni kriteriji. Le tako bo imelo varovanje hidrosfere, ki je ena temeljnih nalog vodnega gospodarstva, lahko zadostno težo v procesih usklajevanja z interesi drugih sektorjev po vodi in prostoru. Prispevek podaja koncept zasnove vodnogospodarskih strokovnih podlag za potrebe usklajevanja prostorskega razvoja in njihove umestitve v sistem prostorskega planiranja.

5. CONCLUSION

To have an effective policy for the protection of waters and aquatic environments, water professionals must develop expert studies and maps that are easily understandable by everyone who participates in the process of decision making that concerns the environment. At the same time, we have to make sure that those water management topics, which we defined as system "environment", are included as restrictive criteria very early on in the harmonization process in spatial planning. Only in this way, will the protection of the hydrosphere, which is one of the basic tasks of water management, be able to be included into the harmonization process in spatial planning, and prevail in relation to the various interests for the economic use of waters and aquatic environments. This is probably the most important possibility for preventing such land use which forces water management into building structures that are not in accordance with the principles of the sustainable management of waters.

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RAZVOJ SODOBNIH HIDROLOŠKIH MODELOV
DEVELOPMENT OF CONTEMPORARY HYDROLOGICAL MODELS

Mitja BRILLY

Razvoj sodobnih hidroloških modelov je pogojen s potrebami vodarstva, ki se ukvarja z iskanjem rešitev, ustreznih trajnostnemu razvoju. Kljub velikim uspehom v razvoju različnih hidroloških modelov, se srečujemo z vprašanjem njihove uporabnosti oziroma točnosti. Posamezni hidrološki modeli dobro simulirajo posamezna območja kroženja vode v naravi, kot so površinski odtok, podzemne vode ipd. Modelov, ki bi lahko simulirali kroženje vode v celoti, je malo in niti niso uporabni v vseh primerih. Zahtevni sodobni modeli s prostorsko razporejenimi parametri zahtevajo množico podatkov in obsežno dodatno bazo metapodatkov, da bi jih lahko zanesljivo uporabljali. Izkušnje o primerjavi rezultatov simulacije z različnimi modeli kažejo, da glede zanesljivosti ni bistvene razlike med posameznimi modeli. Zelo zahtevni modeli z veliko parametri lahko dajo velika odstopanja pri analizi posameznih pojavov in obratno, enostavni empirični modeli lahko dajo zelo dobre rezultate.
Ključne besede: *hidrološki modeli, merilo, metapodatki*

Development of contemporary hydrological modelling depends on water management, which is challenged by sustainable development. The traditional dilemma of hydrological modelling: "What is better?- a model with lumped parameters or a model with distributed parameters - is still open. Some models can simulate the particular processes of the hydrological cycle such as surface flow and groundwater flow, etc. quite well. A small number of models are useful for the simulation of the entire hydrological cycle and they are not useful for all purposes. The results of a comparison made twenty years ago and today are the same; both kinds of models are useful. Distributed hydrological models need a lot of data and sophisticated calibration, which should be equipped with meta data.
Key words: *hydrological models, scale, meta data*

1. UVOD

Razvoj sodobnih hidroloških modelov je pogojen s potrebami in z zahtevami razvoja vodarstva. Ugotavljanje vplivov različnih posegov, zaradi ciljev trajnostnega razvoja, zahteva razvoj hidroloških modelov, ki so poleg kakovosti vode, sposobni simulirati tudi ekološke parametre. Sodoben razvoj hidroloških modelov je usmerjen tako v ugotavljanje zakonitosti oblikovanja odtoka vode na posameznih povodjih (količinsko in kakovostno) kot v razvoj metod meritev prostorsko opredeljenih spremenljivk.

Empirični modeli, zasnovani na enostavni regresiji in koeficientu odtoka oziroma indeksu predhodnih padavin, so bili znani že pred pojavom sodobnih računalnikov. S pojavom računalnikov se je začel razvoj modelov s prostorsko razporejenimi parametri,

1. INTRODUCTION

The development of hydrological models depends on water management needs today. Hydrological models should simulate water quantity, quality and ecological parameters in order to be useful for environmental impact assessment as a part of sustainable development. Today the development of hydrological models is oriented: in distributed hydrological modelling - the tracing of water movement from small catchments and the development of methods for space distributed parameters and input data.

Empirical models developed in pre-computer times are designed on a simple regression and antecedent precipitation index. The computer era provided the possibility for design semi-distributed models such as HEC kot so HEC 1 in model Stanford ter nadaljeval z modeloma TOP in SHE. Razvoj je danes usmerjen v uporabo geografskih informacijskih sistemov in rezultatov prostorsko opredeljenih meritev, zasnovanih na metodah daljinskega zaznavanja, opazovanja sledil in meteoroloških modelov.

Hidrološke modele uporabljamo za napoved vplivov različnih ukrepov na režim voda. Zato so primerni samo koncepcijski modeli s prostorsko razporejenimi parametri, ki pa za simulacijo zahtevajo veliko količino multidisciplinarnih podatkov, opremljenih z ustreznimi informacijami o njihovi zanesljivosti.

2. ZASNOVA HIDROLOŠKIH MODELOV

Zasnova hidrološkega modela je odvisna od ciljev modeliranja in razpoložljivih podatkov oziroma znanja. Pri tem je treba opredeliti merilo obravnavanega pojava. Problem merila ni le preprosto kvantitativno zmanjševanje ali povečevanje obsega nekega pojava ali predmeta znotraj celovitega prostora. Taka zasnova je le ekstrapolacija vsakodnevnih izkušenj, ko poskušamo zaradi preprostejše analize v zmanjšanem merilu prikazati projekt hiše ali topografsko karto.

V naravi merilo ni samo geometrijski pojem, temveč pomeni tudi naraščanje mase in spremembo ravnotežja notranjih sil. Merilo v tem primeru ponazarja kakovostna razmerja in je vezano na oblike pojava snovi. Čeprav omenjena merila niso številna, je bilo v razvoju znanosti potrebno tisoče let, da bi jih dojeli in spoznali njihove temeljne lastnosti. Tako je šel razvoj znanosti skozi revolucionarne skoke odkrivanja posameznih meril fizikalnih pojavov. Vsakič, ko se je odkrilo novo področje, je v kratkem času znanost doživljala zelo hiter razvoj, dokler ni spoznanje doseglo meje merila. Razvoj disciplin na mejah merila je bil počasen, odkritja pa manj odmevna (Klemeš, 1983).

Zanimivo je, da se znanost ni enakomerno razvijala po lestvici meril. Predhodnik razvoja molekularne fizike je odkritje zakonitosti merila atoma. Znanost je prišla v antičnih

1, the Stanford model, followed by the TOP and SHE models. Today the development of modelling in hydrology is oriented in the implementation of geographical information systems, remote sensing, tracer measurement and meteorological models.

Hydrological models should give predictions for different impacts on the water regime and, for these purposes, only conceptual models with space distributed parameters are useful. This type of of a model requires a lot of data from different sources as well as data equipped with meta data with information of their uncertainty.

2. BASIC APPROACH FOR MODELLING IN HYDROLOGY

The design of hydrologic models depends on scope, goals, knowledge and available data. The scale of the modelling should be determined first. The question of scale is not only simply increasing or decreasing some features in space. Such a simple approach we use in the presentation of some objects in different scale mapping. Inside the natural processes the scale is not only geometric, but means different mass balance and different relations in the inside energy balance. The scale represents qualitative connections and relations of a different kind of substance phenomena.

In nature, scale is not only a geometric phenomena but also means mass increase and the change of the balance of internal forces. That scale illustrates the qualitative relation and it is connected with the form of matter apperance. Eventhough the mentioned scales are not numerous it took years in the history of science for the understanding of their fundamentals. The development of science has gone through revolutionary leaps in the discovery of particular scale phenomena. Science has developed explosively on a newly discovered scale. The development on the border of the scale domain was slower and less dominant (Klemeš, 1983).

It is interesting, that the development of časih prej do sprejemljivega modela planetarnega sistema, kot pa do modela hidrološkega kroga. Razvoj vesoljske tehnologije je danes podlaga za odkritja na zemeljski površini. Tako doživljamo izredno hiter razvoj hidrologije in meteorologije, zahvaljujoč zbiranju podatkov z daljinskim zaznavanjem.

Posamezne ravnine meril so diskretne in oddaljene ena od druge. Na posameznih ravneh prevladujejo različni zakoni fizike. Pri tem posamezne zakonitosti na višji ravni vsebujejo povprečne vrednosti ali integrale odnosov z nižjega merila. Posledica omenjenih odnosov je omejena veljavnost matematičnih modelov fizikalnih pojavov na posameznih ravneh. V hidravliki so znani problemi pri raziskavah na fizičnih modelih. Podobni problemi so pri analizi povodij različnih razsežnosti, hidrodinamični disperziji in turbulenci.

Z našimi čutili lahko spremljamo pojave na področju človekovega merila od desetinke milimetra do par kilometrov v prostoru ter od desetinke sekunde do nekaj desetletij v času. Na tem področju spremljamo odnose in pojave s svojimi čuti in pridobivamo izkušnje. Za analizo na drugih področjih, zunaj dosega naših čutil, to ni dovolj. Uporabiti moramo različne aparature in inštrumente, ki nam omogočajo zbiranje informacij s sicer nedostopnih področij, pri tem pa je intuicija obremenjena z izkušnjami z območja, ki ga dosežemo z lastnimi čutili. Tako smo pri reševanju težav bolj naklonjeni iskanju problema, kjer lahko uporabimo znano rešitev, kot pa, da za znani problem iščemo novo rešitev.

Pri praktičnih hidroloških analizah za inženirske potrebe nas zanima predvsem del kroga zunaj atmosfere in oceanov. Ker smo izločili le del kroga, so se posamezne vezi potrgale in je sistem odprt - ima svoj vhod in izhod. Bolj nazorno za naše podnebne razmere so posamezni odnosi in vezi izločenega dela kroga, prikazane na sliki 1. Sistem je sestavljen iz treh podsistemov, ki jih analiziramo ločeno (Jovanović 1974):

science doesn't move from one scale to another. Phenomena on atomic scale were recognised before that on the molecular scale. The model of the planter system was discovered in ancient times before the model of the hydrologic cycle. The remote sensing and development on the planetary scale give us the opportunity to discover global atmospherics and regional phenomena. Today the development in meteorology and hydrology is closely related to the data collected from space.

The scales are discrete and far apart and on each of them different physical laws are dominant. Parameter and variables on the upper scale often incorporate averaged or integrated values from the lower scale. Mathematical models are then useful on the proper scale. The transfer of results from the laboratory scale generates some errors such as with hydraulic physical modelling and the analysis of hydrodynamic dispersion, turbulence etc.

The human scale covers the range from dust particles to hills and from seconds to years that we remember, but no less and no more. We discover and recognise phenomena on the human level by the use of our perception. We can enlarge our knowledge on a scale outside of our perception only by instruments and an intuition loaded with experience on a human scale. Researchers then often try to find a problem that can be solved by a known mathematical model rather than trying to find a new solution for a known problem.

Engineering hydrology is interested in the hydrologic cycle outside of the ocean and the atmosphere. If we exclude part of the hydrologic cycle, the cycle is open with some input and output variables. The hydrological system presented in Figure 1 is developed according to the climatic conditions in Slovenia. The system consists of three sub-systems which are analysed separately (Jovanović, 1974):

Podsistem površinske in podpovršinske vode (A)

Ta podsistem zajema površinski in podpovršinski sloj zemljine, kjer se zaradi padavin oblikuje površinski in podpovršinski odtok, voda se zadržuje v biosferi, v manjših vdolbinah na površini ter v porah pod površino. Izredno pomemben člen vodne bilance podsistema je izhlapevanje. Vhod v podsistem so padavine, izhod pa izhlapevanje, površinski in podpovršinski odtok v hidrografski mreži ter infiltracija vode v podtalnice. Pojave v tem podsistemu analiziramo za potrebe melioracij, preračun efektivnih padavin in za določanje bogatenja podzemnih voda. Sistem je zapleten in zahteven za modeliranje

Podsistem površinskih voda v vodotokih in jezerih (B)

Ta sistem zajema površinski odtok v hidrografski mreži vodotokov. Vhod so efektivne padavine na površino povodja (izhod iz podsistema A), izhod pa pretok vode v določenem bilančnem prerezu vodotoka. Analiza pojavov v tem podsistemu nas zanima zaradi urejanja vodotokov ter rabe površinskih voda in je temeljno področje "klasične" hidrologije.

Podsistem C

Ta podsistem zajema podzemne vode. Vhod sta infiltracija padavin in vode iz hidrografske mreže, izhod pa bazični odtok podzemnih voda v vodotoke. Pojave v tem posistemu analiziramo za potrebe melioracij in oskrbe z vodo.

Analize pojavov v posameznih podsistemih izvajamo z izhodiščem, da so procesi med seboj neodvisni. Zaradi časovnega zamika in dinamike vode obravnavamo površinski odtok vode ločeno od podzemnega toka. Ločen razvoj je pogojen tudi z zahtevami različnih strok (agronomija, hidrogeologija, gozdarstvo ipd.).

Delitev hidrološkega kroga na podsisteme, ki je bil zelo učinkovit pri razvoju hidroloških modelov v preteklosti, ne zadovoljuje več sodobnih potreb in razvoja hidrologije.

Sub-system of surface and sub-surface water (A)

Sub-system (A) consists of the surface and sub-surface layers of the earth. Precipitation produces surface and sub-surface water flow. Water is intercepted in the biosphere, accumulates in surface depressions and in pores below the surface. Evapotranspiration is the dominant process in the system. The input in the sub-system is the precipitation and the outputs are evapotranspiration, surface and subsurface flow including groundwater recharge. The phenomena in the sub-system A are important for irrigation and drainage, and estimation of the surface runoff and ground water recharge. The sub-system is very complex due to heterogeneity and space distributed variables.

Sub-system of surface water in rivers and lakes (B)

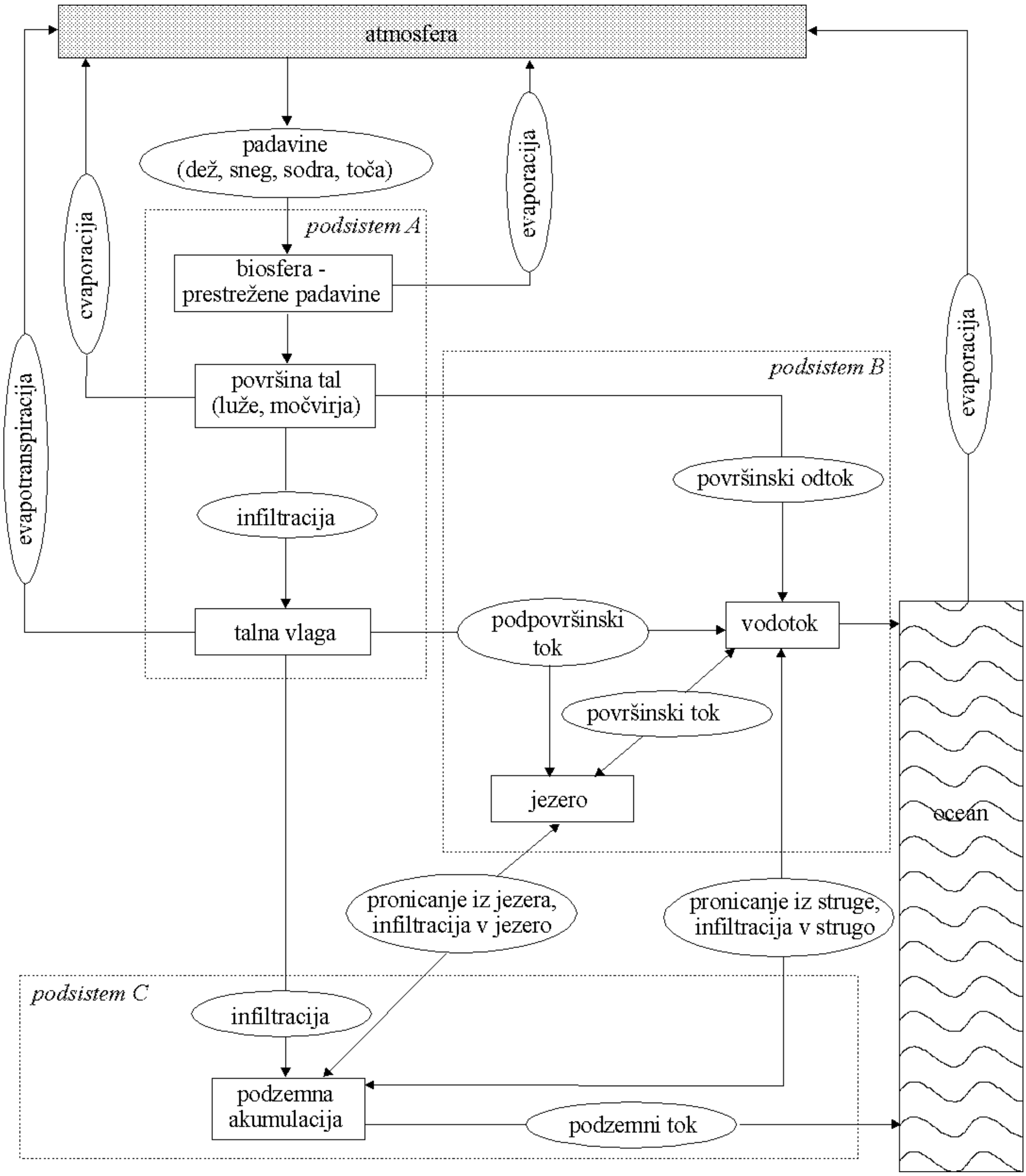
Sub-system (B) consists of surface runoff in streams and lakes. The input is the surface and subsurface runoff (output from the sub-system A) and the output is the discharge in a particular stream cross section. The phenomena in the sub-system B are important for river regulations and water resource management dominant in engineering hydrology.

Sub-system of ground water (C)

Sub-system (C) consists of groundwater flow. The input in the sub-system is the water recharges from the surface, streams and lakes. The output is the ground water leakage in springs, rivers, lakes, oceans, etc. Water management interest is in the drainage and water supply.

The particular sub-systems have been separately developed and analysed. Differences in the time lag and velocities of water in different systems allow the possibility for the separate analysis of surface and ground water. Also, the various engineering disciplines (agriculture, hydrogeology, forestry etc) cause their separate development.

The division of the hydrologic cycle into subsystems has been efficient in the past, but it is not useful for today's development of hydrology.



Slika 1. Hidrološki krog.

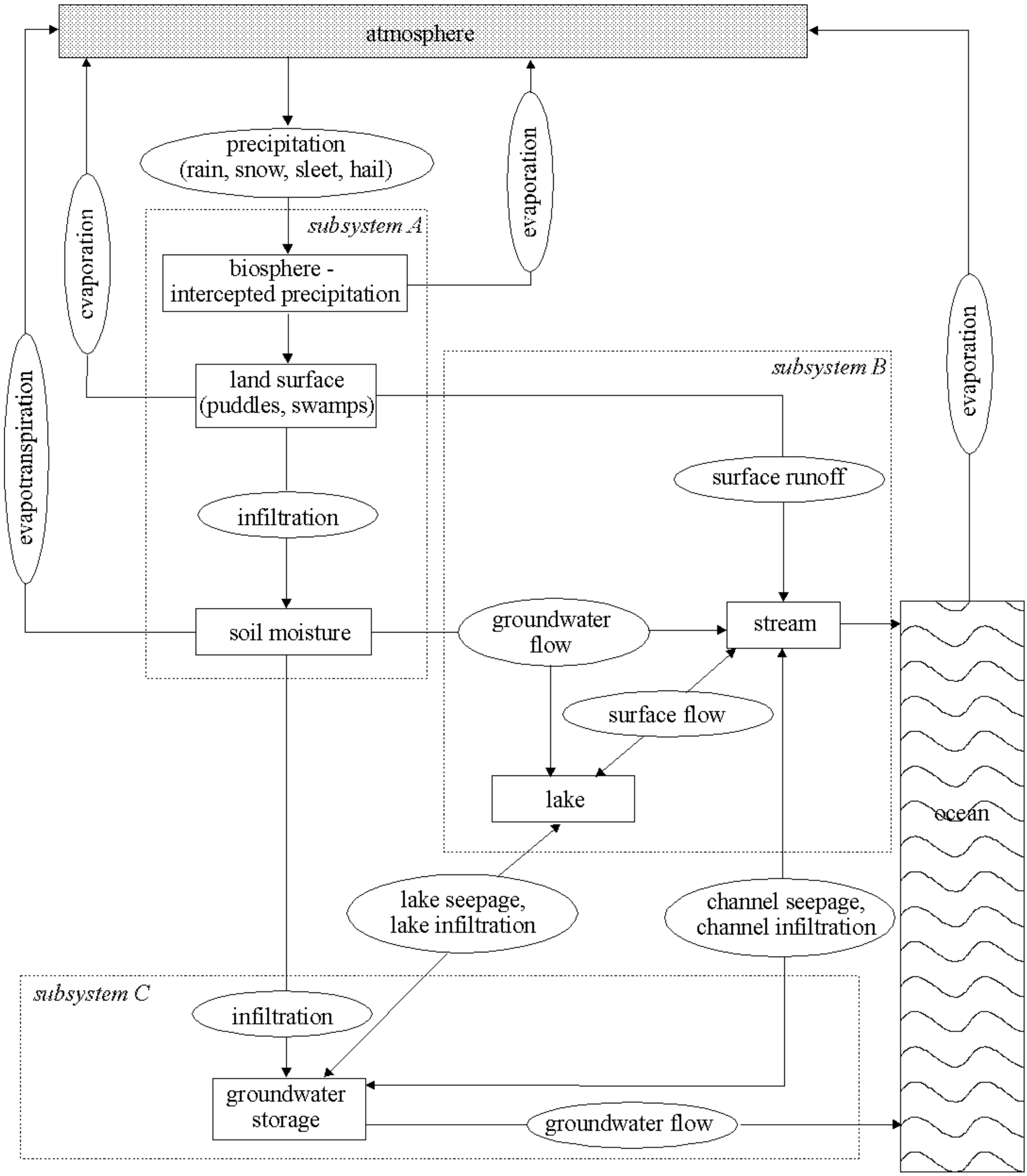


Figure 1. Hydrologic cycle.

Pri sodobnem razvoju se srečamo z modeli, ki presegajo merila, kakršnih smo bili vajeni. Potrebe po hidroloških napovedih podnebnih sprememb zahtevajo simulacijo pojavov v globalnem merilu. Tako se tudi pri nas srečujemo s potrebami po modeliranju hidroloških pojavov v različnih merilih (preglednica 1).

Today's development of hydrological models should often take a large scale for global simulation of climatic change or a very small scale for urban drainage. The hydrological circle should be modelled with different scale models (Table 1).

Preglednica 1. Merila hidroloških modelov.

merilo	modeli in pojavi
globalno merilo – površine večje od 10^6 km^2	globalni modeli
srednje merilo I 1000 – 1000000 km^2	regionalni podnebni modeli
srednje merilo II 10 – 1000 km^2	heterogena območja, večja porečja
srednje merilo III 1-10 km^2	posamezna povodja
mikro merilo I od 100 m^2 do 1 km^2	posamezne prispevne površine in zbiranje površinskega toka
mikro merilo II od 1 do 100 m^2	disperzni površinski tok
mikro merilo III manj od 1 m^2	vlažnost, točkovna polucija, ekologija

Table 1. The scale of hydrological modelling.

Scale	Models, scale of features and purpose
global scale – surface of more than 10^6 km^2	global modelling
meso scale I 1000-1000000 km^2	regional climatic modelling
meso scale II 10-1000 km^2	heterogeneous catchments, large river basins
meso scale III 1-10 km^2	single catchments
micro scale I 100 m^2 -1 km^2	concentrated surface flow
micro scale II 1-100 m2	dispersed surface flow
Micro scale III less than 1 m^2	soil moisture, ecology and point pollution

3. SODOBNI HIDROLOŠKI MODELI

Sodoben razvoj hidroloških modelov je usmerjen v celostno analizo kroženja vode z upoštevanjem podpovršinskega, površinskega in podzemnega odtoka vode. Omenjeni razvoj je omogočen z dosežki na področju daljinskega zazanavanja, GIS in uporabe sledil pri spremljanju hidroloških procesov. Analize odtoka vode s pomočjo sledil so pokazale (Shultz, 1999):

- presenetljivo visok delež podpovršinskega odtoka v odtoku vode s povodja;
- pri manjših padavinah je v vodotoku večji delež podpovršinske in podzemne vode;
- delež podpovršinskega odtoka upada z naraščanje pretoka vode;
- vpliv podzemnih voda na celoten odtok je podcenjen;
- infiltracija padavin hitro povzroča odtok podzemnih voda.

Pri tem so razmerja med posameznimi odtoki vode odvisna od geoloških, pedoloških, bioloških lastnosti in vlažnosti tal ter od razporeditve padavin v prostoru in času oziroma vsako povodje ima lasten režim odtoka, ki se razlikuje pri vsakem posamičnem pojavu padavin.

3.1 MODEL SHE

Model SHE je nastal kot plod sodelovanja danskih (Danish Hydraulics Institute), francoskih (SOGREAH) in angleških (Institute of Hydrology) raziskovalcev. Model je zamišljen kot celosten sistem, ki združuje vse tri podsisteme (slika 1). Model je razdeljen na posamezne module, ki simulirajo:

- evapotranspiracijo
- površinski odtok
- vodo v površinskem nenasičenem sloju zemljine
- podtalnico
- tajanje snega ter
- infiltracijo vode iz vodotokov v podtalnico in dreniranje podtalnice v vodotoke.

Moduli so združeni na podlagi enotne mreže končnih prirastkov ali končnih elementov, na katere je razdeljen prostor. Tako organiziran model omogoča dokaj preprosto simulacijo tokov vode, vpliva pa na točnost pri opredeljevanju parametrov v posameznih

3. CONTEMPORARY HYDROLOGICAL MODELS

Today's hydrological modelling has an integrated approach which includes surface, subsurface and underground flows. Geographical information technology (GIS), remote sensing and tracers provide an opportunity for the development of such hydrological models. The runoff analysis by tracers has shown (Shultz, 1999) that:

- Indirect flow decrease with increasing runoff,
- Smaller precipitation produces more pre-event water,
- A surpassingly high proportion of flow is subsurface flow,
- The influence of groundwater on the total runoff is underestimated, and
- Infiltration quickly activates outflow from ground water to rivers.

The particular part of runoff depends on geological, pedological and biological conditions, moisture, and precipitation distribution. Each watershed has its own runoff regime, different for each rainfall event.

3.1 SHE MODEL

The SHE model was developed as a European Union project by the Danish Hydraulics Institute, SOGREAH - French Institute and the Institute of Hydrology from Walingford, Great Britain. The model was developed as an integrated system including all three subsystems (Figure 1). It consists of modules for the simulation of:

- evapotranspiration,
- surface runoff,
- soil moisture,
- ground water,
- snow melt,
- ground water recharge and drainage.

The modules are connected by an finite difference space related network. Such a modulih in na simulacijo toka površinskih voda, če je ta predvsem pod vplivom površinskega odtoka padavin. Umetnost modeliranja je poiskati mrežo, ki se bo zadovoljivo prilagajala potrebam vseh modulov. Model je primeren za analizo pojavov, kjer so površinski vodotoki pod močnim vplivom podzemnih voda, podobno kot model TOPMODEL ali model podzemnih voda, ki so pod močnim vplivom površinskih voda in moramo pojav analizirati s celostno analizo vseh treh podsistemov. Za simulacijo kraških pojavov ali poplavnih valov v površinskih vodotokih model ni primeren.

3.2 TOPMODEL

Model TOPMODEL so razvili na univerzi v Leedsu leta 1974. Model se je po letu 1985 nadalje razvijal na univerzi v Lancastru. Kot model SHE, so tudi model TOPMODEL razvili za analizo odtokov manjših nižinskih vodotokov pod zelo močnim vplivom režima podzemnih voda. Izdelali so ga za simulacijo toka studenčnic, ki se izcejajo iz plitvih vodonosnikov, pri katerih je gladina vode opredeljena s površino terena. Parametri modela in odtočni koeficienti so vezani na topografijo prispevne površine.

Model se v različnih različicah nadalje razvija na različnih univerzah. Program s kodo modela je za potrebe razvoja mogoče dobiti, kar omogoča dodatno programiranje. Hidrološki pogoj za uporabo modela je pozitivna vertikalna bilanca posameznih delov povodja v daljšem obdobju oziroma vpliv podtalnice v posameznih podpovodjih ves čas simulacije (Beven et al., 1994).

Modelirano območje razdelimo na posamezne manjše enote - podpovodja, za katere opredelimo parametre za izračun vodne bilance, ki vključuje padavine, izhlapevanje, infiltracijo vode pod površino, akumulacijo vlage v nenasičeni coni zemljine, akumulacijo podtalnice, podpovršinski in površinski odtok. Podpovršinski odtok se v modelu pojavi le pri polni zasičenosti zemljišča oziroma pri večjih padavinah. Podpovršinski odtok je določen z lastnostmi zemljine in nagiba površine. Odtod tudi ime modela.

Model je zelo uspešen pri simulaciji vpliva plimovanja na hidrološke procese na območjih, ki so pod neposrednim vplivom morske gladine. Dobri rezultati so doseženi pri modeliranju povodij v Švici (Iorgulescu, 1994).

simple structure of the model gives the possibility for integrated simulation, but has difficulties in parameter estimation in different modules. The state of the art is the network estimation useful for all modules. The model is useful for surface flow simulation with strong impact of ground water as in the TOPMODEL. The model is also useful for ground water modelling, including the strong impact of surface water. The model is useless for karst flow phenomena and pure surface flood flows.

3.2 TOPMODEL

The Model TOPMODEL was at first developed at the University of Leeds in 1974, and later on (1984) development took place at the University in Lancaster. The TOPMODEL is developed, like the SHE model, for the simulation of surface flow with the dominant ground water drainage component. The model is useful in practice for the modelling of shallow ground water flow with the water table close to the ground surface and the ground flow is under the control of the surface topography. The parameters of the model depend on surface conditions.

The developer of the model opens a source code and gives an opportunity for further development. The model is useful under the hydrologic condition of the positive vertical balance, i.e.: a higher precipitation rate than evapotranspiration or ground water flow under the watershed (Beven et al., 1994).

The modelled watershed is divided into smaller units - sub watersheds, and for each of them estimated variables of water balance including precipitation, evapotranspiration, infiltration, soil moisture, ground water, surface and subsurface flow. Subcatchment discharges are routed to the catchment outlet using a linear routing algorithm with constant channel velocity and internal subcatchment routing velocity.

The model is useful for the modelling of runoff processes under the strong impact of tidal movement. A good result occured in the implementation of the simulation in Switzerland (Iorgulescu, 1994).

3.3 SIMULACIJA HIDROLOŠKIH POJAVOV Z ORODJI GIS

Geografski informacijski sistemi (GIS) kot sodobno računalniško orodje za obdelavo prostorsko opredeljenih podatkov so prisotni pri simulaciji hidroloških pojavov že od samega začetka razvoja hidroloških modelov. Razvoj uporabe je šel skozi različne faze razvoja in dokončnega rezultata s povezavo GIS in hidrološkega modela v celosten program še ni (Brilly, 1997).

Trenutno je v razvoju veliko modelov GIS za vključevanje podatkov daljinskega zaznavanja (satelitskih posnetkov in posnetkov meteorološkega radarja) pri določanju vertikalne bilance. Vhodne vrednosti padavin so določene na podlagi posnetkov meteorološkega radarja.

Pri bolj zahtevnih modelih upoštevamo digitalni model površine pri oblikovanju površinskega toka vode (Smith 1992; Schumann & Geyer, 1997). Modeli zahtevajo veliko podatkov in pri manjših prispevnih površinah omogočajo zelo dobre rezultate. Nadaljnji razvoj modelov je opuščanje pravilnih pravokotnih oblik prispevnih površin in upoštevanje naravnih meja prispevnih površin in hidrografske mreže.

S sodobnimi meteorološkimi modeli lahko modeliramo vertikalno bilanco vode v pravilni mreži (Vrhovec et al., 1998). Z rezultati izračuna padavin z modelom ALADIN dobimo vhodne podatke za hidrološke modele, zasnovane na naravni hidrografski mreži in prispevnih površinah.

3.3 GIS IN HYDROLOGIC MODELLING

A geographical information system is a useful tool for multidimensional data manipulation and it has been incorporated in hydrological modelling since from the beginning. The relationship between GIS and hydrologic modelling passes through different phases and a final coupled solution has not been reached yet (Brilly, 1997).

Lot GIS models are developed for the manipulation of remote sensing data (satellite images, meteorological radar images) for the calculation of water balance and the estimation of the space distribution of rainfall data.

Some models incorporate a digital terrain model (DTM) for generating surface runoff (Smith, 1992; Schumann & Geyer, 1997). The models are useful for the modelling of runoff from small cathcments and need a lot of data. Further development will be in the incorporation of natural irregular shapes of watershed boundaries and stream flows in modelling.

Today meteorological models provide us with the useful forecast of rainfall data in ordinary rectangular network (Vrhovec et al., 1998). GIS helps in the transformation of those data on the irregular network useful for hydrologic modelling.

3.4 VZPOREDNA ANALIZA RAZLIČNIH HIDROLOŠKIH MODELOV

V zadnjih desetletjih je bilo izdelanih veliko modelov za simulacijo odtoka padavin, s katerimi so doseženi zelo dobri rezultati, po mnenju samih avtorjev modelov. Zakaj se potem razvijajo novi modeli in zakaj je enotni hidrogram najbolj pogosto uporabljen postopek, čeprav se je pojavil že pred šestdesetimi leti? Svetovna meteorološka organizacija (Franchini & Pacciani, 1991; WMO, 1975) je izvedla raziskovalni projekt leta 1975, da bi ugotovila dejansko uporabnost rezultatov različnih modelov. Posameznim avtorjem modelov je WMO poslala podatke o eksperimentalnih povodjih z ustreznimi

3.4 COMPARATIVE ANALYSIS OF DIFFERENT HYDROLOGICAL MODELS

A lot of useful hydrological models for simulation have been developed in the past tens of years. The question is why new models are in development and why the unit hydrograph is so frequently used for modelling? The World Meteorological Organisation (Franchini & Pacciani, 1991; WMO, 1975) researched this in 1975. The WMO sent data for the calibration of models and data input data for tests to authors without results. The results of modelling were meteorološkimi in hidrološkimi podatki za umerjanje modelov in vhodne podatke za testne primere. Avtorjem modelov niso bili znani rezultati meritev odtoka pri testnih primerih. Skupina strokovnjakov WMO je nato opravila analizo rezultatov izračunov in meritev testnih primerov. Rezultati so pokazali, da:

1. tudi z zelo preprostimi modeli lahko zadovoljivo simuliramo spremembe odtoka vode s prispevne površine. Vedno lahko najdemo za posamezni model in posamezno povodje poplavo, ki jo bo model zadovoljivo simuliral.
2. ne glede na to, kateri model uporabimo pri simulaciji, lahko vedno najdemo pojav poplav z velikim odstopanjem med meritvami in izračunom.
3. ne moremo dokazati, da modeli, zasnovani na fizikalnih zakonih, bolje simulirajo procese odtoka kot enostavni empirični modeli. Vsekakor pa nam modeli, zasnovani na fizikalnih zakonih, omogočajo simulacijo vpliva različnih posegov v okolju na oblikovanje poplavnega vala.
4. Za potrebe napovedi ali določene potrebe upravljanja z objekti na povodju lahko uporabimo za simulacijo odtoka enostavne empirične modele z dvema ali s tremi parametri.

Do podobnih rezultatov so prišli tudi strokovnjaki Meteorološkega zavoda ZDA (Smith et al., 1999). Točnost rezultatov različnih modelov je bila namreč podobna. Ponavadi pričakujemo od modelov, zasnovanih na fizikalnih zakonih in s prostorsko razporejenimi parametri, večjo točnost glede na množico podatkov in zahtevnih izračunov. Toda tudi razvoj teh modelov zahteva veliko dela pri umerjanju posameznih podprogramov in območij modela, kar pa pogosto ni mogoče, zaradi pomanjkanja ustreznih podatkov. Tako umerjamo model samo delno in ga obremenimo z napakami neustreznega umerjanja ter dobimo podobne rezultate kot z enostavnimi empiričnimi enačbami, zasnovanimi na korelaciji.

Uporaba zahtevnih modelov s prostorsko razporejenimi parametri je upravičena le pod pogojem, da imamo na voljo prostorsko razporejene lastnosti prispevne površine in prostorsko razporejene vhodne podatke (padavine, vlažnost tal, izhlapevanje, tajanje snega ipd.), v nasprotnem primeru so modeli z združenimi parametri bolj uporabni (Schultz,

collected later on and independent experts compared and analysed the collected results. The conclusion was that:

1. Even very simple models are useful for runoff simulation. It is always possible to find for a chosen watershed a flood situation, which may be satisfactorily simulated by a chosen model.
2. For each model we may use for simulations, an event could be found with great discrepancy between calculation and measurement.
3. It is not evident that conceptual models simulate runoff better than empirical ones. It is for sure that conceptual models give us the possibility of simulating different environmental impacts.
4. Empirical models with two or three parameters are useful for runoff forecast or some decisions for the management of hydraulic structures.

Researchers from the NOAA found similar results (Smith et al., 1999). Accuracy of different models is similar. We expect from conceptual models based on physical laws and with distributed parameters better accuracy due to a greater amount of data and sophisticated computations. But the calibration of such models is very sophisticated and often impossible due to the lack of needed data. The models are than only partially calibrated. The performed simulation is then overloaded by the error of improper parameters and the accuracy is similar or lower than that given by the simulation of simple empirical models, based on correlations.

Models with distributed parameters are useful if we have space distributed data of watershed characteristics and space distributed input data (rainfall, soil moisture, evapotranspiration, snow melt, etc); otherwise, models with lumped parameters are better. Simply, the model with distributed parameters can physically more accurately simulate the

1999). Preprosto, modeli s prostorsko razporejenimi parametri fizično bolj točno simulirajo pojav kroženja vode, vsebujejo pa veliko parametrov, ki jih je treba določiti na podlagi podatkov o lastnostih prispevne površine in zahtevajo prostorsko razporejene vhodne podatke ter meritve površinskega, podpovršinskega in podzemnega odtoka. Podatkov za uporabo modelov s prostorsko razporejenimi parametri je v svetu sorazmerno malo. Obstajajo le podatki, zbrani na eksperimentalnih povodjih kot rezultat posebnih in občasnih raziskav. Podatki, ki jih zbirajo hidrološke službe (HMZ), ne zadoščajo za uporabo modelov s prostorsko razporejenimi parametri.

4. METAPODATKI

Zapleteni sodobni hidrološki modeli zahtevajo množico podatkov in zahtevno umerjanje modela. Kratki članki v strokovnih in znanstvenih publikacijah ne omogočajo celostne in poglobljene analize in ne predstavljajo celotnega opravljenega dela. Tudi podatkov, primernih za umerjanje modelov in primerjanje njihovih rezultatov, je malo. Zato so metapodatki vse pomembnejši za nadaljnji razvoj.

Sami podatki še niso informacija. Šele ko jim damo nek pomen, dobimo informacijo, ki je zanesljiva v tolikšni meri, kolikor so zanesljivi podatki, na podlagi katerih je bila izdelana. O zanesljivosti podatkov lahko sklepamo na podlagi metapodatkov oziroma na podlagi podatkov o podatkih. V posameznih znanstvenih disciplinah je stopnja zanesljivosti podatkov nekako samoumevna. Interdisciplinarne raziskave zahtevajo interdisciplinarno delo in izmenjavo podatkov iz različnih virov, različnih področij z različno stopnjo točnosti, kar lahko povzroča nesporazume.

Zanesljivi in točni podatki so dragi in tudi dragoceni. Uporabljali bi jih lahko tudi raziskovalci, ki niso seznanjeni z vsemi podrobnostmi izvajanja meritev in zbiranja podatkov. Objavljanje rezultatov je temelj znanstveno-raziskovalnega dela in pogosto edini cilj. Objavljanje podatkov, na podlagi katerih so doseženi rezultati, pa nima posebne tradicije.

Raziskovalci NASA (Vogal, 1998) so izdelali analizo o razlogih oziroma izgovorih znanstvenikov, zakaj ne objavljajo podatkov, vključno z metapodatki. Rezultat analize je seznam najpogostejših razlogov, zaradi katerih se podatki ne objavljajo. Opremljanje

hydrologic cycle, but it contains a lot of parameters that should be estimated by measurement, require space distributed input data and measured surface, subsurface flow and ground water flow. There are a few data sets available for models with distributed parameters. Available are only data from experimental watersheds with temporary measurement for scientific purposes. Data collected by hydrological survey are not enough for models with space distributed parameters.

4. META DATA

Complex hydrologic models require a lot of data and complicated calibration. Short articles in scientific publications do not make possible the integrated presentation and analyses of the job which was done. Also, there are not enough available data for modelling and that is the reason why meta data are essential for the further development of models with distributed parameters.

Data are not yet information. Information is data that contains some sense. The reliability of information depends on the accuracy of the data. Inside each scientific discipline, accuracy of data is the obvious state of the art. Multidisciplinary research requires collective work and an exchange of data from different sources, different disciplines with a different accuracy that causes misunderstanding.

Accurate and available data are valuable and expensive. It could be used for a scientific community that is not familiar with all details of the experiment. The publishing of the results of scientific research is the main task for scientists, but the publishing of data has not yet been realised.

NASA (Vogal, 1998) investigated the reason for the excuse of scientists - why they don't publish data and meta data. There is a long list of the most common reasons. The podatkov z informacijami in metapodatki zahteva dodatno delo in stroške ter izpostavlja delo raziskovalca, ki objavlja podatke. Zbrani obsežni podatki z eksperimentalnih povodij so redki in dragoceni, zahteve razvoja in doseganja dokazljive kakovosti opravljenega dela pa brez objave metapodatkov ni več mogoča.

Problem objave podatkov je star toliko kot znanost. Informacijska revolucija zahteva spremembe tudi na tem področju. Sodobne baze podatkov in internet omogočajo objavo celotnega raziskovalnega dela in ne samo po obsegu omejenih člankov. Problem je, kako spodbuditi raziskovalce, da objavljajo svoje podatke. Rešitev je lahko v zahtevi, da se članki ne objavljajo, dokler podatki niso shranjeni v arhivu. Časopisi s področja genetike poznajo tako zahtevo. V znanosti moramo uveljaviti dovoljenja za vnovično uporabo podatkov in poskrbeti za plačilo dela, ki je potrebno za opremljanje in urejanje podatkov.

5. ZAKLJUČKI

1. Sodoben razvoj in potrebe analize hidroloških procesov zahtevajo razvoj modelov s prostorsko razporejenimi parametri, ki omogočajo sočasno simulacijo površinskega, podpovršinskega in podzemnega toka vode.
2. Modele s prostorsko razporejenimi parametri je smiselno uporabiti le v primeru, če imamo na voljo dovolj podatkov in informacij za simulacijo. Sicer je bolje uporabiti enostavne modele z združenimi parametri.
3. Uporaba velikega števila podatkov, zbranih iz različnih virov, z različno zanesljivostjo zahteva njihovo opremljanje z metapodatki o kakovosti podatkov.

publishing of data and meta data takes additional work, time, funds and makes scientific research more transparent.

The question of data publishing is as old as science itself, but the information revolution asks for changes on this subject. Today's data base software and the Internet give us the possibility of publishing data and meta data that is not possible for limited scientific papers. The question is also how to encourage the scientist to publish data. The solution is in the request that papers could not be published before the data are available in the database as it is arranged in genetic science. We should promote an award for data publishing and find additional funding for this.

5. CONCLUSIONS

1. The models with distributed parameters and integrated simulation for surface, subsurface and ground water flows are the challenge of today's development of hydrological science.
2. The models with distributed parameters are useful if space distributed data and input variables are available; otherwise models with lumped parameters are better for simulation.
3. Data collected from different sources should be equipped by meta data for integration in the same model.

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PRIMERJAVA USTANOV GOSPODARJENJA Z VODAMI V EVROPI NA PODLAGI VERTIKALNIH POROČIL
COMPARING WATER MANAGEMENT INSTITUTIONS IN EUROPE ON THE BASIS OF VERTICAL REPORTS

Tomaž UMEK
Primož BANOVEC

Gospodarjenje z vodami ima v vsaki državi specifično tradicijo. Ta se odraža v trenutnem razmerju med ustanovami, ki se ukvarjajo z njegovimi različnimi prvinami. Kljub temu, da so organizacijske oblike in razmerja med ustanovami zaradi različne zgodovine pravnih razmerij v posamezni državi precej različne, pa vse obravnavajo relativno podoben vodni sistem in morajo zato tudi vse imeti sorodne prvine, ki jih je nato mogoče horizontalno povezovati. V članku je predstavljen horizontalni prerez preko ustanov, ki je nastal pri izdelavi vertikalnega poročila za vsako posamezno državo. Tako se slovensko vertikalno poročilo vključuje v sistem vertikalnih poročil, izdelanih v projektu Eurowater, in s tem omogoča primerjavo institucionalne pokritosti nekaterih temeljnih prvin gospodarjenja z vodami. Glede na sodobne smernice, ki tudi v Evropski zvezi postopoma prinašajo zakonsko urejen in zato mnogo bolj poenoten način gospodarjenja z vodami, pa vertikalno poročilo in njegova izpeljava - horizontalno poročilo, omogočata zlasti primerjavo obstoječih izkušenj na področju ustanov gospodarjenja z vodami.
Ključne besede: *gospodarjenje z vodami, zakonodaja, vertikalno poročilo, horizontalno poročilo, vodni sistem*

Water management has its own, specific tradition in each European state. This is reflected in the current relationship among institutions dealing with its different aspects. In spite of the fact that organisational forms and relationships among institutions are quite different because of the different histories and legal circumstances in specific countries, they deal with relatively similar water systems, and, therefore, should have similar features that could be compared on a horizontal level. In the article, a horizontal overview of institutions is presented, based on the data prepared for each individual state in its national vertical reports. In this manner, the Vertical Report for Slovenia enters the system of vertical reports prepared within the Eurowater Project. This allows a comparison of the institutional coverage of some basic water management elements. Modern trends also reflected in the European Union legislation gradually lead towards the implementation of a more unified institutional and procedural system. The vertical report and its derivation - the horizontal report, enable us to make a comparison of existing practices and experiences regarding institutions for water management.
Key words: *water management, legislation, vertical report, horizontal report, water system*

1. UVOD

Pet držav članic Evropske zveze (EZ) je v okviru projekta Eurowater (Correia, 1998c) izdelalo vertikalna poročila, ki podajajo pregled in oceno institucionalnih, pravnih, ekonomskih in socialnih izhodišč, ki so podlaga za pobude na področju politike do voda.

1. INTRODUCTION

Five member states of the European Union (EU) have, within the Eurowater Collaborative Research Programme (Correia, 1998c), prepared vertical reports, giving an overview and assessment of institutional, legal, economic and social backgrounds that present a framework for incentives in the field of water policy.

Na podlagi izdelanih vertikalnih poročil posameznih držav je bilo podrobno obdelanih deset (horizontalnih) področij. Tako so nastala naslednja **horizontalna poročila** (Correia, 1998), ki so ključnega pomena za evropsko politiko do voda in za katere lahko rečemo, da predstavljajo sintezo vertikalnih poročil:

- politika gospodarjenja z vodami v Evropski zvezi,
- povezave med vodno in okoljsko politiko,
- meddržavni in medregionalni problemi pri gospodarjenju z vodnimi viri,
- ekonomski instrumenti gospodarjenja z vodami in mehanizmi financiranja vodnogospodarske infrastrukture,
- gospodarjenje z vodami (na državnem in drugih ravneh),
- načrtovanje in gospodarjenje z vodami v povodjih,
- problematika nadzora onesnaževanja voda,
- zakonodaja na področju voda v državah EZ,
- razvoj in uporaba politike do voda,
- subsidiarnost - vzajemnost in politika do voda.

Na sliki 1 (Correia, 1998c) je prikazana povezanost med vertikalnimi in horizontalnimi poročili.

Zaradi kritičnega stanja na področju gospodarjenja z vodami v Republiki Sloveniji (RS) in zaradi procesov približevanja EZ smo na podlagi enotne metodologije tudi mi izdelali vertikalno poročilo (Umek, 1998). Tako smo dobili temelj za primerjavo stanja na področju gospodarjenja z vodami v RS in nekaterih državah članicah EZ.

Prve rezultate izdelanih primerjav podajamo v tem prispevku. Podrobneje bodo posamezne primerjave na podlagi izdelanih vertikalnih poročil narejene v horizontalnih poročilih za posamezna področja, hkrati pa se moramo zavedati, da izdelava vertikalnega poročila ni bila enkratno dejanje. Sprotno dopolnjevanje (predvsem v smislu izboljšanje kakovosti poročila) mora postati obvezna naloga ministrstva, pristojnega za vode.

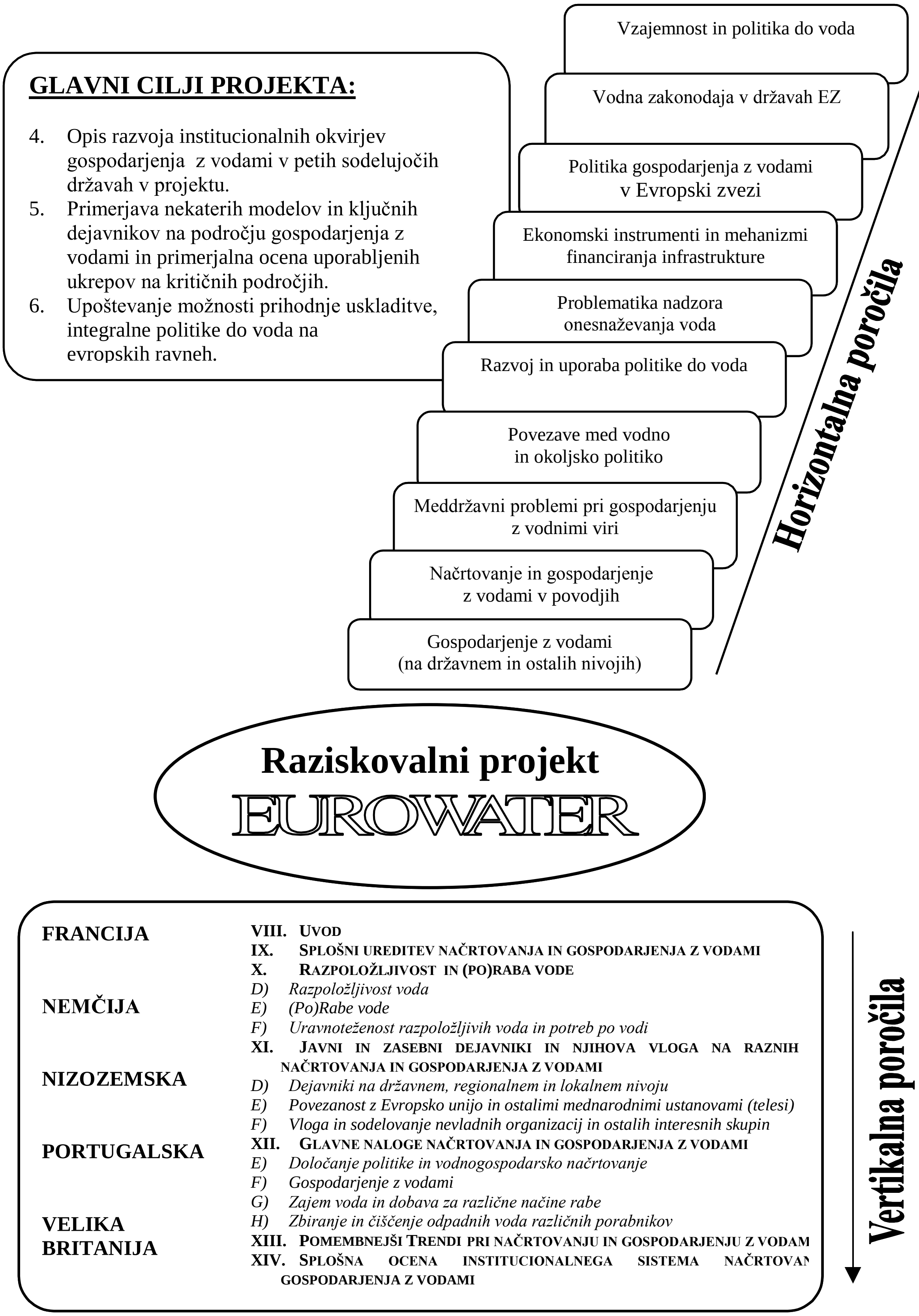
On the basis of some prepared vertical reports of individual states, 10 (horizontal) topics were selected and elaborated. In that way, a **horizontal report** (Correia, 1998) was prepared, one that is of key importance for the European water policy. It presents a synthesis of all vertical reports. The following topics were analysed in the Horizontal Report:

- Water resources information policy,
- River basin planning and management,
- Trans boundary issues in water resources,
- Relationships between water policy and environmental policy,
- Regulation and enforcement of water policies,
- Selected emerging issues in water quality control policies,
- Economic instruments of water management and the financing of infrastructure,
- Public and private water management in Europe,
- Water rights and administration in Europe,
- Subsidiarity and water policy.

Figure 1 schematically presents the relationship between Vertical and Horizontal reports (Correia, 1998c).

Because of the current situation in the field of water management in the Republic of Slovenia (RoS) and the EU accession processes, we have prepared a Vertical Report for Slovenia on the basis of common methodology (Umek, 1998). In this way, we have prepared foundations for the comparison of the situation in the field of water management in the RoS with some other EU member states.

In this article only an overview of water resources management issues is presented. Detailed elaboration of specific topics for the next horizontal report is the next step that will have to be made jointly by an international group of experts. At the same time, one has to be aware that the preparation of the vertical report should not be a unique act. Permanent updating and improvement of the report should become a task of the ministry responsible for water management.



Slika 1. Povezava med vertikalnim in horizontalnimi porocili (Correia 1998c).

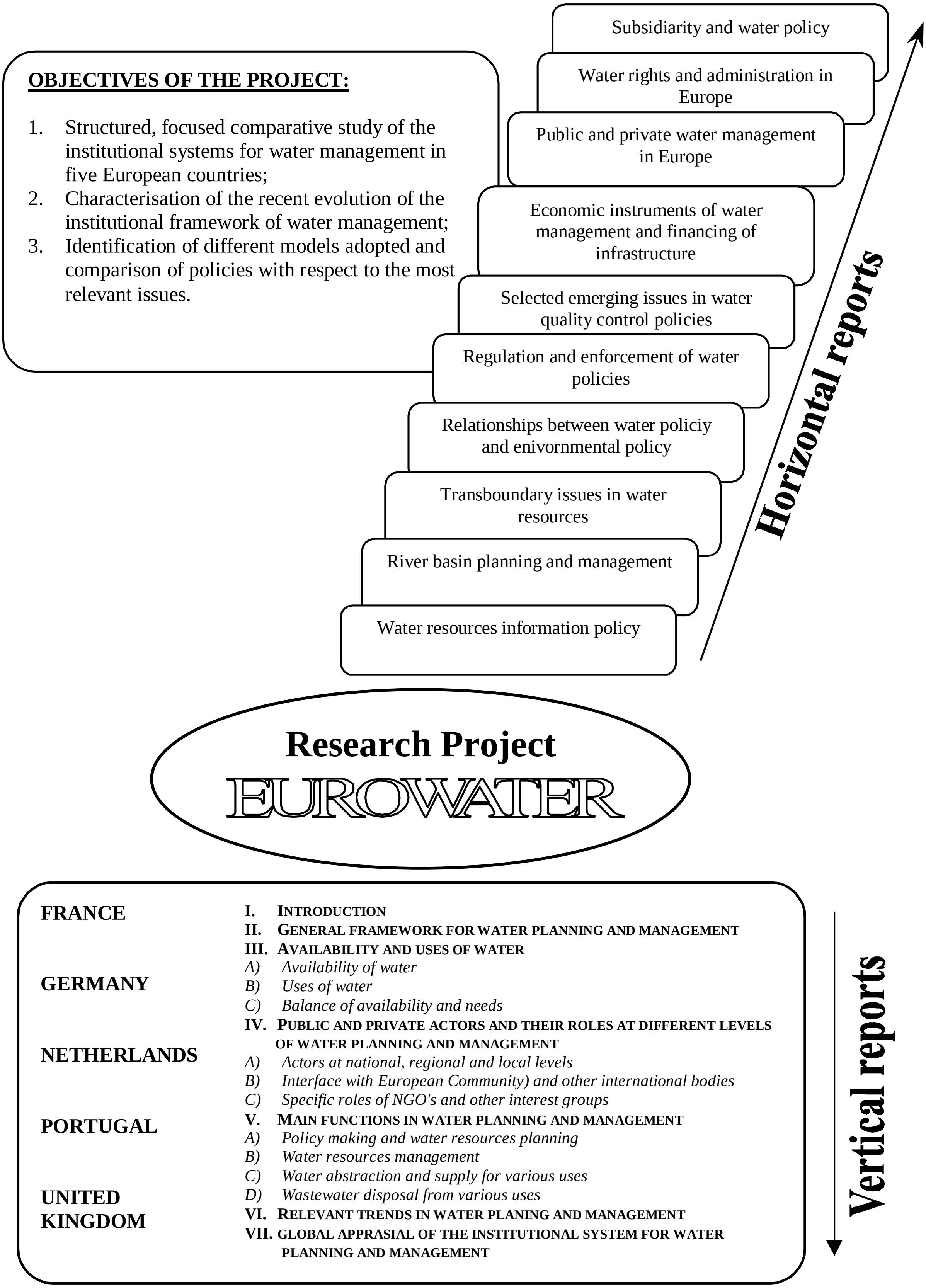


Figure 1. Structure and objectives of EUROWATER research project (Correia, 1998c).

2. PRIMERJAVA USTANOV GOSPODARJENJA Z VODAMI V EVROPI

2.1 UVOD

V nadaljevanju podajamo kratko primerjavo stanja na področju gospodarjenja z vodami v šestih evropskih državah. Pet držav je že članic EZ (Francija, Nemčija, Nizozemska, Portugalska in Velika Britanija), šesta - Slovenija pa že izvaja pristopne aktivnosti za vključitev v EZ.

Podlaga za analizo stanja so izdelana vertikalna poročila (Correia, 1998a) v omenjenih državah, za vseh pet držav članic EZ skupaj pa so izdelana že tudi horizontalna poročila (Correia, 1998b), ki mnogo podrobneje obravnavajo izbrane tematike. Za začetek smo se odločili, da izdelamo kratko primerjalno analizo za vseh šest držav.

Najprej bomo primerjali splošne značilnosti posameznih držav, saj imajo različne politične in geografske značilnosti držav pomemben vpliv na sistem organiziranja gospodarjenja z vodami v državah. V nadaljevanju bomo izdelali primerjalni pregled ustanov gospodarjenja z vodami, mehanizmov gospodarjenja z vodami v posameznih državah in na kratko organizacijo sistemov preskrbe s pitno vodo in odvajanja odpadnih voda.

Za zaključek je narejen izvleček najpomembnejših značilnosti za posamezne države. Kljub temu, da so bila poročila izdelana z vnaprej predpisano vsebino, je izdelava enotnega pregleda za vse države težavna naloga, saj je od posamezne države odvisno, kateremu področju je bil namenjen večji poudarek in kako kakovostno je bilo posamezno vprašanje obdelano.

2. OVERVIEW OF WATER RESOURCES MANAGEMENT ISSUES

2.1 PRELIMINARY REMARKS

Following, a short overview of some of the most relevant issues in the field of water management in six European states is presented. Five of them (France, Germany, The Netherlands, Portugal and The United Kingdom) are EU member states; the sixth – Slovenia - is currently in the EU association process.

Background for the presented comparisons are the prepared vertical reports (Correia, 1998a) for the above mentioned states, for which horizontal reports dealing in detail with selected topics were published as well (Correia, 1998b).

At the first stage, a comparison is given of some basic water management issues for individual states. A varied political and geographic development has significantly influenced the organisation of water management in some of them. Following is comparative overview of institutions for water management, tools and mechanisms for water management, and the organisation of water supply and wastewater disposal.

In the Conclusion, a summary of the most important features is prepared for the individual states. In spite of the fact that the report was prepared with firmly determined contents, the preparation of a common overview is a difficult task, as it varies substantially from one state to another. It also depends on the priority of individual issue and the quality of their elaboration in each individual state.

VB: Anglija in Wales

Gospodarjenje z vodami od izvira do izliva.

Najpomembnejša raba vode je preskrba z vodo.

Glavne vire vode predstavljajo reke, jezera in zbiralniki vode, manj pa podtalnica.

Značilna je visoka stopnja preskrbljenosti s pitno vodo iz vodovodnih sistemov ter visoka stopnja povezanosti na sisteme odvajanja odpadnih voda.

Nizozemska

Izliv treh pomembnejših evropskih rek - poudarek je na prekomejni problematiki kakovosti voda.

Je najbolj gosto naseljena evropska država, zato se največ vode porabi za preskrbo z vodo, pomembna pa je tudi raba vode v industriji in za potrebe kmetijstva.

Glavni vir za preskrbo z vodo je podtalnica.

Značilna je visoka stopnja preskrbljenosti z vodo iz sistemov ter odvajanja odpadnih voda v zbiralnikih.

27 odstotkov pokrajine leži v depresiji (pod nivojem morja).

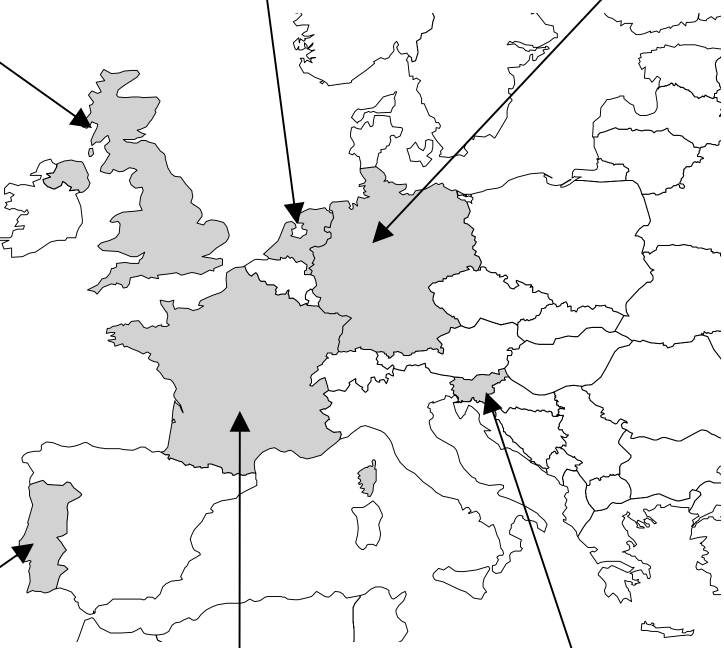
Nemčija

Je dežela s povirnimi in z nižinskimi vodotoki.

Je visoko industrializirana država, zato je velika poraba vode v industriji.

Okoli 70 odstotkov pitne vode zagotavlja podtalnica.

V Zahodni Nemčiji je visoka stopnja preskrbljenosti s pitno vodo iz vodovodnih sistemov ter visoka stopnja povezanosti na sisteme odvajanja odpadnih voda, v Vzhodni Nemčiji pa veliko investirajo v te sisteme, da bi dosegli podobne standarde.



Portugalska

Je dežela z nižinskimi vodotoki - večina jih priteče iz Španije, zato je velik poudarek na prekomejni problematiki količine voda.

Glavni porabnik vode so namakalni sistemi za potrebe kmetijstva.

Več kot 90 odstotkov vode za preskrbo s pitno vodo iz podtalnice.

Značilna je nizka stopnja preskrbljenosti s pitno vodo iz sistemov ter skupnega odvajanja odpadnih voda (v primerjavi z ostalimi državami).

Francija

Je dežela s povirnimi in z nižinskimi vodotoki.

Najpomembnejša raba vode je preskrba s pitno vodo.

Okoli 60 odstotkov vode za preskrbo s pitno vodo je iz podtalnice.

Veliko je ruralnega prebivalstva - 35 odstotkov vsega prebivalstva ni priključenega na sisteme odvajanja odpadnih voda, vendar so decentralizirani kanalizacijski sistemi ob pravilnem upravljanju lahko tudi učinkoviti.

Slovenija

Je dežela s povirnimi in z nižinskimi vodotoki.

Približno polovica uporabljene vode je namenjena preskrbi prebivalstva s pitno vodo, ostala polovica pa za potrebe kmetijstva in industrije.

Več kot polovica preskrbe s pitno vodo je iz podtalnice.

Le slaba polovica prebivalcev je priključenih na javna kanalizacijska omrežja.

Slika 2. Pregled splošnih značilnosti posameznih držav.

England and Wales

Source to sea management in all but a few minor cases

Public supply is the main water use
Large majority of demand met from rivers, lakes, and reservoirs rather than groundwater

Very high level of connection to water mains and sewers

The Netherlands

Delta of three major international rivers – transboundary issues are important

As the most densely populated country in Europe, public supply is the main use but industry and agriculture are also very important

Majority of water supplied from groundwater

Very high level of connection to water mains and sewers

Water exclusion is a major issue; 27% of land is under sea level

Germany

Upstream and downstream country

Highly industrialized; therefore, large demand for water from industry

Around 70% of supply derived from groundwater

Very high level of connection to water mains and sewers in the former West Germany and significant investment is being made to achieve these same standards in the former East Germany.

Portugal

Downstream country –several of the main rivers arrive from Spain. Therefore transboundary water quantity issues are very important

Irrigation for agriculture is the main water use.

More than 90% of public water supply from groundwater

Levels of connection to water supply and the sewer system much lower than the other countries, but currently large sums are being invested to increase this

France

Upstream and downstream country

Public water supply is the main water use, but other uses are important

Around 60% of supply derived from groundwater

Large rural population – 35% of population is not connected to sewer, but decentralized sewers are considered to be the most efficient option if managed properly

Slovenia

Upstream and downstream country

Around half of the water use is public water supply; the rest, industry and agriculture.

More than half of supply derived from groundwater

Only less than half of the population is connected to the sewer

Figure 2. General Characteristics of Individual States.

2.2 SPLOŠNE ZNAČILNOSTI POSAMEZNIH DRŽAV

Pred primerjavo institucionalnih ureditev je zelo pomembno poznavanje splošnih značilnosti posamezne države, kot so geografske in hidrološke značilnosti. Te značilnosti in prednosti pri rabi voda v posamezni državi narekujejo tudi načine, ki jih države uporabljajo pri organizaciji gospodarjenja z vodami.

Glavne značilnosti, ki vplivajo na sistem gospodarjenja z vodami, so:

- geografske značilnosti - velikost in gostota naseljenosti,
- hidrološke značilnosti,
- vodne količine,
- uporaba površinskih voda za potrebe preskrbe s pitno vodo,
- stopnja preskrbljenosti prebivalstva s pitno vodo in razširjenost kanalizacijskih sistemov za odvajanje odpadnih voda in čistilnih naprav.

V tem pogledu najbolj izstopa Velika Britanija (v analizi sta zajeta samo Anglija in Wales), ki je otoška država in zanjo velja načelo upravljanja od izvira do izliva. Vse ostale države, vključno s Slovenijo, se ukvarjajo tudi s prekomejnim sodelovanjem, saj vodotoki prečkajo državne meje. Pri tem sta Portugalska in Nizozemska v nekoliko drugačnem položaju, saj nimata vodotokov z lastnimi povirji, ampak samo nižinske vodotoke, katerih povirja so v sosednjih državah. Pregled splošnih značilnosti posameznih držav je podan na sliki 2 (Correia, 1998; Umek, 1998).

2.3 USTANOVE GOSPODARJENJA Z VODAMI

Ustanove gospodarjenja z vodami so se v posameznih državah razvijale v odvisnosti od geografskih, kulturnih in zgodovinskih značilnosti posamezne države. Obstoječi sistemi se v posameznih državah razlikujejo, vendar pa poskušajo vse države uveljaviti priporočila EZ in drugih mednarodnih dogovorov. Zaradi naštetih vzrokov je težko predpisati enako ali podobno institucionalno ureditev za vse države, pri analizi stanja pa

2.2 GENERAL CHARACTERISTICS OF INDIVIDUAL STATES

Before considering institutional arrangements, it is very important to understand the general characteristics of each individual state, such as the geographical and hydrological characteristics. These characteristics, and priority uses of water in each individual state, affect the way water management is organised in each one of them.

The Main issues, which affect water management are:

- Geography and population density,
- Hydrological position,
- Water availability,
- Use of surface water as a source for drinking water,
- Levels of connection to drinking water supply and sewerage.

In this comparison, The United Kingdom (England and Wales) is somehow special, because of its situation as an island state managing rivers from their source to the sea. All other countries, including Slovenia, have trans boundary rivers. Portugal and the Netherlands are in a slightly characteristic position, as they are primarily downstream countries, with rivers originating in neighbouring countries. An overview of general characteristics is given in Figure 2 (Correia, 1998; Umek, 1998).

2.3 WATER MANAGEMENT INSTITUTIONS

The institutional arrangements for water management in the selected countries have evolved depending on the geographical, cultural and historical characteristics of each individual state. The systems adopted, therefore, vary widely in the different countries, and continue to evolve to national and EU initiatives and other international agreements. It is, therefore, difficult to assign, due to the already mentioned reasons, an identical or similar institutional framework for primerjamo predvsem:

- porazdelitev odgovornosti med posameznimi ministrstvi,
- razdelitev na državno, regionalno in lokalno raven,
- uporaba javnega in zasebnega kapitala za vodooskrbne in komunalne sisteme,
- način sodelovanja javnosti pri odločanju in
- sistem pritožb na odločbe upravnih organov.

Pregled glavnih značilnosti institucionalnega sistema je podan v preglednici 1 (Correia, 1998; Umek, 1998).

2.4 ORGANIZACIJA GOSPODARJENJA Z VODAMI

Ključno vprašanje, ki se postavlja pri organizaciji gospodarjenja z vodami, je kako porazdeliti odgovornosti in pristojnosti med posamezne ustanove, in to z namenom reševanja konfliktnih situacij, ki se pojavljajo pri različnih interesih zaradi rabe voda in prostora. Zato je pri obravnavi te problematike zelo pomembno, kako učinkovito je organizirano načrtovanje in upravljanje z vodami.

Večina držav ima urejeno gospodarjenje po porečjih (povodjih) in za njih tudi pripravlja vodnogospodarske plane. Na tem področju izstopata Nemčija in Nizozemska, kjer bi načrtovanje na porečjih zaradi mednarodnih vodotokov težje zaživelo. Tudi Slovenija je država, ki ima predvsem mednarodne vodotoke, vendar ti, z izjemo Drave in Mure, izvirajo v Sloveniji, kar omogoča relativno dobro planiranje po povodjih. Tako je bil izdelan pilotni projekt Načrta ureditve povodja reke Kokre (Globevnik, 1998), ki bo podlaga za izdelavo podobnih načrtov za vsa povodja v Sloveniji.

Pregled organizacije gospodarjenja z vodami v posameznih državah je podan v preglednici 2 (Correia, 1998; Umek, 1998).

every country , but it is possible to compare the following:

- Division of responsibilities between ministries,
- Involvement of national, regional and local levels,
- Use of public and private capital in water services,
- Mechanisms for public involvement,
- Last resort for appeals against regulatory decisions.

An overview of the topics related to institutional arrangements is presented in Table 1 (Correia, 1998; Umek, 1998).

2.4 WATER RESOURCES MANAGEMENT

The main issue raised in the context of water resources management organizations is how to divide the responsibilities and competencies among institutions with the aim of resolving conflict situations. That is why it is especially important, when analysing this issue, to discuss and disclose how efficient the water management planning and water management administration are.

Most of the states formulate water management on the river basin or catchment level, and for these areas also perform water management planning. The exceptions are Germany and The Netherlands, where river basin oriented water management is difficult to implement, due to important trans boundary issues. The rivers in Slovenia are also predominantly trans boundary, but they, with the exception of the Drava River and the Mura River, originate in Slovenia, which enables relatively simple river basin management and planning. For this purpose a pilot Catchment management plan was prepared (Globevnik, 1998), which will be used as a guideline for the preparation of catchment management plans in Slovenia. A legal background for water resources management does not yet exist.

An overview of water management mechanisms in individual states is presented in Table 2 (Correia, 1998; Umek, 1998).

Preglednica 1. Institucije gospodarjenja z vodami.

VB: Anglija in Wales	**Nizozemska**	**Nemčija**
Največje pristojnosti na področju gospodarjenja z vodami ima ministrstvo za okolje. Druge ustanove: NRA, HMIP, OFWAT, DWI (kakovost pitne vode) NRA opravlja večfunkcijsko, integralno gospodarjenje z vodami (v povodjih). Značilna so zasebna podjetja za ekonomiko upravljanja (OFWAT). Sodelovanje javnosti poteka preko lokalne skupnosti in posvetovanj ter javnih katastrov. Na Škotskem in Severnem Irskem so institucionalne ureditve različne kot v Angliji in Walesu.	Vloge so porazdeljene med ministrstva. RWS je državna služba, ki skrbi za državne vode, za nedržavne vode je organizirano upravljanje na regionalni/lokalni ravni. Gospodarjenje z vodami je razdeljeno med več organizacij/podjetij. Javna podjetja skrbijo za preskrbo s pitno vodo in čiščenje odpadnih voda, zbiranje in odvajanje odpadnih voda je v pristojnosti lokalnih skupnosti. Sodelovanje javnosti poteka preko voljenih predstavnikov in administrativnih služb.	Glavno vlogo ima Ministrstvo za okolje, posamezne naloge pa so porazdeljene tudi med ostala ministrstva. Deželna ministrstva za okolje so odgovorna za gospodarjenje z vodami. LAWA ima pomembno vlogo koordinatorja. Upravljanje z vodami na državni, regionalni in lokalni ravni. Lokalne skupnosti so odgovorne za preskrbo z vodo in odvajanje odpadnih voda. Značilna je majhna vloga zasebnega kapitala, vendar vodovodi delujejo kot zasebna podjetja. Sodelovanje javnosti poteka preko izvoljenih predstavnikov in administrativnih služb.
Portugalska	**Francija**	**Slovenija**
Ministrstvo za okolje in naravne vire ima najpomembnejšo vlogo, ostala ministrstva so manj pomembna. Nacionalne organizacije so odgovorne za politiko do voda, načrtovanje na področju voda in za kakovost pitne vode. V procesu reorganizacije se je odgovornost na področju gospodarjenja z vodami prenesla na pet regij. Regionalne uprave za okolje in naravne vire, skupaj z regionalnimi zdravstvenimi upravami, so odgovorne za večino aktivnosti gospodarjenja z vodami. Lokalne skupnosti so odgovorne za preskrbo s pitno vodo in odvajanje odpadnih voda.	Glavno vlogo ima Ministrstvo za okolje, vendar imajo pomembno vlogo tudi ostala ministrstva. Dovoljenja za odvzem in izpuste voda izdaja načelnik - prefekt regije. Vodna policija je odgovorna za monitoring dejavnosti v procesu gospodarjenja z vodami (opravljajo delo za več ministrstev). Vodna agencija je odgovorna za pobiranje vodnih prispevkov, za odvzeme in izpuste voda in za upravljanje vodnega fonda. Lokalne skupnosti so odgovorne za preskrbo s pitno vodo in odvajanje odpadnih voda, vedno večji je vpliv zasebnega kapitala, predvsem v podjetjih za odvajanje odpadnih voda. Sodelovanje javnosti poteka preko izvoljenih lokalnih predstavnikov.	Glavno vlogo v sistemu gospodarjenja z vodami ima Ministrstvo za okolje in prostor, čeprav so naloge razdeljene med vsa ministrstva. Država je razdeljena na osem vodnih območij z izpostavami Uprave za varstvo narave, katerih pristojnosti niso natančno definirane. Upravne funkcije na področju gospodarjenja z vodami izvaja več upravnih organov. Redne naloge gospodarjenja z vodami izvajajo javne vodno-gospodarske službe, v katerih pristojnosti je tudi rečno nadzorstvo, ki nima potrebnih pooblastil. Lokalne skupnosti so odgovorne za preskrbo s pitno vodo in odvajanje odpadnih voda.

Table 1. Institutional Arrangements in Individual States.

England and Wales	**The Netherlands**	**Germany**
In England and Wales, one ministry (DoE) has the main responsibility for water management National regulators, NRA (catchment based management of the aquatic environment, HMIP, OFWAT, DWI (drinking water quality) NRA multifunctional, integrated water management Private water companies with economic regulations (OFWAT). Public participation through committees, consultation and registers Appeal against licence conditions to DoE Different in Scotland and Northern Ireland	Major roles for several ministries The national regulator (RWS) is responsible for the state waters, but there is regional/local management of non-state waters Water management is divided between many organisations Publicly owned companies provide water services and publicly owned water boards provide sewage treatment, but municipalities are responsible for the sewer system Public participation through locally elected representatives and administrative courts Appeals against regulatory decisions through administrative courts	The Federal Ministry of the Environment plays the main role, but other ministries also have a major role Lander (States) Environment Ministries have the overall responsibility for water management LAWA has an important coordination role Regulation at state, regional, and local level Municipalities are responsible for water and wastewater services Minor role of private capital, but water supply companies are operated like private companies Public participation through locally elected representatives and administrative courts Appeal against regulatory decisions through administrative courts
Portugal	**France**	**Slovenia**
MARN is the main ministry; other ministries have significant roles National organisations are responsible for water policy, water planning and drinking water quality (INAG/DGA) The state is in the process of reorganising responsibilities to decentralise water management to five regions – not catchment based DRARN and ARS (with INAG) are responsible for most water management activities – integrated water management Municipalities are responsible for water and wastewater services, but there are plans for five (one so far) large multi-municipial companies in metropolitan areas, with up to 49% private capital	The main ministry is MoE, but significant roles of other ministries Perfect at Departement level is responsible for licensing abstractions and discharges The Police de l'Eau are responsible for monitoring water management activities (representing many ministries-fragmented) Agences de l'Eau collect charges for abstraction and discharge and redistribute funds as loans or subsidies for abatement Municipalities are responsible for water and wastewater services, but there is large a involvement of private water companies in the water supply and, increasingly, in the sewer services Public participation through locally elected representatives	The Ministry of Environment and Physical Planning (MEPP) plays the main role; other ministries also have significant roles The State is divided into 8 regional water units of the MEPP – Nature protection administration with unclear tasks Administrative functions in water management are performed by several administrative bodies Public water management service is performed by public companies and water management companies, who also perform river supervision without suitable authorisation Local communities are responsible for water supply and wastewater disposal Appeal against regulatory decisions through administrative courts

Preglednica 2. Organizacija gospodarjenja z vodami.

VB: Anglija in Wales	**Nizozemska**	**Nemčija**
Načrti upravljanja povodij se uporabljajo kot ključni mehanizem za usklajevanje prihodnjih prioritet in kot pomoč pri sistemu odločanja. Za vse izpuste v vode je treba pridobiti dovoljenje. Uporabljajo okoljske standarde kakovosti, v primeru industrijskega onesnaževanja pa enotne emisijske standarde, če so ti strožji od okoljskih. Za odvzem voda morajo uporabniki pridobiti dovoljenje. Vodna povračila morajo pokrivati stroške upravljanja in stroške nadzora.	Načrtovanje ne temelji na povodjih. Za vse izpuste v vode je treba pridobiti dovoljenje, zahtevajo se okoljski standardi za vse onesnaževalce, enotni emisijski standardi so zahtevani, za doseganje načrtovanih ciljev se lahko predpišejo še ostrejše zahteve. Za odvzeme vode je potrebno dovoljenje, za odvzeme voda iz podtalnice za potrebe namakanja pa je potrebna le priglasitev. Sistem obračunavanja vodnih povračil in taks je naravnan tako, da spodbuja racionalno rabo voda. Vodna povračila se zaračunavajo le porabnikom za odvzem vode iz podtalnice.	Načrtovanje v povodjih še ni povsem zaživelo, razen za glavne vodotoke in nekaj manjših vodotokov. Za vse iztoke je potrebno dovoljenje, zahtevajo se enotni emisijski standardi, politika do voda temelji na preprečevanju direktnih (neprečiščenih) iztokov v vode. Za vse odvzeme vode je potrebno dovoljenje. Takse za obremenjevanje voda so naravnane k spodbujanju zmanjšanja obremenjevanja voda z uporabo najboljše razpoložljive tehnologije. Vodna povračila za odvzem vode za posamezne dežele niso enotna.
Portugalska	**Francija**	**Slovenija**
Načrtovanje v povodjih in nacionalni programi nadomeščajo pomanjkanje upravljanja po posameznih povodjih. Zahtevajo se enotni emisijski standardi EZ. Od leta 1995 je treba pridobiti dovoljenje za vsak odvzem vode. Uvajajo sistem vodnih povračil in taks za obremenjevanje voda - do leta 2005.	Načrtovanje v povodjih in podpovodjih temelji na usklajevanju interesov. Za vse izpuste v vode je treba pridobiti dovoljenje, kot minimalni standardi so predpisani enotni emisijski standardi. Za vse odvzeme voda je treba pridobiti dovoljenje. Takse in vodna povračila se stekajo v državni proračun.	Izdelan je bil pilotni projekt Načrta ureditve povodja, ki bo podlaga za izdelavo podobnih načrtov za vsa povodja v državi. Za vse izpuste v vode je treba pridobiti dovoljenje, uvajajo se enotni emisijski standardi. Za odvzeme voda je potrebno pridobiti dovoljenje. Takse in vodna povračila se stekajo v integralni proračun.

Table 2. Water Management Mechanisms.

England and Wales	**The Netherlands**	**Germany**
Catchment plans (164 by 1998) are used as the key to reaching a consensus on future priorities and to guide in decision making Discharge licensing for all discharges. EQs are minimum standards, but UESs are applied for the most polluting industries if these are more stringent than the limits to meet the EQs Abstraction licensing for all uses Charging schemes aim to recover the costs of administration and monitoring	Extensive planning but not on a catchment basis – essential for coordination and integration Discharge licensing for all discharges, UESs minimum requirement; stricter requirements can be applied to meet plan objectives Abstraction licensing for all uses, but agricultural abstractions from groundwater only need declaration Charging schemes are based on incentive charging and revenue raising Abstraction charging only for groundwater	Planning is encouraged, but so far not really accepted, for major, plus a few minor rivers only All discharging requires a license; UESs are a minimum requirement and it is the policy of the water authorities to discourage discharging directly into water All abstractions require a licence Effluent charges are based on an incentive scheme to encourage pollution reduction by BAT Abstraction charging varies from land to land (county to county/province to province/region to region)
Portugal	**France**	**Slovenia**
Statutory catchment plans and national plans balance the loss of catchment based administration (15 panned by 1997) UESs (EU standards only) unless the EQSs allow consent limits to be less stringent Abstraction licensing for all uses to be introduced on a national basis in 1995 (groundwater 1994) Charging schemes will be introduced (1995-2005)	Statutory catchment and sub-catchment plans are based on a consensus (4 so far) All discharges require a licence; UESs are applied as minimum standards All abstractions require a licence Charging schemes for revenue raising	One pilot project of sub-catchment (Kokra) has been prepared as a draft for further planning development. No legal background for water management planning. All discharges require a licence; UESs are gradually being implemented All abstractions require a licence Abstractions and discharges are charged; revenues of the central state budget

2.5 PRESKRBA Z VODO IN ODVAJANJE ODPADNIH VODA

V večini obravnavanih držav, z izjemo Velike Britanije (Anglije in Walesa) in delno Francije, je preskrba z vodo in čiščenje ter odvajanje odpadnih voda v pristojnosti lokalnih skupnosti in podobno je tudi trenutno stanje organiziranosti v Sloveniji. Pri analizi stanja je potrebno še posebno pozornost nameniti naslednjim vprašanjem:

- kako se obračunava porabljena pitna in odpadna voda (razširjenost vodnih števcev - merilnikov pretokov),
- stopnja vključenosti zasebnega kapitala,
- način določanja cen,
- viri financiranja zahtevanih naložb v prihodnosti.

V državah EZ so težnje k delni oz. popolni privatizaciji služb za preskrbo s pitno vodo in odvajanje odpadnih voda, predvsem pa je treba vedeti, da bo potrebna veliko denarja za obnovitve starih in izgradnje novih sistemov v vseh državah. Pri tem bo odigral pomembno vlogo zasebni kapital, od posameznih držav pa bo odvisno, na kakšen način bodo zasebni kapital pritegnile v te dejavnosti. Tudi v Sloveniji se bo treba odločiti, na kakšen način in s kakšnimi mehanizmi bomo reševali obravnavano problematiko. Ne glede na rešitve, ki se bodo pokazale kot najustreznejše, pa bo v sistem celostnega (integralnega) gospodarjenja z vodami treba vključiti tudi lokalne skupnosti in na vseh področjih, za katere je odgovorna lokalna skupnost, okrepiti mehanizme sodelovanja na področju gospodarjenja z vodami (vključitev pri izdelavi vodnogospodarskih načrtov, načrtov ureditev povodij itd.).

V preglednici 3 (Correia, 1998; Umek, 1998) je podan pregled analize stanja preskrbe z vodo in odvajanja odpadnih voda v obravnavanih državah.

2.5 WATER SUPPLY AND SEWER SERVICES

In most of the analysed countries, with the exception of The United Kingdom (England and Wales) and, partially, France, the water supply, wastewater collection and treatment are the responsibilities of the municipalities. This is the case for Slovenia, as well. Issues which deserve special attention in relation to the provision of water services are:

- Types of charging schemes, in particular the extent of metering,
- The degree of private sector involvement,
- The current baseline position with respect to EU legislation,
- The existence of variations of prices both within and between the selected countries,
- Sources of funds to finance the required capital investment in the future.

In the EU member states trends can be observed towards partial or full privatisation of the services providing the drinking water supply, the collection and treatment of waste water. At the same time, new standards dictate large intensive investments to improve existing systems and construct necessary new ones. Private capital will play an important role in this process, but one state differs from another in how to include itself in these activities. In Slovenia, private capital is used in the form of concessions for the construction of two wastewater treatment plants. Irrespective of the source of financing that might prove to be optimal for Slovenia, it will be necessary to include municipalities in a process of comprehensive (integrated) water management, especially in the areas for which municipalities are responsible. This means that it will be first necessary to improve the tools and the process of water management planning (water management planning on the river basin and catchment level) and involve municipalities in it.

An overview in Table 3 (Correia, 1998; Umek, 1998) shows the current status of the provision of water services in the analysed states.

Preglednica 3. Preskrba z vodo in odvajanje odpadnih voda.

VB: Anglija in Wales	**Nizozemska**	**Nemčija**
Samo 7 odstotkov gospodinjstev ima vodne števce. Obstaja 10 podjetij za preskrbo z vodo in odvajanje odpadnih voda ter 21 podjetij za preskrbo z vodo. Imajo popolnoma privatiziran vodni sektor. Sistem je naravnan na ekonomskih načelih s ciljem zaščite potrošnika (OFWAT). Imajo visoko stopnjo priključitve porabnikov na vodovodne in kanalizacijske sisteme. V zadnjih letih so cene narasle zaradi pokritja naložbenih stroškov.	Cena vode temelji na dejanski porabi vode in na pavšalnih plačilih. Več kot 90 odstotkov prebivalstva je priključenih na kanalizacijske sisteme. Preskrbo z vodo zagotavljajo javna podjetja. Za izgradnjo kanalizacijskih sistemov so odgovorne lokalne skupnosti, upravljajo pa jih vodne uprave - javne službe. Vodna povračila in kanalščino določajo država, regija, vodna uprava in lokalna skupnost. V zadnjih letih so se cene znatno povečale zaradi pokrivanja naložbenih stroškov.	91 odstotkov porabnikov plačuje vodo glede na dejansko porabo, ostalih 9 odstotkov pa pavšalno. 98 odstotkov prebivalstva je priključenih na kanalizacijske sisteme. Preskrba z vodo in odvajanje odpadnih voda je v pristojnosti lokalne skupnosti, zaželena pa je tudi udeležba zasebnega kapitala. Cene določa lokalna skupnost. Potrebne so znatne naložbe v sisteme, zlasti v Vzhodni Nemčiji.
Portugalska	**Francija**	**Slovenija**
V večini primerov se poraba voda obračunava z merilniki porabe vode. Manj kot 40 odstotkov prebivalstva je priključenih na kanalizacijske sisteme. V procesu privatizacije vodnega sektorja se uporablja francoski model. Cene določajo lokalna skupnost in podjetja za preskrbo in odvajanje voda. Za doseganje standardov EZ bodo potrebna znatna naložbena sredstva.	Za obračunavanje porabljene vode se uporabljajo različni pristopi, od plačevanja pavšalov do obračuna z vodnimi števci. 80 odstotkov prebivalstva je priključenih na kanalizacijske sisteme, ostalih 20 odstotkov na druge sisteme čiščenja. Prisotna je velika udeležba zasebnega kapitala v javna upravljavska podjetja. Cene se določajo s pogodbo. Pričakujejo porast cen zaradi novih naložb.	Podlaga za obračunavanje porabljene vode je v večini primerov dejanska poraba vode. Velika večina prebivalstva dobiva vodo iz javnih sistemov. Manj kot 50 odstotkov prebivalstva je priključenih na kanalizacijske sisteme. V veliki večini preskrbo z vodo in odvajanje odpadnih voda zagotavljajo javna podjetja, ki so v lasti lokalnih skupnosti. Za doseganje standardov EZ bodo potrebna velika naložbena sredstva.

Table 3. Water and Wastewater Services.

England and Wales	**The Netherland**	**Germany**
Only 7% of domestic customers have water meters 10 private water and sewage companies and 21 water only companies Fully privatized water sector. Natural monopolies by the creation of an economic regulator are charged with the duty of protecting customer interests A large proportion of the population is connected to water supply and sewerage network Charges have increased in order to fund investment over the last few years	Water prices are standing charge and volume related Over 90% of the population is connected to sewers Sewer services are provided by water boards, but the sewer system is the responsibility of municipalities. Water and wastewater levies are raised by the State, provinces, water boards and municipalities Charges have increased significantly to fund investment over the last few years.	Metering is extensive - 91% of the charges are related to the volume consumed, whilst 9% is for the standing charge 98% of the population is connected to sewers Water services re provided by the municipalities, but some input of private capital is sought Charges are raised by the municipalities Significant investments are needed, particularly in the former East Germany
Portugal	**France**	**Slovenia**
Meters are widespread Less than 40% of the population are connected to sewers Privatisation of the sector using the French model Charges are set by municipalities and water companies, where present Significant capital investment is required in order to meet EU standards	A variety of approaches has been adopted combining standing charges and volume used, but metering is widespread Around 80% are connected to sewers; the remaining 20% will retain decentralized sewage treatment Large involvement of private capital through a system where the operation is contracted out to private companies under public management Charges depend upon contract Price rises are forecast in order to finance capital investment	Meters are widespread The majority of the population is supplied from public supply systems Less than 50% of the population is connected to sewers In general, water supply and disposal is performed by public companies owned by municipalities. Charges are raised by public companies; prices are confirmed by municipalities, and the Ministry of Economic Relationships and Development Significant capital investment is required in order to meet the EU standards

Preglednica 4. Kratek povzetek ključnih ugotovitev.

VB: Anglija in Wales	**Nizozemska**	**Nemčija**
Možno je gospodarjenje z vodami od izvira do izliva v morje. Opazen je izrazit centralističen nadzor. Značilna je visoka stopnja preskrbljenosti s pitno vodo in priključitvijo na kanalizacijske sisteme. Zaradi popolne privatizacije sektorja so značilni visoka stopnja naložb v sisteme in učinkoviti mehanizmi ekonomskega nadzora. Relativno nizke so cene pitne vode in kanalščine.	Zelo velik poudarek je na prekomejnem sodelovanju in obrambi pred poplavami, ki sta ključna elementa politike do voda. Značilna je visoka stopnja priključitve na sisteme preskrbe z vodo in odvajanja odpadnih voda. Značilno je decentralizirano delovanje v sklopu širšega načrtovanja z učinkovito koordinacijo in integracijo politike do voda. Prihodki od povračil in taks se stekajo v državni proračun, stimulirajo pa zmanjšanje obremenjevanja voda. Sodelovanje javnosti poteka preko izvoljenih lokalnih predstavnikov.	Prekomejno sodelovanje ima pomembno vlogo. Značilna je visoka stopnja povezanosti na sisteme, potrebne so velike naložbe v Vzhodni Nemčiji. Federalni sistem - odgovornost za gospodarjenje z vodami je v pristojnosti deželnih uprav. Učinkovita zakonodaja zagotavlja minimalne standarde v celotni državi. Javne službe so v pristojnosti lokalnih skupnosti, zaželena pa je udeležba zasebnga kapitala. Cene so različne, stimulirajo pa zmanjšanje stopnje onesnaženja voda. Sodelovanje javnosti poteka preko izvoljenih lokalnih predstavnikov.
Portugalska	**Francija**	**Slovenija**
Pomembno je prekomejno sodelovanje, predvsem s količinskega vidika. Poteka proces decentralizacije sistema gospodarjenja z vodami na regionalno raven. Opazna je trenutno nizka stopnja povezanosti na sisteme, potekajo obsežne naložbe s podporo EZ. V manjših lokalnih skupnostih poteka privatizacija sektorja, v združenju lokalnih skupnosti pa je do 49 odstotkov zasebnega kapitala. Zagotovljeno je sodelovanje javnosti preko izvoljenih lokalnih predstavnikov.	Visoka stopnja ruralnega prebivalstva. 20 odstotkov prebivalstva ni priključenih na kanalizacijske sisteme, probleme rešujejo z lokalnim čiščenjem. Decentraliziran sistem gospodarjenja z vodami, ključni dejavniki so država, lokalne skupnosti in Vodna agencija. Načrtovanje v povodjih poteka z usklajevanjem interesov. Znatna je udeležba zasebnega kapitala. Prihodki od povračil in taks se stekajo v državni proračun. Sodelovanje javnosti poteka preko izvoljenih lokalnih predstavnikov.	Po osamosvojitvi je bilo vnovično uveljavljeno prekomejno sodelovanje. Značilna je visoka stopnja preskrbljenosti s pitno vodo, manj kot polovica prebivalstva je priključenih na kanalizacijske sisteme. Sistem gospodarjenja z vodami je v veliki krizi, ni ustreznih ustanov za gospodarjenje z vodami, čakamo na novo zakonodajo. Prihodki od vodnih povračil in taks za obremenjevanje voda se stekajo v integralni proračun. Sodelovanje javnosti poteka na javnih obravnavah in preko izvoljenih lokalnih predstavnikov.

Table 4. Summary of Key Issues in Selected Countries.

England and Wales	**The Netherlands**	**Germany**
Source to sea management is possible Strong central control Integrated catchment based management High level of connection, water supply and sewerage (metering is not wide spread) The effective level of investment in services is due to fully privatised service provision with effective regulation Relatively low charges for water and sewerage	Transboundary and flood issues are the key drivers of the water policy High level of connection to public service provisions Significant degree of decentralisation, but extensive planning provides effective co-ordination and integration of the environmental policies (not on a catchment basis) Incentive and revenue charging system Public participation through locally elected representatives	Transboundary issues are key High level of connection but significant investment is needed in former East Germany Federal system – the overall responsibility for water management lies with 16 Lander A strong legal framework ensures minimum standards across the country Municipalities provide water services, but private input is sought Charging schemes vary, but, for discharges, act as a strong incentive to reduce pollution. High abstraction charges in one land (county/province/region) (Hesse) have reduced pollution Public participation is through locally elected representatives
Portugal	**France**	**Slovenia**
Transboundary water quantity issues are of increasing importance In the process of re-organising responsibilities to decentralise water management to the regional level where investment and planning are decided At present there is a low level of connection to the water supply and sewer system, but there are large investments in this area with financial support from the EU Plans for municipal companies with up to 49% private capital; smaller municipalities can also involve private capital Public participation is through locally elected representatives	High rural population with significant involvement at the local level 20% of the population is not connected to the sewer, but decentralised sewerage is considered to be the most efficient option if managed properly Largely decentralized system for water management; State, municipalities, and The Agence de l'Eau are the key players Statutory, consensus catchment planning Revenue raising is through a charging system for discharges and abstractions Public participation is through locally elected representatives Large involvement of private capital	Active transboundary cooperation High level of public water supply; less than 50% are connected to the sewer system Water management system without proper institutional arrangements; new legislation is expected Income from water use taxes and discharge taxes is a revenue of the central state budget Public participation is through public hearing for individual projects and elected representatives on the municipal level A large investment for waste water treatment is expected

2.6 POVZETEK KRATKE ANALIZE STANJA NA PODROČJU GOSPODARJENJA Z VODAMI V EVROPI

V preglednici 4 (Correia, 1998; Umek, 1998) je izdelan kratek povzetek primerjave ključnih ugotovitev za posamezne države. Na problematiko je treba gledati v vsaki državi posebej celovito, saj se posamezni mehanizmi od države do države razlikujejo tudi zaradi različnih institucionalnih ureditev. Skupni cilj, h kateremu so zavezane vse države EZ glede na izvajanje okoljske politike, pa je trajnostni razvoj, ki pa ne pomeni ovire v razvoju, ampak uravnotežen ekonomski razvoj s poudarkom na varovanju okolja. Ključni element pri doseganju zastavljenega cilja je smotrno gospodarjenje z vodami, ki zahteva ustrezno organiziranost za učinkovitejše delovanje.

2.6 SUMMARY OF KEY ISSUES FOR EACH STATE REGARDING WATER MANAGEMENT

Approach towards the water management issues has to be performed in each state in a comprehensive manner, as individual mechanisms differ from one state to another, and also because of different institutional arrangements. The common goal to which all EU member states, as well as other states, are obliged to approach with their environmental policies is sustainable development. One should not understand this principle as a hindrance to any development with nature conservation aims, but as a balanced economical development going hand in hand with the environment. One of the key elements in achieving this goal is rational water management, which requires a suitable organisational structure for the effective performance of its tasks. A brief summary of key issues affecting water management in individual states is presented in Table 4 (Correia, 1998; Umek, 1998).

3. ZAKLJUČEK

V prispevku smo se omejili na primerjalno analizo ustanov za gospodarjenje z vodami v obravnavanih državah EZ in v Sloveniji, ki so ključnega pomena za obravnavo vseh drugih vidikov, obravnavanih v vertikalnih poročilih. Ne glede na institucionalne in zakonodajne razlike med posameznimi državami bo v EZ sčasoma prevladala skupna politika do voda, ki se jim bodo morale prilagoditi strategije posameznih držav. Podrobnejša analiza stanja (s pomočjo izdelave horizontalnih poročil za posamezna področja) v RS v primerjavi z ostalimi obravnavanimi državami EZ nam bo pokazala kritične točke našega sistema gospodarjenja z vodami in omogočila, da izberemo oz. določimo ukrepe za izboljšanje trenutnega položaja. Podobno analizo so na podlagi izdelanih vertikalnih poročil petih držav izdelali tudi v EZ, in se bo lahko uporabljala za določanje skupne politike do voda v državah EZ.

3. CONCLUSION

In the paper, we have limited our analysis to some key water management issues, focused especially towards the analysis of water management institutions and mechanisms in selected EU member states and Slovenia. Those are of key importance for discussion on the other aspects analysed in vertical reports. Independent from institutional and legal differences between individual states, a common framework for water policy to which individual strategies will have to adopt will gradually prevail. A more detailed analysis on the basis of full vertical reports and full horizontal topics for Slovenia and the other states will clearly expose the critical elements of our water management system. It will enable us to select adequate measures to improve the current situation, knowing, as well, the experiences learned in other states. In a similar way, the reports are, and will be, used by the EU to enable improved decision making regarding the development of a common framework for water policy in the EU.

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Pregledni znanstveni članek Scientific paper

HIDRODINAMIČNO MODELIRANJE KANALIZACIJSKIH OMREŽIJ HYDRODYNAMIC MODELLING OF SEWER SYSTEMS

Uroš CERAR

Prispevek predstavlja pomen hidrodinamičnega modeliranja kanalizacijskih omrežij in opis metodologije za izdelavo hidroloških in hidrodinamičnih modelov. Z izdelavo umerjenega hidrodinamičnega modela za obstoječe omrežje in s simuliranjem dogajanja na omrežju lahko v perspektivi pridobimo bistveno več informacij o delovanju kanalizacijskega omrežja kakor z uporabo klasičnih metod hidravličnih izračunov z upoštevanjem predpostavljenih koeficientov odtoka. Predstavljena je vloga meritev in njihov vpliv na kakovost rezultatov modeliranja. Hidrodinamično modeliranje v povezavi z analizami količinskih in kakovostnih vplivov omrežja na recipient predstavlja temelj za izdelavo razvojnih načrtov kanalizacijskih omrežij.
Ključne besede: *kanalizacija, odpadne vode, modeliranje, meritve, pretok, hidrologija*

The paper presents the significance of the hydrodynamic modelling of sewer systems and the methodology of constructing hydrological and hydrodynamic models. By performing simulations on a calibrated hydrodynamic model we gain much more information than by using classical methods of hydraulic calculations, where we only assume a runoff coefficient. The significance of the measurements and their influence on the quality of results is presented. The results of hydrodynamic modelling with quantity and quality analyses of the influence on the recipient are basic knowledge for preparing Masterplans of sewer systems.
Key words: *sewer, wastewater, modelling, measurments, discharge, hydrology*

1. UVOD

Kanalizacijsko omrežje predstavlja napravo za odvod odpadnih in padavinskih voda z urbaniziranih območij do čistilne naprave. Delovanje čistilne naprave (ČN) oz. njen učinek je odvisen tudi od delovanja kanalizacijskega omrežja. Dobro urejeno in delujoče kanalizacijsko omrežje, predvsem glede na ustrezno nizko stopnjo infiltracije čiste vode in nizkih frekvenc prelivanja odpadne vode preko razbremenilnikov, pomeni predpogoj za učinkovito delovanje čistilne naprave. Če sistem ni urejen prihaja ob deževju do nekontroliranega prelivanja odpadne vode v recipient in s tem do prevelikega razredčenja odpadne vode ter posledično do slabšega učinka ČN. Ker predstavlja ČN s pripadajočim kanalizacijskim omrežjem enovit sistem, je poznavanje delovanja omrežja enako pomembno kot poznavanje delovanja ČN.

Temeljno poznavanje delovanja kanalizacijskih omrežij temelji na rezultatih hidravličnih izračunov, pri katerih se kot

1. INTRODUCTION

The sewer network is a device for the draining of sewage and storm water from urbanised areas to the wastewater treatment plant. The efficiency of the treatment plant is also dependent on the proper operation of the sewer system. A sewer network with a low infiltration/inflow ratio and small yearly frequencies of overflow means that the preliminary condition for the efficient operation of the treatment plant or the high frequency of yearly overflows cause the organic dilution of the wastewater coming into the treatment plant, and the consecutively lower efficiency of the plant. The wastewater treatment plant with a sewer network is one type of system, so knowledge about the system is as important as knowledge about the treatment plant.

Basic knowledge about the operation of sewer systems is based upon the results of hydraulic calculations with rational formula or metoda izračuna uporablja racionalna formula ali njene izboljšave. Prav tako pomemben vir informacij so izkušnje vzdrževalnega osebja na terenu. Pri takem pristopu obravnavamo le količine ob mejnih situacijah, pomembnih za dimenzioniranje omrežja. Običajno nas zanimajo pretoki ob padavinah, merodajnih za dimenzioniranje in najmanjše hitrosti potrebne za samoizpiranje kanalizacijske mreže. Kanalizacijo v naseljih dimenzioniramo na enoletne padavine, večje povratne dobe padavin pa uporabljamo pri dimenzioniranju kanalizacije pomembnejših objektov, kot so npr. avtoceste ipd.

Pri klasičnem pristopu ostaja nepojasnjeno, kakšna je dinamična slika dogajanja v sistemu. Zajezitve ali občasno celo protitokovi, vplivi razbremenilnikov itd. nam sliko dogajanja lahko povsem spremenijo. Postavlja se nam tudi vprašanje, kolikšne so mejne padavine, pri katerih sistem še deluje (zmogljivost omrežja), kje so kritične točke na sistemu, kakšne so posledice dinamičnih efektov, kakšna je bilanca vtokov in iztokov iz omrežja v daljšem obdobju ipd.

Odgovore na našteta vprašanja nam lahko da uporaba hidrološkega in hidrodinamičnega (HD) modeliranja. Hidrološke modele uporabljamo za ugotavljanje deležev komponent odtoka, s hidrodinamičnimi modeli pa analiziramo dogajanje v samem omrežju.

2. VRSTE PODATKOV, POTREBNIH ZA IZDELAVO HD MODELA

Količina podatkov, potrebna za uspešno hidrodinamično modeliranje, je neprimerno večja kot pri klasičnem pristopu. Potrebujemo naslednje vrste podatkov: o kanalizacijskem omrežju, prispevnih območjih, priključenih na omrežje, o meritvah pretokov in padavin, o porabi vode.

2.1 KANALIZACIJSKO OMREŽJE

Zaradi omejitve pri računskih časih in racionalne porabe časa za vnos podatkov je treba najprej določiti obseg modela in natančnost pri vnosu podatkov.

V primeru relativno majhnih omrežij ali delov omrežij do skupne dolžine približno 30

their modifications. An additional important source of knowledge is the experience of maintenance personnel. This classical approach gives us information about hydrodynamic values for the situations important for the designing of the system. Typical values are discharges for so-called design rains (one year rain for urban areas; rain with a higher return period for important structures like highways etc.) and minimal self-cleansing velocities in the system for dry weather flow.

For the classical approach we don't know anything about the dynamic behaviour of the system. The phenomenon of backwater or reversal flows, the influence of overflows, etc. can change the operation of the system dramatically. Other questions not answered by the classical approach are: what is the limit capacity of the system; where are critical points of the system; what are the influences of dynamic effects; what is the long term balance of inflows and outflows, etc. We can get answers to those questions using hydrological and hydrodynamic (HD) modelling. We use hydrological models for determining the hydrological components of runoff. The behaviour of the sewer system we analyse using hydrodynamic models.

2. DATA NEEDED FOR THE HYDRODYNAMIC MODEL

The amount of data needed for successful hydrodynamic modelling is much greater than for the classical approach. We need data about the sewer system, catchment areas, water consumption, discharge and rain measurements.

2.1 SEWER SYSTEM

The first important step is to define the extent of the model and its accuracy, because we have limitations on computer time, and we have to be rational in the consumption of time for data input.

km vnesemo običajno v model kar celotno omrežje. Pri večjih omrežjih so potrebne poenostavitve modela. Če bi vnesli celotno mrežo z vsemi kanali, se računski časi zaradi prevelikega števila nebistvenih podatkov o drobnem sekundarnem in terciarnem omrežju preveč podaljšajo. V takem primeru modeliramo glavne zbiralnike z vsemi vitalnimi deli, kot so: razbremenilniki, črpališča in zadrževalni bazeni.

Podatke zajemamo iz katastrskih načrtov meril 1:500 ali 1:1000, iz vzdolžnih profilov, podrobnih načrtov ali elektronskih podatkovnih baz. Zajem podatkov iz digitalnega katastra pomeni velik prihranek pri porabi časa.

Pozornost je treba posvetiti predvsem tistim podatkom, ki imajo lahko večji vpliv na rezultate: mesta sprememb profilov in padcev, združitve zbiralnikov, črpališča, prelivi razbremenilnikov, zadrževalni bazeni, iztoki v zajezbi.

Potrebni podatki za posamezne elemente omrežja :

- jaški: oznaka, geometrijske koordinate, kota dna in pokrova, morebitne kaskade
- zbiralniki : gorvodni in dolvodni jašek za vsak odsek, prečni profil odseka in material s pripadajočo hrapavostjo
- črpališča: oznaka, geometrijske karakteristike, število črpalk, Q-H krivulje črpalk, kote vklopa in izklopa, sistem vklapljanja in izklapljanja, morebitni varnostni preliv
- razbremenilniki : oznaka, vrsta preliva (čelni, bočni), kota krone preliva, dolžina preliva
- zadrževalni bazeni : geometrijske karakteristike, varnostni preliv

Pomembna faza pri zajemu podatkov je tudi dodatna kontrola oz. preverjanje na terenu, če odkrijemo nejasnosti oz. nelogičnosti pri njihovem pregledu.

Pomembno je poudariti, da je treba kataster organizirati tako, da se poleg katastra kanalov vodi tudi kataster objektov. Navedeno pomeni lahko velik prihranek pri porabi časa v fazi priprave podatkov.

Some practical experience shows that in the case of small networks or only parts of larger networks to a total length of 30 km, we can make(design) a model of the complete network. For larger networks simplification is necessary. In general, in that case, we model only the main collectors with all the vital parts, such as pumping stations, overflows, storage basins, etc.

The sources of network data are cadaster maps to a scale of 1:500 or 1:1000, longitudinal profiles of collectors and detail maps or electronic databases. Big savings of time consumption for data input can be achieved if the data are organised in a digital form.

It is necessary to more precisely check data that more greatly influence the results: changes in profile diameter and channel slope; collector joints; pumping stations; weirs of overflows; storage basins; a submerged outflow.

Data needed for elements of network:

- manholes : denotation, geometric coordinates, bottom level, top level, level of cascade
- collectors : for each part of the collector (section) upstream and downstream manhole, diameter, type of material with roughness
- pumping stations : denotation, geometric characteristics, number of pumps, Q-H curves of pumps, levels of switching on and off, working cycle of pumps, eventual security overflow
- overflows : denotation, type of weir (front, side), weir level and length
- storage basins : geometric characteristics, security overflow

The important phase of data input is the additional field control of the data in the case of inconsistencies. It is also important to point out that cadaster maps have to be organised in two parts: as cadasters of collectors and cadasters of objects on collectors, as this can provide time savings during data input.

2.2 PRISPEVNE POVRŠINE

V pomoč pri določanju prispevnih površin so nam lahko podatki iz predhodnih hidravličnih izračunov omrežja ali posameznih delov.

Predvsem je pomembna presoja o velikosti površin, ki so dejansko priključene na omrežje in o realnih koeficientih odtoka. Koeficient odtoka ni konstanten, ampak je odvisen od mnogih dejavnikov (namočenosti in infiltracijske sposobnosti zemljine, intenzitete padavin, retenzije v mikrodepresijah, temperature, letnega časa, …) (Kompare, 1991).

Ta del priprave podatkov je zelo pomemben, saj je od tega neposredno odvisna natančnost modela. Če so koeficienti odtoka korektno ocenjeni, oz. je ustrezno vsaj njihovo razmerje, bodo umerjeni koeficienti na celotnem območju realni oz. vsaj blizu realnim v okviru zadovoljive natančnosti.

2.3 PRETOKI

Podatki o pretokih na omrežju se uporabljajo pri umerjanju hidrološkega in hidrodinamičnega modela. Za umerjanje hidrološkega modela, pri katerem ugotavljamo odziv omrežja v daljšem časovnem obdobju, so potrebni podatki o dnevnih pretokih na iztoku iz omrežja, običajno pred ČN, v obdobju vsaj zadnjih treh let.

Za umerjanje hidrodinamičnega modela potrebujemo podatke meritev pretokov na enem ali več merskih mestih v obdobju približno treh mesecev, oz. vsaj toliko, da imamo registriran odziv na 3 večje deževne dogodke. Izbira števila merskih mest je odvisna od velikosti omrežja in nivoja obdelave. Običajno na eno mersko mesto gravitira približno 10 prispevnih površin. Odčitki pretokov naj bodo vsaj na 5 minut.

2.4 PADAVINE

Za hidrološko analizo daljšega obdobja zadoščajo podatki o dnevnih padavinah najmanj za tri leta, medtem ko je za hidrodinamične analize delovanja sistema potrebna večja natančnost meritev. Padavine merimo z odčitavanjem na 5 minut v istem obdobju kot pretoke na omrežju. Primeren čas

2.2 CATCHMENTS

Data from previous hydraulic calculations of the network or its component parts can help us in the determining of catchment areas. It is important to correctly determine the borders of catchments and to assume runoff coefficients as precisely as possible. The runoff coefficient is not constant, but is dependent on many factors (soil moisture, infiltration capacity, rain intensity, surface retention, temperature, annual period, …) (Kompare, 1991).

The correctness of the catchment data is very important because it has great influence on the model accuracy. If runoff coefficients or at least their ratios are correctly assumed then the calibrated coefficients will be at least nearly equal to the actual ones and within the range of satisfactory precision.

2.3 FLOW DATA

We need flow data for the measuring campaign for the calibration of the hydrological and hydrodynamic model. For the calibration of the hydrological model, where we determine the response of the network for longer periods, it is necessary to have data about daily discharges at the inlet to the wastewater treatment plant within a period of at least three years.

For the calibration of the hydrodynamic model, it is necessary to have data about discharges from one or more locations in the system within a period of three months or as long as we have data from at least three stronger rain events. Selection of measuring locations depends on how large the system and level of study is. In general, ca. 10 catchments gravitate to 1 measuring site. Resolution of the data has to be at least 5 minutes.

2.4 RAIN DATA

For hydrological analyses of longer periods, it is enough to have daily rain data for at least three years, but for hydrodynamic analysis, data with a higher resolution is needed. We measure rain with a time resolution of 5 minutes in the same period as we measure discharges in the system. The proper time meritev je tri mesece oz. vsaj toliko, da ujamemo tri večje deževne dogodke, ki bodo lahko služili za kalibracijo in validacijo hidrodinamičnega modela.

Pri načrtovanju meritev padavin je treba posvetiti pozornost lokacijam instrumentov, da zagotovimo regularnost podatkov v primeru različne jakosti padavin na prispevnih območjih ali v primeru izpada instrumenta.

Poleg merjenih podatkov o padavinah uporabljamo pri izračunih tudi podatke o gospodarsko enakovrednih nalivih.

2.5 PORABA VODE

Podatki o porabi vode so namenjeni oceni odtoka odpadne vode. Zajeti je treba vse vodne vire uporabnikov kanalizacijskega omrežja. Poleg podatkov o porabi vode iz javnega vodovodnega omrežja je treba pridobiti tudi podatke o porabi vode iz internih zajetij in vodnjakov. Na podlagi ocene porabljene vode za prehrano in v industrijskih procesih lahko dobimo informacijo o količini odpadne vode. Točnost podatkov naj bo največja pri večjih porabnikih.

3. HIDROLOŠKO MODELIRANJE

Namenjeno je ugotavljanju vodne bilance in deležev komponent odtoka v daljšem obdobju, npr. 10 let.

Celotni odtok v mešano kanalizacijo z nekega prispevnega območja je vsota več komponent odtoka, in sicer:

- površinski odtok (HO)
- podpovršinski odtok oz. infiltracija (PO)
- odtok odpadne vode.

Površinski hitri odtok predstavlja del odtoka, ki se aktivira takoj ob nastopu padavin in traja samo do konca padavin. Pri tem je treba upoštevati tudi čas potovanja vode po površini od najbolj oddaljene točke prispevnega območja do vtoka v kanalizacijski sistem. Predstavlja neposredni odziv na padavine in je zato neodvisen od predhodnih hidroloških situacij. Poleg površinskega odtoka lahko štejemo sem še tisti del infiltracije, ki v enakem času odteče v sistem.

Počasni odtok oz. infiltracija predstavlja del odtoka, ki se odziva počasneje na padavine. Sestavljen je iz preostanka od padavin

measurement is three months or as long as we register three bigger rain events suitable for the calibration and validation of the hydrodynamic model.

When we plan the measuring campaign, it is necessary to pay attention to the locations of the rain gauges to ensure the regularity of data in the case of different rain intensity or a rain gauge breakdown.

Besides the measured rain data we also use data from intensity-duration-frequency (IDF) curves for calculations.

2.5 WATER CONSUMPTION

Water consumption data serves for the assumption of dry weather flow. It is necessary to include all the water resources of the sewer network users: the public water network and internal industrial wells. Data have to be more precise for large consumers. On the basis of the assumption of water consumed for industrial processes and food, we can get information about dry weather flow.

3. HYDROLOGICAL MODELLING

With hydrological modelling we determine water balance and parts of runoff components for longer time periods; for example, 10 years.

The total inflow to the combined sewer system from the catchments is the sum of three components:

- surface runoff or rapid runoff component (FRC)
- infiltration or slow runoff component (SRC)
- dry weather flow (DWF)

The rapid runoff component is the part of the surface runoff that activates immediately at the beginning of the rain and lasts until the cessation of the precipitation, including the travel time of the water from the most distant part of the catchment to the sever inlet. It represents a direct response on the precipitation and is independent from historical hydrologic situations.

Besides the surface runoff we also add to the rapid runoff component that part of the infiltration that loads the sewer system at the povzročene infiltracije in infiltracije odtoka odpadne vode. Komponenta je močno odvisna od predhodne hidrološke situacije. Pri tradicionalnem pristopu običajno deleže infiltracije predpostavimo v višini 100 odstotkov sušnega odtoka ali kot specifični odtok 0,15 l/s·ha.(Imhoff & Imhoff, 1993). Delež infiltracije je odvisen od mnogih dejavnikov, zato je s tako predpostavko težko opisati učinek.

Odtok odpadne vode vključuje deleže odpadnih vod iz gospodinjstev, obrti in industrije

Za določen deževni dogodek je hidrogram pretokov lahko različen, odvisno od hidroloških karakteristik predhodnih obdobij, kar nam ponazarja slika 1.

Če nas zanima samo komponenta površinskega odtoka, lahko uporabimo modele za površinski odtok, kot so npr. najbolj preprosta racionalna formula, metoda izohron (čas površina), metoda Soil Conservation Service, metode s hidrogramom enote in sintetičnim hidrogramom, retenzijska metoda, model IZH in druge (Kompare, 1991).

Če želimo dobiti tudi informacijo o prispevku počasne komponente odtoka, moramo uporabiti kompleksnejše hidrološke modele. Uporabimo jih lahko za simulacije enega deževnega dogodka ali daljšega obdobja, npr. 10 let.

Kot primer hidrološkega modela bom opisal princip hidrološkega modela MOUSE NAM, ki so ga razvili na Danskem hidravličnem inštitutu. Je primer determinističnega, konceptualnega modela ter obravnava prispevno območje kot celoto z enakimi parametri. Opisuje celotno kopensko fazo hidrološkega cikla s sistemom rezervoarjev in fizikalnimi ter polempiričnimi relacijami med njimi. Vključeni so snežni rezervoar, površinski rezervoar, rezervoar v koreninski coni in podzemni rezervoar (DHI, 1994).

Za umerjanje in validacijo hidrološkega modela potrebujemo podatke o merjenih dnevnih pretokih (običajno pred čistilno napravo) za čim daljše obdobje, najmanj pa vsaj 3 leta. Polovico podatkov uporabimo za umerjanje, drugo polovico pa za validacijo umerjenih koeficientov. Priporočljivo je, da delamo z daljšimi serijami meritev, kot npr. pri umerjanju hidrološkega modela kanalizacijskega sistema Ljubljane, kjer je bila uporabljena serija meritev gladin na merski

same time.

The slow runoff component or infiltration represents part of the runoff which reacts slowly on precipitation. It consists of infiltration caused by remainder precipitation and infiltration caused by dry weather flow. This component is strongly dependent on previous hydrological situations. For the traditional approach we assume the infiltration part as 100% dry weather flow or as specific infiltration 0.15 l/s·ha (Imhoff & Imhoff, 1993). Infiltration is dependent on many factors, so it is difficult to describe this phenomenon in easy way.

Dry weather flow consists of domestic wastewater and wastewater from trade and industry.

For a specific rain event, the discharge hydrograph depends on the hydrological characteristics of previous periods as shown in Figure 1.

If we are only interested in the surface runoff component, we can use some surface runoff models; for example, the most simple rational formula, the method of isochrons (time-area), the method of the Soil Conservation Service, methods with unit and synthetic hydrographs, the retention method, model IZH and others (Kompare, 1991).

If we would like to have information about a slow runoff component, it is necessary to use more complex hydrological models. We can simulate only one rain event or a very long period of time; for example, 10 years.

As an example of a hydrological model, let's look at the principle of the hydrological model MOUSE NAM developed by the Danish Hydraulic Institute. It is a deterministic, conceptual model. It supposes constant hydrological parameters on the whole catchments and describes the whole land phase of the hydrological cycle with its system of reservoirs and the empirical and semiempirical relations between them. Water travels through snow reservoirs, surface reservoirs, root zone reservoirs and groundwater reservoirs (DHI, 1994).

For calibration and the validation of the hydrological model, we need daily discharge data on the treatment plant for a long period; a minimum of three years. We use half of the data for calibration and the other half for the validation of the calibrated coefficients. It is recommended that we use sets of data postaji Fužine v obdobju 1979-1986 (DHI, 1996).

Hidrološki model nam daje kot rezultat totalni odtok z nekega prispevnega območja. Pri tem moramo upoštevati, da hidravličnega dogajanja z navedenim modelom ne zajamemo, čeprav tudi vpliva na masno bilanco (npr. voda odteka iz sistema tudi preko razbremenilnikov, opis kdaj delujejo in kdaj ne in koliko vode se preliva, pa dobimo le s pomočjo hidrodinamičnega modela). Posredno lahko tako s hidrološkim modelom ocenimo, kolikšen je volumen prelite vode preko razbremenilnikov v obravnavanem obdobju.

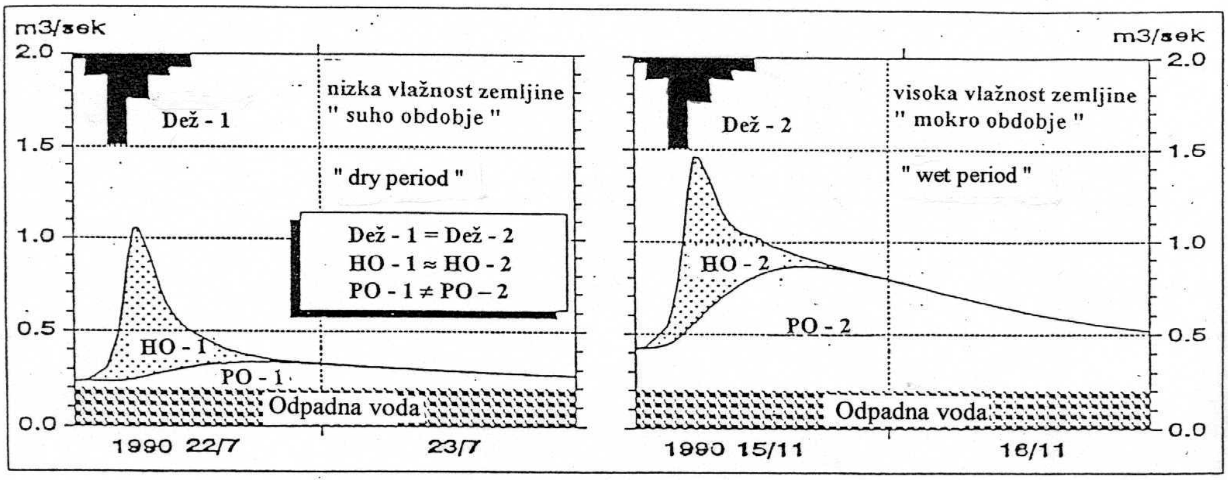
Rezultat hidrološkega modeliranja je ovrednotena vodna bilanca in vrednosti komponent odtoka. Pomemben rezultat hidrološke analize je predvsem delež infiltracije, saj preko njega ugotavljamo, kakšna je kakovost kanalizacijske mreže v smislu tesnosti. Parametri modela so umerjeni globalno za celotno prispevno območje, ki gravitira na mersko mesto. Običajno v naslednji fazi parametre za celotno območje distribuiramo na prispevna območja, ki jih uporabimo v hidrodinamičnih izračunih. Pri tem moramo seveda upoštevati hidrološke karakteristike posameznih podobmočij. Vsota reduciranih prispevnih površin vseh območij za komponenti hitrega in počasnega odtoka mora biti enaka reducirani prispevni površini za hitri in počasni odtok za celotno prispevno območje, dobljeni z modelom.
Koeficiente odtoka je mogoče preverjati z dodatnimi nekajmesečnimi meritvami na delih kanalizacijskega sistema.

spanning ten years; for example, for the calibration of the hydrological model of the Ljubljana sewer system, a series of level measurements at Fužine station during the period between 1979-1986 was used (DHI, 1996).

The hydrological model gives us the total outflow from the catchment. But, the hydraulic components, which are not included in it, also influence the mass balance of the sewer system through overflow. The overflow discharges can be directly calculated using a hydraulic model, while a hydrological model can only indirectly assume the overflow volume in a certain period.

The result of hydrological modelling is an adjusted water balance and volumes of the runoff components. An important part of the hydrological analyses is the infiltration part, because it gives us information about the quality of the sewer system. The parameters of the model are calibrated globally for the whole catchment that gravitates to the measuring station. Usually, in the next phase, we make a distribution of the global parameters to the catchments used in hydrodynamic calculations. Of course we have to take into account the hydrological characteristics of the subcatchments. The sum of the reduced catchment areas for rapid and slow runoff components calculated from the measurements have to be equal in the model.

We can check rapid runoff component coefficients with an additional two or three months measurements of the component of the sewer system.



Slika 1. Vpliv predhodne vlažnosti zemljine na hidrogram odtoka (DHI, 1994).
Figure 1. Influence of soil moisture on runoff hydrograph (DHI, 1994).

4. HIDRODINAMIČNO MODELIRANJE

Hidrodinamični izračun je namenjen analizi dinamičnega delovanja kanalizacijske mreže ob ekstremnih padavinah in v daljšem obdobju.

Umerjanje hidrodinamičnega modela izvajamo s pomočjo podatkov meritev pretokov in padavin na omrežju ali delih omrežja, ki naj trajajo vsaj toliko časa, da registriramo vsaj 3 večje padavinske dogodke in z resolucijo zapisov na 2 do 5 minut. S hidrodinamičnim modelom, zaradi večje resolucije podatkov meritev kot pri hidrološkem modelu in kratkega odzivnega časa, natančneje umerimo komponento hitrega odtoka. Če je potrebno, spreminjamo tudi hidravlične parametre (koeficienti hrapavosti, lokalne izgube).

V tej fazi je potrebno v primeru večjih odstopanj meritev od rezultatov včasih izvesti še dodatna preverjanja na terenu, predvsem glede geometrijskih karakteristik, nastajanja sedimentov, ovir ipd.

4.1 KRATKOROČNE ANALIZE

Kratkoročne analize obsegajo simulacije delovanja sistema ob enkratnih deževnih dogodkih. Zanima nas predvsem hidravlično dogajanje. Kot obremenitev sistema uporabljamo lahko realne nalive ali sintetične nalive iz krivulj gospodarsko enakovrednih nalivov s povratnimi dobami 1, 2, 5, 10 in več let. Rezultati analiz so nivogrami in hidrogrami v določenih točkah modela. Pri tem ugotavljamo, kakšni so dinamični učinki na sistemu (zajezbe, povratni tokovi na združitvah kanalov), kje je mreža preobremenjena, kje premalo obremenjena, kje so dosežene največje hitrosti, kako delujejo odseki z negativnimi padci, pri kakšnih nalivih začnejo delovati razbremenilniki itd. S simulacijami z nalivi različnih povratnih dob in ustreznega trajanja je mogoče ugotoviti, kolikšna je zmogljivost obstoječega kanalizacijskega sistema in kje so mesta na sistemu, ki jih je treba sanirati. Če imamo na voljo podatke o kritičnih kotah na sistemu (nizko ležeči priključki) lahko ugotavljamo poplavno varnost priključenih objektov.

4. HYDRODYNAMICAL MODELLING

Hydrodynamic simulations serve as analyses of the sewer network operation during periods of extreme precipitation and longer periods of time.

The calibration of the hydrodynamic model is achieved with high-resolution (2 to 5 minutes) discharge and precipitation data from the network or a part of it. Because of a higher measured data resolution than for the hydrological model and a short response time, it is possible to calibrate more precisely a rapid runoff component. We can also change hydraulic parameters (roughness coefficient, local losses, etc.) if it is necessary.

If there are greater differences between the measurements and the results of the model, it is necessary to do field checking (correct geometric characteristics, sediments, obstacles, etc.).

4.1 SHORT-TERM ANALYSES

Short-term analyses are simulations of the network operation at single rain events. We are interested mainly in hydrodynamic values: levels, discharges, velocities. As a load of the system we can use actual rain or synthetic rain from intensity-duration-frequency curves with return periods 1, 2, 5, 10 and more years. The results of the analyses are level and hydrographs in certain calculation points of the model. We analyse dynamic effects in the system (backwater, reversal flows at collector junctions), where the network is overloaded or under loaded, where there are sections with high velocities, an operation of a section with negative slopes at which rain the overflows begin to work, etc.). Simulations with rains of different return periods and proper duration can give us information about the capacity of the system and locations needed to be reconstructed. If we have data about critical levels in the system (low lying connections) it is possible to determine the flooding safety factor of connected objects.

4.2 DOLGOROČNE ANALIZE

Dolgoročne analize obsegajo simulacije delovanja sistema v daljšem obdobju. Običajno izberemo realne padavine v tipičnem povprečnem letu, lahko pa tudi večletno obdobje. Pri taki analizi nas zanimajo predvsem količine, ki dotekajo v sistem in iztekajo iz sistema preko razbremenilnikov in čistilne naprave. Glede na namen simulacij in zaradi krajših računskih časov lahko model kanalizacijske mreže poenostavimo toliko, da daje še vedno pravilne količinske rezultate v primerjavi z natančnejšim modelom, namenjenim za kratkoročne analize.

Na podlagi dolgoročnih analiz dobimo vrednosti letnih volumnov na čistilni napravi in posameznih razbremenilnikih, krivuljo trajanja dotokov na čistilno napravo, letne frekvence prelivanja za razbremenilnike itd.

4.3 ROBNI POGOJI

Analiziramo najprej obstoječi sistem in na podlagi rezultatov analiz delovanja obstoječega sistema izvedemo korekcije oz. izboljšave sistema, kot so povečanje premerov cevi, izgradnja oz. rekonstrukcija zadrževalnih bazenov, črpališč, razbremenilnikov ipd. Nato simulacije vnovič izvedemo in ugotavljamo izboljšanje. S pomočjo ekonomske analize stroškov in pridobitev sanacije je mogoče določiti optimum.

Omenjene vrste analiz je mogoče uporabiti tudi pri načrtovanju novih omrežij. Dimenzije cevi, izračunane na podlagi dinamičnega preračuna so lahko manjše od dimenzij, dobljenih s klasičnimi preračuni pri enakih robnih pogojih, predvsem v primeru večjih omrežij, kar pomeni prihranek pri naložbi.

Pomembna faza pri izvajanju analiz delovanja omrežja je izbira meril oz. robnih pogojev, ki jih mora izpolnjevati nek kanalizacijski sistem. Upoštevati je treba poplavno varnostna in okoljevarstvena merila.

Poplavno varnostna merila predpisujejo poleg nalivov, merodajnih za dimenzioniranje tudi tiste mejne nalive, pri katerih mora sistem še delovati brez motenj in imajo večje povratne dobe od nalivov, uporabljenih za dimenzioniranje. Kanalizacijski sistem je lahko v tem primeru pod tlakom, ne sme pa prihajati do preplavljanja cestišč in kleti. Omrežja v naseljih so običajno dimenzionirana na nalive z enoletno povratno dobo, hkrati pa

4.2 LONG-TERM ANALYSES

Long-term analyses are simulations of network operation during longer time periods. Usually we use real precipitation from a typical average year or several years. We are interested in the loading of the system and outflows from the system through the overflows and the treatment plant. Regarding the purpose of simulations and limitations in computer time, we can simplify the sewer system model so far that it still gives correct information about the volumes in the system.
A long-term analysis gives us yearly volumes for the treatment plant and at overflows, a duration curve for the treatment plant, yearly frequencies for overflows, etc.

4.3 BOUNDARY CONDITIONS

First we analyse the existing system and, on the basis of the results of the existing system operation, we make corrections or improvements to the system. This includes increased pipe diameters, building or reconstructing of storage basins, pumping stations, overflows, etc. With simulations on the reconstructed system we analyse the improvements. The final step in the way to the optimal solution is the cost benefit analysis of system reconstruction.

Such analyses can also be used for the designing of new systems. With dynamic calculations it is possible to reduce pipe diameters, first calculated with classical methods, at the same boundary conditions, especially for the larger systems.

An important phase of system analyses is the definition of criteria or boundary conditions that the sewer system has to fulfil; they consist of flood security and environmental criteria.

Flood security criteria also determines, besides the design rainfall, the maximal return period of rainfall for which the system still has to operate with no disturbances. The return period of this limit rainfall is higher than that of rain design. The sewer system can be under pressure, but without streets and basements flooding. Design rain for cities usually has a mora sistem delovati brez preplavitev tudi pri nalivih z višjimi povratnimi dobami, npr. 5 ali 10 let.

Okoljevarstvena merila predpisujejo dovoljeno obremenjevanje odvodnika preko razbremenilnikov in so kvantitativni in kvalitavni. Kvalitativni kriteriji predpisujejo dovoljene koncentracije snovi na iztokih iz razbremenilnikov v odvodnik, analogno kot predpisi o dovoljenih koncentracijah na iztoku iz čistilne naprave, kvantitativni pa, koliko odpadne vode se lahko prelije v odvodnik preko razbremenilnikov v opazovanem obdobju, npr. 1 letu. Primerno merilo za ureditev razbremenilnikov je lahko določena letna frekvenca prelivanja in skupni volumen prelite vode na razbremenilnikih v odstotkih od količine, ki priteče v sistem v 1 letu.

Naša zakonodaja trenutno še ne predpisuje vseh poplavno varnostnih in okoljevarstvenih meril, ki jih mora izpolnjevati nek kanalizacijski sistem. Niso določene povratne dobe nalivov, pri katerih mora nek sistem še delovati brez preplavitev, niti ni predpisano delovanje razbremenilnikov v pogledu obremenjevanja okolja.

V evropskem prostoru je verjetno trenutno dosegla najvišjo raven okoljevarstvene zaščite odvodnikov Švedska, kar je posledica dolgoletnega prizadevanja za zmanjšanje emisij. Okoljevarstvena merila niso enotna za celo državo, temveč se prilagajajo lokalnim pogojem, t.j. občutljivosti odvodnika. Sprejemljive frekvence prelivanja preko razbremenilnikov znašajo od 0,1 do 10-krat letno, dovoljen volumen vode prelite preko razbremenilnikov znaša povprečno okoli 0,5 odstotka letnega dotoka v omrežje. Z razvojem monitoringa in matematičnega modeliranja pa se vedno bolj upoštevajo kot merilo tudi mejne količine in koncentracije polutantov (DHI, 1996).

Pri izdelavi generalnega načrta razvoja kanalizacije Ljubljane je bila kot merilo glede na skandinavske izkušnje izbrana frekvenca prelivanja 10-krat letno in skupni volumen prelite vode na razbremenilnikih 1 odsotek od letnega dotoka v omrežje (Kranjc et al., 1996).

Hidrodinamični model lahko nadgradimo z modelom kakovosti, s katerim analiziramo kvalitativne procese v omrežju in obremenjevanje okolja, predvsem odvodnikov, preko iztoka ČN in razbremenilnikov.

Umerjen in optimiziran HD model nam lahko služi tudi kot temelj za avtomatizacijo delovanja sistema.

one year return period, while limit rainfall has a return period five or ten years.

Environmental criteria regulates the permitted loading of recipients through overflows. Quality criteria are based on the permissible concentrations of pollutants on the overflow outlet, on the analogy with permissible concentrations of pollutants at each treatment plant outlet. Quantity criteria determines the permissible overflow volume within a certain period; for example, 1 year. Suitable criteria for overflows can be expressed in limiting overflow frequency and the ratio between the total overflow volume and the loading volume in the system during one year.

Slovenian legislation at this moment does not regulate all flood security and environmental criteria for sewer network systems. It is necessary to determine limit rain return periods at which the sewers have to operate without flooding and the environmental criteria for overflows.

In Europe, Sweden has achieved probably the highest level of environmental protection of recipients, which is the result of long-term efforts for the reducing of emissions. Environmental criteria are not unique for the whole country, but they are adapted to local conditions, e.g. recipient sensitivity. Acceptable overflow frequencies are 0,1 to 10 times per year; average allowed overflow volume is 0,5 % of the yearly loading of the system. Recently, with progress in monitoring and modelling, the limiting of total mass and concentrations of pollutants can be used as criteria (DHI, 1996).

Environmental criteria used for the Ljubljana Sewer System Masterplan was, according to Scandinavian experience, a yearly overflow frequency of 10 times per year and a total overflow volume of 1% of the total yearly loading of the system (Kranjc et al., 1996).

On the basis of the hydrodynamic model we can construct a quality model for the analyses of quality processes in the system and loading the environment (recipient) throughout treatment plant and overflows.

A calibrated and optimised hydrodynamic model also serves as the basis of an automisation of the sewer network.

5. ZAKLJUČKI

- Hidrodinamično modeliranje je namenjeno analizi delovanja obstoječih kanalizacijskih omrežij, delov omrežij, pri načrtovanju omrežij novih sosesk.
- Za izdelavo modela potrebujemo podatke o omrežju z vsemi objekti, prispevnih površinah, pretokih, porabi vode in padavinah.
- Za umerjanje modela so pomembne kvalitetno izvedene meritve pretokov in padavin.
- Vodno bilanco in deleže komponent odtoka, od katerih je še posebej pomembna infiltracija, ugotavljamo s hidrološkimi modeli.
- S kratkoročnimi HD simulacijami ugotavljamo dinamično delovanje in poplavno varnost kanalizacijskih omrežij.
- Dolgoročne HD analize nam služijo za analizo delovanja sistema in kvantitativnega obremenjevanja okolja preko iztoka ČN in razbremenilnikov.
- Z ekonomsko analizo stroškov in koristi posameznih variant sanacije izvedemo optimizacijo sistema.
- HD model predstavlja temelj za izdelavo kvalitativnega modela.
- Optimiziran HD model kanalizacijskega omrežja je temelj za avtomatizacijo omrežja oz. t.i. realno kontrolo omrežja v času.

5. CONCLUSIONS

- Hydrodynamic modelling is useful for the analyses of the operation of existing sewer systems or parts of the system and for the planning of sewer systems in new urban areas
- For a successful model we need a network, catchment, discharge, precipitation and water consumption data
- Calibration of the model is strongly dependent on quality discharge and precipitation measurements
- Water balance and runoff components, especially infiltration, are analysed with hydrological models
- Short-term hydrodynamic simulations analyse dynamic operations and the flood security of sewer networks
- Long-term hydrodynamic simulations analyse the operation of the system during longer periods and the loading to the environment through overflows and treatment plant outlets
- Cost benefit analysis of network reconstruction solutions determines optimisation of the network
- Hydrodynamic model is the basis for quality modelling
- Optimised hydrodynamic model of sewer network can be integrated in real time control of the system

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MATEMATIČNO MODELIRANJE PRIRASTA KOSMOV V BIOKEMIJSKIH REAKTORJIH
MATHEMATICAL MODELLING OF THE GROWTH OF FLOCKS IN THE BIOCHEMICAL REACTOR

Jože PANJAN

V bazenu za poživljanje - biološkem reaktorju, v katerem v bistvu pospešeno poteka naravno samočiščenje, želimo pretvoriti raztopljene in neusedljive snovi v usedljivo obliko. To nam omogočajo mikroorganizmi, ki tvorijo razpršeno biološko maso v vodi biokemijskega reaktorja. Da pride do rasti mikroorganizmov, mora odpadna voda zadostiti najmanjšim pogojem za njihovo rast. Organizmi v poživljenem blatu prevzamejo organsko in delno mineralno snov iz odpadne vode in jo spreminjajo v nove organizme. Ti potem tvorijo kosme poživljenega blata v naknadnih (sekundarnih) usedalnikih. Procese prirasta kosmov lahko ocenjujemo eksperimentalno pa tudi z matematičnimi modeli. Pri matematičnem modeliranju uporabljamo enačbe difuzije glukoze (sladkorja) in kisika v kosem. Prikazali bomo matematične modele za kosme okrogle, cilindrične in diskaste oblike ter enačbo za strižne sile, ki določajo največjo velikosti kosmov v reaktorju ter enačbo za stabilnost kosmov.
Ključne besede: *matematični model, biološki reaktor, mikroorganizmi, kosmi, blato*

The purpose of the biochemical reactor, in which an accelerated natural self-purification is carried out, is to covert dissolved and insoluble substances into a settleable form. This process is enabled by microorganisms which constitute a part of the dispersed biomass in the water of the biochemical reactor. Wastewater should satisfy the minimum conditions for the growth of microorganisms. Organisms in the activated sludge take over organic and partially inorganic compounds and transform them into new organisms which form flocks of the activated sludge in the secondary treatment basin. Processes of the growth of flocks can be evaluated experimentally or by mathematical models. Diffusion equations for glucose and oxygen into flocks are applied. Mathematical models for spherical, cylindrical and disklike flocks, the equation for shearing forces which determine the maximal dimensions of flocks in the reactor and the stability equation will be demonstrated.
Key words: *mathematical model, biological reactor, microorganisms, flocks, sludge*

1. UVOD

Pri čiščenju odpadnih voda tako v naravi kot v biološkem reaktorju komunalnih čistilnih naprav sodelujejo mikroorganizmi. V biološkem reaktorju lahko spremljamo procese na makro ali mikro ravni. Nas v tem primeru zanimajo predvsem dogajanja na mikro ravni, to je na mikroorganizmih. Eni najpomembnejših temeljnih nosilcev biološkega čiščenja med mikroorganizmi so bakterije. Bakterije so zelo majhna bitja, ki merijo le nekaj tisočink milimetra oz. par deset

1. INTRODUCTION

Microorganisms participate in wastewater treatment in a natural state and also in the biochemical reactor of the sewage plant. Processes in the biochemical reactor can be studied on both the macro and micro levels. In this case we are especially interested in processes on the micro level, those taking place with microorganisms. Bacteria are one of the most important participants of the biochemical treatment among microorganisms. Bacteria are very small beings, measuring only a few thousandths of a millimetre, mikronov. Poznamo krogličaste, paličaste – valjaste (ravne ali krive), diskaste in spiralne. Poleg teh so še bakterije posebnih oblik, od katerih nekatere prehajajo, meje ne moremo natančno določiti, h glivam. Živijo posamezno ali v kolonijah. Pri bakterijah je težko ali nemogoče diferencirati genetski material od ostale vsebine celice in nimajo pravega jedra. So skoraj vedno brez klorofila (zelenih barvil). Bakterije se razmnožujejo z delitvijo celic. Poleg bakterij so pomembne tudi protozoe ali praživali. Protozoi so živalski enoceličarji, ki imajo v nasprotju z bakterijami, že pravo jedro, eno ali celo več. Glede na njihovo zgradbo poznamo razmeroma preproste oblike, npr. amebe ali pa tudi zelo diferencirane, predvsem kar zadeva oblikovanje jedra in načine za izločanje vode, premikanje, občutenje dražljajev, kot npr. parameciji. Protozoi so z vidika velikosti bistveno večji od bakterij, vendar so še vedno mikroskopsko majhni, saj večina akvatičnih oblik meri manj kot 1/10 mm.

V tem članku bomo prikazali prirast biomase mikroorganizmov (celic) različnih oblik na mikro ravni. Sama delitev - hitrost prirasta je različna. Večina tistih bakterij, ki živijo od organske snovi, se deli v času manj kot ene ure.Večina bakterij sicer živi od mrtve organske substance, ki jo razkraja v navzočnosti kisika, v okviru izmenjave energije in snovi. Razpolovna doba protozoev je pri optimalnih pogojih, pri manjših oblikah nekaj ur, pri večjih pa več dni.

2. PRIRAST BIOMASE IN MOŽNOST KOSMIČENJA V BIOLOŠKEM REAKTORJU

V bazenu za poživljanje - biološkem reaktorju, v katerem v bistvu pospešeno poteka naravno samočiščenje, želimo pretvoriti raztopljene in neusedljive snovi v usedljivo obliko. To nam omogočajo mikroorganizmi, ki tvorijo razpršeno biološko maso. Da pride do rasti mikroorganizmov, mora odpadna voda zadostiti minimalnim pogojem za njihovo rast.

respectively, few microns, which appear in spherical, sticklike – cylindrical (straight and curved), disklike and spiral forms. Besides these, some bacteria appear in special forms – some of them represent the transition to fungi without any clearly established boundary. They live solitary or in colonies. It is difficult or even impossible to distinguish genetic matter from the rest of the bacterial cells, as they have no discernible nucleus. They are nearly always without chlorophyll. Multiplication by cell division is common with them. Protozoa, in addition to bacteria, are also important. Protozoa are unicellular animals, which have one or more discernible nuclei in contradiction to bacteria. Relatively simple forms are known with respect to their structure, as , for instance, amoeba, or also very differentiated ones – especially with respect to the formation of their nucleus and methods for the excretion of water, movement and the perception of stimuli, as, for instance, paramecia. Although protozoa are much larger than bacteria, they are still of a microscopic size, as most of the aquatic forms measure less than 1/10 of a millimetre.

The biomass increase of microorganisms (cells) of different forms at the micro level will be presented in this article. The very cell division - the rate of growth is different. Most bacteria living on organic compounds multiply in less than an hour. They live on dead organic matter, which is degraded by them in the presence of oxygen in the cycle of the exchange of energy and matter. The half-life period of protozoa is a few hours for smaller forms and a few days for larger ones under optimal conditions.

2. THE GROWTH OF THE BIOMASS AND THE POSSIBILITY OF FLOCCULATION IN THE BIOCHEMICAL REACTOR

The biochemical reactor is intended to convert dissolved and insoluble substances into settleable ones by means of an accelerated natural self-purification. This is enabled by the microorganisms which form a dispersed biomass. Wastewater should satisfy some minimal conditions to achieve the growth of microorganisms. These are especially:

To pa so predvsem:
- zahteva po lastnosti hranilne raztopine (substrata)
- ustrezna temperatura
- zagotovljena količina zraka ali kisika
- stalno gibanje, da ne pride do usedanja in da imajo mikroorganizmi čim boljši stik s hrano in kisikom
- vrednost pH oz. nevtralnost je lahko v mejah od 5 do 9.

Prvemu in drugemu pogoju zadostuje večina komunalnih odpadnih voda. Tretjega in četrtega zagotovimo s turbinskimi mešali, z vpihovanjem zraka, s kisikovo atmosfero ali mešanjem s curkom, vrednost pH pa moramo zagotoviti že pri predčiščenju industrijskih odpadnih voda. Zagotovljeni pogoji v okolju omogočajo razvoj različnih združb mikroorganizmov (biocenoze), ki se glede na spremembe pogojev tudi sami spreminjajo - iz nižjih v višje razvite oblike in obratno, ali npr. en tip združbe prevlada nad drugimi. Organizmi v poživljenem blatu prevzamejo organsko in delno mineralno snov iz odpadne vode in jo spreminjajo v nove organizme (I. faza čiščenja), ki tvorijo kosme poživljenega blata v naknadnih (sekundarnih) usedalnikih.

Osnovni kosmi - flokule imajo velikost 10^{-3} do 1 µm, super koloidi od 1 do 50 µm in neraztopljene in težko usedljive (lebdeče) snovi velikost od 50 do 100 µm (Lau et al., 1984; Panjan, 1996). Mikroorganizmi in koloidi so usedljivi - izločljivi šele, ko tvorijo velike kosme. Usedanje se prične šele v naknadnih usedalnikih v mirujočem vodnem okolju po skosmičenju primarnih kosmov, ko imajo ti premer, večji od 50 do 100 µm. Premeri skosmičenih kosmov so sicer po naših meritvah in literaturi od 20 do 3500 µm, pri tem je srednja vrednost oz. mediana 30 do 200 µm.

Biološko kosmičenje postane mogoče šele, ko intenzivnost rasti bakterij in drugih mikroorganizmov prične upadati in ko se začnejo izločati naravni polimeri - koloidi, ki premostijo razdalje med mikroorganizmi (II. faza). Zaradi velike turbulentnosti v biološkem

- demand on the properties of a nutritional solution (substrate)
- suitable temperature
- supply of the necessary amount of air or oxygen
- continuous movement to avoid sedimentation and to ensure microorganisms the best possible contact with nutriments and oxygen
- pH value should be in the range between 5 and 9.

The first and second conditions are satisfied by most sewage wastewater. The third and forth conditions are assured by the use of a turbine mixer, aeration, with an oxygen atmosphere or by mixing with a jet. The pH value must be arranged prior to the purification of the industrial wastewater. The assured conditions in the medium enable the development of different communities of microorganisms (biocenoses) which change themselves as conditions change from lower to higher developed forms and vice versa, or, for instance - the domination of one living form over another. Organisms in the activated sludge take over the organic and partially inorganic compounds from the wastewater and transform them into new organisms (1st phase of treatment), forming flocks of activated sludge in the secondary basin.

Basic flocks have a size of 10^{-3} to 1 µm, super colloids 1 - 50 µm and insoluble and hardly settleable (floating) matter, a size of 50 - 100 µm (Lau et al., 1984; Panjan, 1996). Microorganisms and colloids are settleable - eliminable - only when they form larger flocks. Sedimentation begins only after the flocculation of the primary flocks in a stagnant water medium of the secondary settling tank, when they reach a diameter greater than 50 - 100 µm. The diameter of the flocculated flocks is from 20 to 3500 µm with an average, respectively, median value of 30 - 200 µm, according to our measurement and literature data.

Biological flocculation becomes possible when the intensity of the growth of bacteria and other microorganisms begins to decline and when natural polymers - colloids start to be excreted and bridge the distances between the microorganisms (2nd phase). Flocculation of the primary particles doesn't occur due to reaktorju torej ne prihaja do kosmičenja primarnih delcev, ampak se bistveno poveča njihovo število oz. volumska koncentracija delcev z rastjo mikroorganizmov, njihove žive in odmrle substance (približno 50 do 100-krat glede na dotok na komunalno čistilno napravo) (Degremont, 1991; Droste, 1997).

3. MATEMATIČNO MODELIRANJE PRIRASTA FLOKUL - KOSMOV

Kinetiko izmenjave snovi v kosmu (flokuli) lahko opišemo z difuzijskim, sorbcijskim in encimskim procesom. V prvem delu procesa gre za mehansko difuzijo v pomičnem mediju, ki poteka še znotraj celice, v drugem delu prihaja do adsorpcije zaradi površinskih sil ter absorpcije zaradi kemičnih zvez, v tretjem delu pa proti notranjosti celice-delčka potekajo encimske reakcije in difuzijski procesi (v smeri manjše koncentracije).

Zaradi zapletenosti vseh biokemijsko - fizikalnih dogajanj si poglejmo le model povečevanja poživljenega blata oz. nastajanja kosmičev bakterij - prirasta biomase po literaturi (Lau, 1884) v stacionarnem stanju za okrogle, cilindrične (valjaste) in diskaste oblike kosmov.

Za mineralizacijo organske snovi ali pa za rast novih celic je treba prevzeti organsko snov v notranjost celice, kjer potekajo najpomembnejši biokemijski procesi. Pri heterotrofnih (živalskih) organizmih biokemijske reakcije potekajo tako, kot prikazuje shema na sliki 1, ki prikazuje zgradbo kosmov in potek razkroja beljakovin v končne produkte (vodo, ogljikov dioksid, nitrate itd.). Najprej si izračunajmo masno bilanco (Panjan, 1994; 1997; Tyagi, 1996).

the high turbulence in the biochemical reactor. Instead, the number or volume concentration of the particles is essentially increased with the growth of microorganisms - their live and dead matter (approximately 50 to 100 times with respect to their affluence into the municipal sewage plant) (Degremont, 1991; Droste, 1997).

3. MATHEMATICAL MODELLING OF THE GROWTH OF FLOCULAE - FLOCKS

The kinetics of the exchange of matter in a flock can be described with diffusion, sorption and enzymatic processes. Mechanical diffusion in the moving medium and inside each cell takes place in the first part of the process. Adsorption due to the surface forces and adsorption due to the chemical bonding takes place in the second part of the process. The enzyme reactions and diffusion processes (in the direction of lower concentration) take place in the third part of the process.

Due to the high complexity of all these biochemical - physical processes, only the model of the growth of the activated sludge, respectively, the formation of the bacterial flocks - increase of biomass after literature (Lau, 1884) and in the stationary state for the spherical, cylindrical and disklike flock forms is considered.

It is necessary to introduce organic compounds into the interior of the cell, where the most important biochemical processes take place, to accomplish the mineralization of organic compounds. Biochemical reactions take place in heterotrophic (animal) organisms as is shown with the schematic in Figure 1, which represents the structure of flocks and the course of protein degradation into final products (water, carbon dioxide, nitrate etc). Let's first calculate the balance of the mass (Panjan, 1994; 1997; Tyagi, 1996).

3.1 MASNA BILANCA

3.1.1 Okrogli kosmi

Za ta primer lahko zapišemo:

$$4 \cdot \pi \cdot r^2 \cdot N_{r+dr} - 4 \cdot \pi \cdot r^2 \cdot N_r = 4 \cdot \pi \cdot r^2 \cdot R \cdot dr \quad (1)$$

Pri tem je:

$$R = \mu \cdot \frac{M}{Y} \quad (2)$$

$$\mu = \mu_{\max} \cdot \left[\frac{S_1}{(S_1 + K_1)} \right] \cdot \left[\frac{S_2}{(S_2 + K_2)} \right] \quad (3)$$

kjer pomenijo:

- d_p premer delca [m]
- r odmik od centra delca [m]
- r_f polmer delca [m]
- No masni pretok hranil skozi površino [mg/(s.cm^2)]
- R prirast biomase po Monodu [mg/(s.cm^2)]
- μ specifična hitrost rasti biomase [dan^{-1}]
- μ_{max} maksimalna specifična rast biomase [dan^{-1}]
- M gostota suhega dela žive mase snovi (sušina) oz. kosmov [mg/l]
- Y razmerje med težo tvorjene biološke mase in porabo hraniv (koeficient proizvodnje oz. prirasta) [mg/mg]
- K Monodov koeficient: $\mu = \mu_{max}/2$
- S koncentracija hraniv (substrata) - indeks 1 ali S_b in koncentracija kisika O_2 - indeks 2 v [mg/l]

3.1 THE BALANCE OF THE MASS

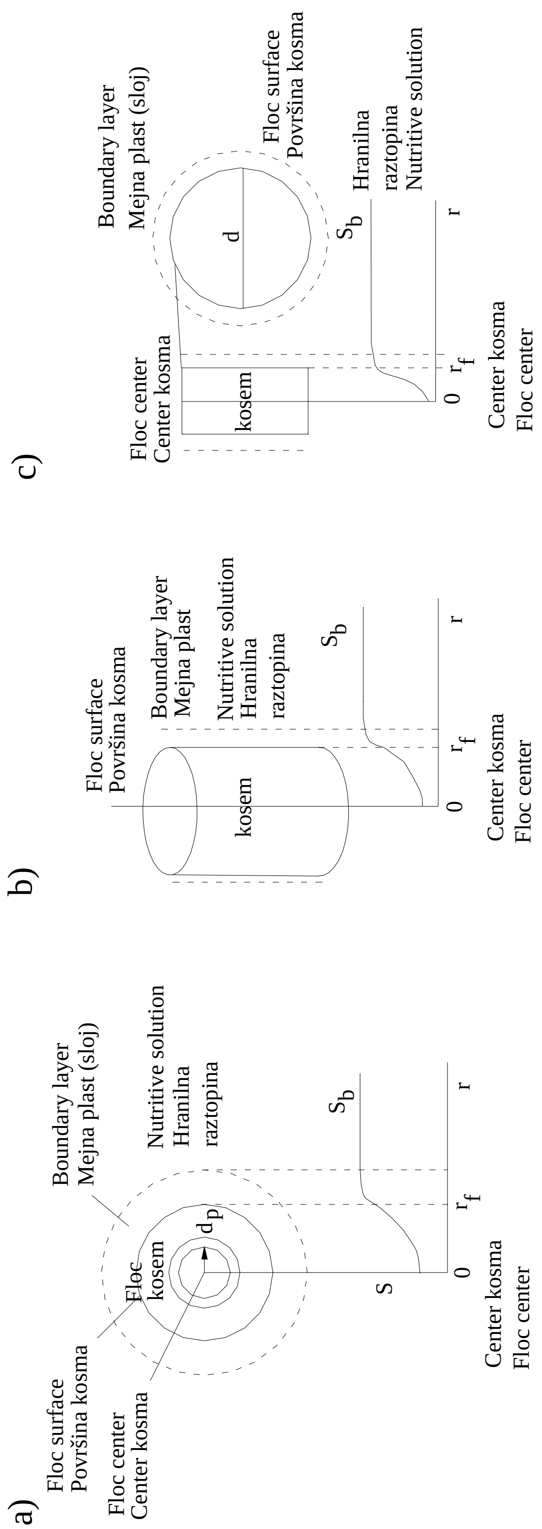
3.1.1 Spherical flocks

We can write for this case:

in which it is

where it means:

- d_p diameter of the particle [m]
- r distance from the centre of the particle [m]
- r_f radius of the particle [m]
- N_o mass flow of nutriment through the surface [mg/(s·cm^2)]
- R increment of biomass after Monod [mg/(s·cm^3)]
- μ specific rate of growth of biomass [day^{-1}]
- μ_{max} maximal specific rate of growth of biomass [day^{-1}]
- M density of the dry part of the live mass of matter [mg/l]
- Y ratio between produced biomass and consumption of nutriment (production coefficient respectively increment) [mg/mg]
- K Monod coefficient: $\mu = \mu_{max}/2$
- S concentration of nutriment (substrate) - index 1 or S_b and oxygen concentration O_2 - index 2 in [mg/l]



Slika 1. Profil koncentracije hranil (substrata) v aktivnem kosmu blata: a) kroglaste oblike, b) valjaste (cilindrične) oblike in c) diskaste oblike kosmov (Lau et al., 1984).
Figure 1. Concentration profile of nutriment (substrate) in the active sludge flock: spherical shape, b) cylindrical shape, c) disklike shape of the flock (Lau et al., 1984).

Če enačbo delimo s $4 \cdot \pi \cdot \mathrm{dr}$, dobimo:

Dividing the equation (1) with $4 \cdot \pi \cdot \mathrm{dr}$ we obtain

$$\frac{(r^2 \cdot N_{r+dr} - r^2 \cdot N_r)}{dr} = r^2 \cdot R \tag{4}$$

ko gre dr→0, velja:

when dr→0 it is

$$\frac{d \cdot (r^2 \cdot N_\phi)}{dr} = r^2 \cdot R \tag{5}$$

Upoštevati moramo tudi Fickov zakon za difuzijski pretok v notranjost poroznega kosma:

Fick's law for diffusion flow into the interior of a porous flock must be taken into account:

$$N_\phi = De \cdot \frac{dS}{dr} \tag{6}$$

$$De = \frac{N_\phi \cdot r}{(S_{02} - S_2)} \tag{7}$$

kjer so:

- N_Φ difuzijski pretok v notranjost kosma
- De efektivna difuzija hraniv v kosem [m²/s]
- S_{02} nasičena koncentracija kisika v vodi [mg/l]
- S_2 povprečna koncentracija kisika v raztopini [mg/l]

where it is:

- N_Φ diffusion flow into the interior of the flock
- De effective diffusion of nutriment in the flock [m²/s]
- S_{02} saturated concentration of oxygen in water [mg/l]
- S_2 average concentration of oxygen in solution [mg/l]

Če upoštevamo enačbo (6), dobimo:

When equation (6) is taken into account we obtain:

$$De \cdot \left(\frac{d^2 \cdot S}{dr^2} + \frac{2 \cdot dS}{r \cdot dr} \right) = R \tag{8}$$

Z uvedbo nove spremenljivke *R* pa dobimo dve diferencialni enačbi:

With introduction of the new variable *R* we get two differential equations:

za hraniva (sladkor - glukozo):

for nutriment (sugar - glucose):

$$\left(\frac{d^2 \cdot S_1}{dr^2} + \frac{2 \cdot dS_1}{(r \cdot dr)} \right) = \mu_{\max} \cdot \frac{M}{D_1 \cdot Y_1} \cdot \left(\frac{S_1}{S_1 + K_1} \right) \cdot \left(\frac{S_2}{S_2 + K_2} \right) \tag{9}$$

za kisik:

for oxygen:

$$\left(\frac{d^2 \cdot S_2}{dr^2} + \frac{2 \cdot dS_2}{(r \cdot dr)}\right) = \mu_{\max} \cdot \frac{M}{D_2 \cdot Y_2} \cdot \left(\frac{S_1}{S_1 + K_1}\right) \cdot \left(\frac{S_2}{S_2 + K_2}\right) \tag{10}$$

Upoštevati moramo naslednja robna pogoja:

1. Na površini kosma ($r=r_f$) je koncentracija hraniv enaka prostorninski koncentraciji hraniv v reaktorju:

The following boundary conditions must be considered:

1. Concentration of nutriment on the surface of the flock ($r = r_f$) is equal to the concentration of nutriment in the reactor:

$$S_{1_{r=rf}} = S_{b1}, S_{2_{r=rf}} = S_{b2} \tag{11}$$

2. Izberemo, da je v notranjosti kosma pri ($r = 0$) poraba hraniv in kisika enaka nič:

2. We assume that consumption of nutriments and oxygen in the interior ($r = 0$) of the flock is equal to zero:

$$\frac{dS_1}{dr_{r=0}} = 0, \ \frac{dS_2}{dr_{r=0}} = 0 \tag{12}$$

Da se izognemo nekaterim potrebnim podatkom o kosmih (premer, koncentracija aktivne biomase v kosmu, difuziji hrane v kosem), v zgornje enačbe uvedemo brezdimenzijske parametre:

Dimensionless parameters are introduced in the upper equations to avoid some necessary data about flocks (diameter, concentration of active biomass in the flock, diffusion of nutriment into the flock):

$$y_1 = \frac{S_1}{S_{b1}}, \ y_2 = \frac{S_2}{S_{b2}} \tag{13}$$

$$\phi_1 = \frac{K_1}{S_{b1}}, \ \phi_2 = \frac{K_2}{S_{b2}} \tag{14}$$

$$\Omega_1 = \frac{\mu_{\max} \cdot r_f^{\ 2} \cdot M}{(D_1 \cdot S_{b1} \cdot Y_1)}, \ \Omega_2 = \frac{\mu_{\max} \cdot r_f^{\ 2} \cdot M}{(D_2 \cdot S_{b2} \cdot Y_2)} \tag{15}$$

$$z = \frac{r}{r_f} \tag{16}$$

Tako dobimo naslednje izraze:

za hraniva (glukozo):

So the following expressions are obtained:

for nutriment (glucose):

$$\left(\frac{d^2 \cdot y_1}{dz^2} + \frac{2 \cdot dy_1}{z \cdot dz}\right) = \Omega_1 \left(\frac{y_1}{y_1 + \phi_1}\right) \cdot \left(\frac{y_2}{y_2 + \phi_2}\right) \tag{17}$$

za kisik:

for oxygen:

$$\left(\frac{d^2 \cdot y_2}{dz^2} + \frac{2 \cdot dy_2}{z \cdot dz}\right) = \Omega_2 \left(\frac{y_1}{y_1 + \phi_1}\right) \cdot \left(\frac{y_2}{y_2 + \phi_2}\right) \tag{18}$$

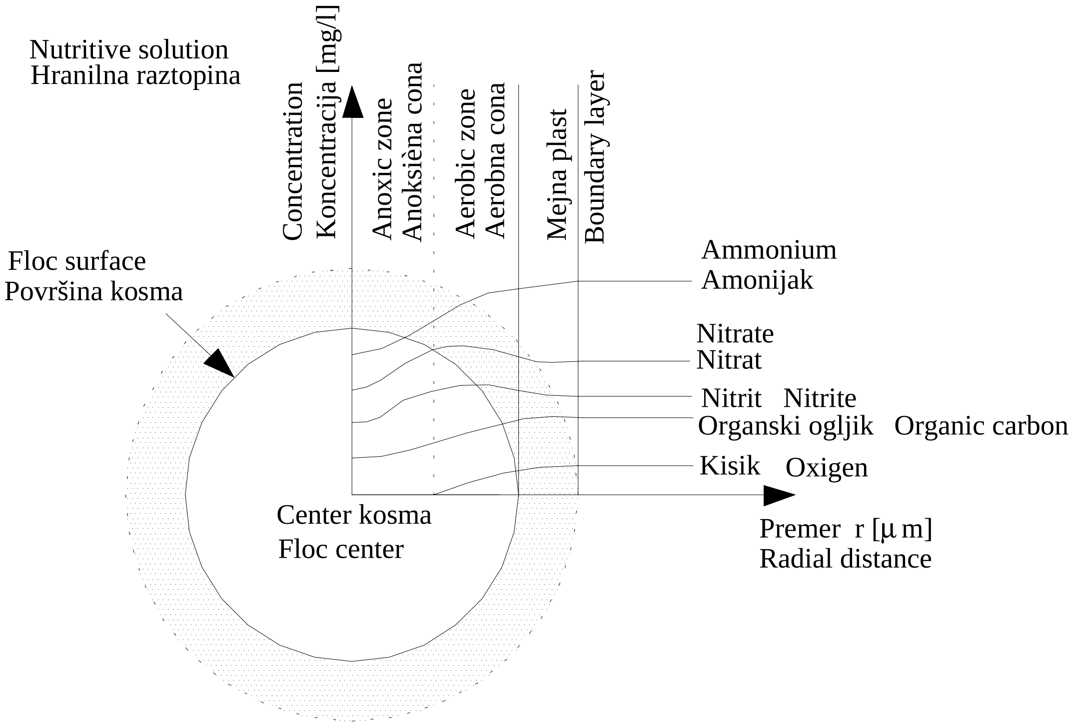
Brezdimenzijski robni pogoji pa se zdaj zapišejo v naslednji obliki:

Dimensionless boundary conditions are written now in the following form:

$$y_{1\,z=1} = 1,\; y_{2\,z=1} = 1,\; \left.\frac{dy_1}{dz}\right|_{z=0} = 0,\; \left.\frac{dy_2}{dz}\right|_{z=0} = 0 \tag{19}$$

To sta nelinearni diferencialni enačbi drugega reda, ki nimata analitične rešitve. Rešujemo ju z ortogonalno numerično metodo, skozi več (sedem) točk. Za reševanje moramo poznati enajst koeficientov.

These are non-linear differential equations of the second order, which have no analytical solution. They are solved by the orthogonal numeric method through more (seven) points. Eleven coefficients must be known for the solution.



Slika 2. Shema simultanih dogajanj nitrifikacije in denitrifikacije v okroglem kosmu (Bakti & Dick, 1992).
Figure 2. Schematic of the simultaneous process of nitrification and denitrification in the spherical flock (Bakti & Dick, 1992).

3.1.2 Valjasta oblika kosmov

Za cilindrično obliko kosmov, višine h in premera r_f, če je $h>>r_f$, je prirast masne bilance enak:

za hraniva (glukozo):

3.1.2 Cylindrical shape of flocks

The increment of the mass balance for the cylindrical shape of flocks with height h and diameter r_f, if $h>>r_f$, is equal:

for nutriment (glucose):

$$\left(\frac{d^2 \cdot y_1}{dz^2}\right) + \left(\frac{dy_1}{z \cdot dz}\right) = \Omega_1 \cdot \left(\frac{y_1}{y_1 + \phi_1}\right) \cdot \left(\frac{y_2}{y_2 + \phi_2}\right) \tag{20}$$

za kisik:

for oxygen

$$\left(\frac{d^2 \cdot y_2}{dz^2}\right)+\left(\frac{dy_2}{z \cdot dz}\right)=\Omega_2 \cdot \left(\frac{y_1}{y_1+\phi_1}\right)\cdot\left(\frac{y_2}{y_2+\phi_2}\right) \tag{21}$$

3.1.3 Diskasta oblika kosmov

Za diskasto obliko kosmov premera *d* in debeline $2r_f$, če je premer $d>>r_f$ velja:

za hraniva (glukozo):

3.1.3. Disklike shape of flocks

For disklike shape of flocks with a diameter d and thickness $2r_f$, if $d>>r_f$, it is

for nutriment (glucose):

$$\frac{d^2 \cdot y_1}{dz^2}=\Omega_1 \cdot \left(\frac{y_1}{y_1+\phi_1}\right)\cdot\left(\frac{y_2}{y_2+\phi_2}\right) \tag{22}$$

za kisik:

for oxygen:

$$\frac{d^2 \cdot y_2}{dz^2}=\Omega_2 \cdot \left(\frac{y_1}{y_1+\phi_1}\right)\cdot\left(\frac{y_2}{y_2+\phi_2}\right) \tag{23}$$

4. MAKSIMALNA VELIKOST PRIMARNIH KOSMOV IN NJIHOVA STABILNOST

Za ugotovitev stabilnosti maksimalne velikosti delcev - kosmov moramo poznati sile, ki delujejo na kosme. Po literaturi (Matsun & Unno, 1981) imamo naslednje sile, ki delujejo na kosem:

4. MAXIMAL DIMENSIONS OF PRIMARY FLOCKS AND THEIR STABILITY

Forces acting on flocks must be known to establish the stability of the maximal particles – flocks size. The following particles are taken into account after literature (Matsun & Unno, 1981):

$$\rho_s \cdot V \cdot \frac{dv_s}{dt}=k_f \cdot \rho \cdot S \cdot v^2+\rho \cdot V \cdot \frac{du}{dt}+\frac{1}{2}\cdot \rho \cdot V \cdot \left(\frac{du}{dt}-\frac{dv_s}{dt}\right)+Fe \tag{24}$$

Tu pomenijo:

- *Fe* zunanja sila (težnost) [N]
- k_f koeficient turbulentnosti [-]
- ρ_s gostota delca [kg/m^3]
- ρ gostota vode [kg/m^3]
- *V* volumen kosma - delca [m^3]
- *S* prerez kosma [m^2]
- v_s hitrost kosma - delca [m/s]
- *u* hitrost tekočine v neposredni bližini kosma [m/s]
- *v* relativna hitrost med tekočino in delcem [m/s]

Here it means:

- *Fe* exterior force (gravity) [N]
- k_f coefficient of turbulence [-]
- ρ_s density of the particle [kg/m^3]
- ρ density of water [kg/m^3]
- V volume of the flock [m^3]
- *S* intersection of the flock [m^2]
- v_s velocity of the flock [m/s]
- *u* velocity of the liquid in the immediate vicinity of the flock [m/s]
- *v* relative velocity between the liquid and the particle [m/s]

Rešitev zgornje enačbe za relativno hitrost je podana v (Matsun & Unno, 1981; Panjan, 1997) v obliki:

Solution of the upper equation is given in (Matsun & Unno, 1981; Panjan, 1997) in the following form:

$$v = \left((\rho_s - \rho) \cdot V\right)^{1/2} \cdot \frac{u}{\left((\rho_s + \frac{\rho}{2}) \cdot V + k_f \cdot \rho \cdot S \cdot \lambda\right)^{1/2}} \qquad (25)$$

Strižne napetosti, ki delujejo na delce pa so enake:

Shearing tensions acting on particles are equal to:

$$\tau = \frac{1}{2} \cdot \lambda_D \cdot \rho \cdot v^2 \qquad (26)$$

Tu so parametri enačbe podani za $\lambda = \lambda_D$ pri maksimalnem premeru kosma (Re - Reynoldsovo število, v_s - hitrost usedanja):

Here the parameters of the equation are given as follows (Re - Reynold's number, v_s - sedimentation velocity):

$$\lambda_D = \frac{K}{(\mathrm{Re})^n}; \qquad (27)$$

$$\mathrm{Re} > 10^3 : K = 0,\ n = 0; \qquad (27a)$$

$$10^3 < \mathrm{Re} < 1 : K = 12,\ n = 1/2; \qquad (27b)$$

$$\mathrm{Re} < 1 : K = 24,\ n = 1 \qquad (27c)$$

$$\mathrm{Re} = \frac{d \cdot v_s}{\nu} \qquad (28)$$

$$v_s = \frac{g}{18} \cdot \frac{d^2}{\nu} \cdot \left(\frac{\rho_s}{\rho} - 1\right) \qquad (29)$$

Maksimalni premer delca - kosma pa je določen z enačbo:

Maximal diameter of the particle - flock is determined by the following equation:

$$d_s = \frac{C}{G^n} \qquad (30)$$

kjer pomenijo:

- *C* konstanto, ki je odvisna od številnih parametrov kosmov in hranilne raztopine [-]
- *G* hitrost mešanja oz. turbulentnosti, izražena z gradientom [s^{-1}]
- ν kinematični koeficient viskoznosti [m^2/s]

where it means:

- *C* constant, which depends on numerous parameters of the flock and the nutritive solution [-]
- *G* velocity of mixing or turbulence expressed with gradient [s^{-1}]
- ν kinematic coefficient of viscosity [m^2/s]

Preglednica 1. Premeri kosmov poživljenega blata, njihov delež in hitrost usedanja - laboratorijske analize (Degremont, 1991; Sedlak, 1991; Panjan, 1994).
Table 1. Diameters of the flocks of activated sludge, their fraction and the rate of sedimentation – laboratory tests (Degremont, 1991; Sedlak, 1991; Panjan, 1994).

PREMER KOSMOV *DIAMETER OF THE FLOCKS* (μm)	DELEŽ *FRACTION* (%)	HITROST USEDANJA *RATE OF SEDIMENTATION* (m/h)
50 - 60	10	3,6
80 - 90	11	5,4
100	35	10,8
120	28	16,2
150	16	25,2

5. ZAKLJUČEK

Pri čiščenju odpadnih voda je faza biološke obdelave vode ena najpomembnejših. Biološki procesi potekajo kot difuzijski, sorbcijski in encimski. Da bi te procese čim bolje razumeli, se čedalje bolj uporabljajo matematični modeli. Modeliranje je mogoče na makro ravni (celotni volumen reaktorja) ali na mikro ravni (mikroorganizmih). Mi smo modelirali procese na mikro ravni oz. v mikroorganizmih majhne velikosti. Pri teh procesih je nekatere parametre, ki so potrebni za izračune, zelo težko določiti. Tej težavi se delno izognemo z uvedbo brezdimenzijskih števil. V našem prispevku smo prikazali matematično modeliranje vnosa hranil in kisika okroglih, valjastih in diskastih oblik mikroorganizmov - kosmov. S temi modeli poizkušamo čimbolj razumeti vnos hranil in porabo kisika ter simultani potek nitrifikacije in denitrifikacije v bioloških reaktorjih. Z njimi ugotavljamo mejo med aerobno in anoksično cono. Izpeljali smo tudi enačbo za oceno maksimalne velikosti kosmov oz. velikost primarnih kosmov v odvisnosti od turbulence oz. intenzivnosti mešanja vodne mase, v kateri se kosmi nahajajo.

5. CONCLUSION

The phase of biochemical wastewater treatment is one of the most important in the purification process. Biochemical processes take place as diffusion, sorption and enzymatic ones. Mathematical models are more and more often employed for a better understanding of these processes. Modelling is possible on the macro level (whole volume of the reactor) or on the micro level (in microorganisms). We have modelled these processes on the micro level, respectively in tiny microorganisms. It is very difficult to determine some parameters which are necessary for the calculation in these processes. This problem is partially avoided by the introduction of dimensionless numbers. In our article we have demonstrated a mathematical modelling of the introduction of nutriments and oxygen into the spherical, cylindrical and disklike microorganisms – flocks. With these models we try to understand as well as possible the introduction of the nutritive, oxygen demand and the simultaneous course of nitrification and denitrification in biochemical reactors. The boundary between the aerobic and anoxic zones is also established by their means. We have also carried out an equation for the estimation of the maximal dimension of the flocks, respectively, dimension of the primary flocks in dependence of the turbulence, respectively, intensity of the mixing of the water medium in which flocks are present.

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NAVODILA ZA PRIPRAVO PRISPEVKOV

1. Prispevki za *Acta hydrotechnica*

1.1 *Acta hydrotechnica* je znanstveno-strokovna periodična publikacija, katere izdajatelj in založnik je Univerza v Ljubljani, Hidrotehnična smer Fakultete za gradbeništvo in geodezijo (FGG), ki jo sestavljajo Katedra za mehaniko tekočin z laboratorijem (LMTe), Katedra za splošno hidrotehniko (KSH) in Inštitut za zdravstveno hidrotehniko (IZH). Predstavniki omenjenih enot tudi sestavljajo izdajateljski odbor revije.

1.2 *Acta hydrotechnica* izhaja dvakrat na leto v obliki zaporednih številk, dodatno razvrščenih v letnik.

1.3 *Acta hydrotechnica* je namenjena objavam prispevkov strokovnjakov in raziskovalcev s področja vodarstva in hidrotehnike. *Acta hydrotechnica* objavlja prispevke s področja vodarstva in hidrotehnike v obliki izvirnih in preglednih znanstvenih člankov, preliminarnih objav in strokovnih člankov.

1.4 Prispevki so napisani enakovredno v slovenskem in angleškem jeziku, kar zagotavlja ohranjanje in razvijanje slovenskega strokovnega izrazoslovja na področju vodarstva in hidrotehnike ter obenem zagotavlja berljivost revije v tujini. Dolžina prispevka je omejena na 30 000 znakov. Dolžina prispevka, ki je povzetek magistrske naloge ali doktorskega dela, je omejena na 100 000 znakov. Prednost pri objavi imajo krajši prispevki.

1.5 Prispevke je treba oddati v elektronski in pisni obliki na uredništvo *Acta hydrotechnica*.

1.6 Vsi prispevki so oblikovno podvrženi uredniški recenziji v skladu s temi navodili in vsebinsko podvrženi recenziji dveh strokovnjakov s področja prispevka.

1.7 Pri oblikovanju prispevkov za *Acta hydrotechnica* je treba upoštevati slovenske standarde za dokumentacijo in informatiko.

1.8 Za vsebino prispevkov in prevod v angleški jezik odgovarjajo avtorji.

1.9 Vsi prispevki so lektorirani, tako slovensko kakor tudi angleško besedilo.

2. Oblikovanje prispevkov za *Acta hydrotechnica*

2.1 Vsak prispevek mora biti sestavljen iz naslednjih enot, enakovredno podanih v slovenskem in angleškem jeziku:

- ❑ naslov prispevka
- ❑ podatki o avtorju ali avtorjih
- ❑ izvleček (abstract) in ključne besede (key words)
- ❑ glavno besedilo
- ❑ zahvala (acknowledgements) naročniku naloge, raziskave ali študije (neobvezno)
- ❑ pregled uporabljenih izrazov (terminology) in oznak (notations) (neobvezno)
- ❑ viri (references)

Njihov natančnejši opis je podan v naslednjih odstavkih.

2.2 Naslov prispevka naj bo jasen, jedrnat in naj izraža bistvo prispevka. Dolžina naslova je največ 90 znakov, razen ko gre za povzetke magistrskih in doktorskih del, kjer je lahko naslov prispevka enak uradnemu naslovu dela.

2.3 Podatki o avtorju obsegajo ime in priimek, opis znanstvene strokovne stopnje in poln naslov delovnega mesta.

2.4 Vsak prispevek mora spremljati izvleček (abstract) v obsegu okoli 150 besed v vsakem od obeh jezikov. Izvlečka morata strnjeno podati celoten prispevek vključno z zaključki.
Avtor naj navede do 8 ključnih besed.

2.5 Glavno besedilo naj bo razdeljeno po decimalnem sistemu (1. PRVO POGLAVJE, 1.1 PRVO PODPOGLAVJE, 1.1.1 Zadnja poddelitev).
Vire v besedilu navedemo z imenom avtorja in letnico objave (Manning, 1892), (Strickler & Nikuradse, 1924b), (Einstein et al., 1951), (Colebrook, 1932; 1934).
Merske enote naj bodo v skladu z veljavnim sistemom SI. Datum naj bo podan po naslednjem vrstnem redu : dan-mesec-leto (23.4.1998).
Kratice in opombe pod črto naj se uporabljajo le izjemoma.

Ilustracije (preglednice in slike) v besedilu naj bodo skozi vse besedilo enotno oštevilčene z arabskimi številkami in naj se ne okrajšujejo (preglednica 1, slika 14, Table 2, Figure 4). Praviloma mora biti ilustracija dvojezična. Če je ilustracija privzeta iz drugega že objavljenega dela, je potrebno ob njenem opisu dodati tudi njen izvor.

Enačbe v besedilu naj bodo oštevilčene z arabskimi številkami v okroglih oklepajih enotno skozi vse besedilo, pri daljših prispevkih (več kakor 1 avtorsko polo) lahko tudi enotno za vsako poglavje posebej. Navajanje enačb naj v besedilu ne bo okrajšano (enačba (11), enačba (2.17)).

2.6 V besedilu uporabljeni viri morajo biti navedeni v abecednem vrstnem redu in neoštevilčeno, na koncu prispevka, enotno za oba jezika. Če je vir pisan v jeziku, ki ni angleški, naj naslovu vira v oklepaju sledi prevod naslova v angleščino, na koncu navedbe pa dostavek, v katerem jeziku je pisan, npr. (in Slovenian). Glede na vrsto mora avtor navesti vire takole:

- ❑ knjige : Schumm, S.A., Mosley, M.P., Weaver, W.E. (1987). *Experimental fluvial geomorphology*. Wiley, New York, 413 p.
- ❑ posamezne prispevke v knjigi : Large, A.R.G., Petts, G.E. (1994). “Rehabilitation of River Margins” in P. Calow, G.E. Petts, Eds., *The Rivers Handbook - Volume 2*. Blackwell, Oxford, 401-418.
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- ❑ objave, kjer je avtor pravna oseba (skupinski avtor) : VGI (1993). Vodnogospodarski ureditveni načrt Save Dolinke - idejna zasnova (Water Management Master Plan of the Upper Sava River). VGI, Ljubljana, Report C-161 (in Slovenian).
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