ENGINEERING FOR BETTER WATER MANAGEMENT

Water Resources Engineering Associate Prof.: Unami, K./Assistant Prof.: Takeuchi, J.

Water is a key medium for understanding interaction between man and his environment. Our laboratory applies engineering disciplines to management of water resources in rural areas, equally emphasizing theoretical developments, field studies, laboratory experiments, and numerical computations.

Theoretical fundamentals

Mathematical methods are consistently applied for discussing better management of water resources. Current research topics include but not limited to structure of turbulence, physicochemical interaction between soil and water, hydrological processes in rural watersheds, dynamics of aquatic ecosystems, and stochastic control of storage systems. Theories are founded on rigorous demonstrations and experiments. Our hydraulics laboratory operates in Maizuru City to conduct precise experiments on channel flows, seepage flows, and/or density driven currents.

Measurement of turbulence in an agricultural drainage canal

Study fields

Several study fields are set for implementing surveys and observations to evaluate developed models. Few examples are introduced here. Being a part of Lake Biwa Basin of Japan, Takashima area mostly consists of forest watersheds, irrigated paddy fields, and urbanized zones. Optimal farming practices are proposed in order to protect sound water environment in Lake Biwa Basin. Gbullung West inland valley (GbW-IV) is a subsistence farming area located in Northern Region of Ghana, comprising well-drained uplands and hydromorphic valley bottoms with micro-dams. Pioneering studies are being conducted to support sustainable development in semi-arid regions of Sub-Saharan Africa.

One of the micro-dams in GbW-IV at the end of the dry season

Numerical analysis

Computational fluid dynamics (CFD) techniques such as finite element method (FEM) and finite volume method (FVM) are used for simulating flow fields of surface and subsurface water as well as transport phenomena occurring there. Design of hydraulic structures and assessment of water environment are major applications of CFD. Innovative numerical schemes are theoretically or experimentally verified. CFD techniques are further applied to different stochastic process models, which are constructed in terms of stochastic differential equations.

Optimization

Management of water resources involves making decisions to achieve certain goals related to human welfare. Optimal strategies are considered for controlling floods, improving agricultural production, and protecting water quality environment including aquatic biota. Optimization models derived from mathematical programming and optimal control theories serve as decision support tools for water management practices. A large computational effort is required in linear programming as well as in design of feedback controllers.

Key words

Runoff Processes, Irrigation and Drainage, Micro-Dams, Aquatic Biota, Hydraulic Experiment, Water Quality Environment, Computational Fluid Dynamics, Stochastic Processes, Mathematical Programming, Optimal Control

Recent publications

Stochastic control of a micro-dam irrigation scheme for dry season farming
Unami K, Yangyuoru M, Alam AHMB, Kranjac-Berisavljevic G (in press)
Stochastic Environmental Research and Risk Assessment DOI:10.1007/s00477-012-0555-3

Optimization model for cropping-plan placement in paddy fields considering agricultural profit and nitrogen load management in Japan
Chono S, Maeda S, Kawachi T, Imagawa C, Buma N, and Takeuchi J (2012)
Paddy and Water Environment 10(2):113-120

Stochastic process model for solute transport and the associated transport equation
Yoshioka H, Unami K, Kawachi K (2012)
Applied Mathematical Modelling 36:1796-1805

Rationalization of building micro-dams equipped with fish passages in West African savannas
Unami K, Yangyuoru M, Alam AHMB (2012)
Stochastic Environmental Research and Risk Assessment 26(1):115-126

Concurrent use of finite element and finite volume methods for shallow water flows in locally one-dimensional channel networks
Unami K, Alam AHMB (2012)
International Journal for Numerical Methods in Fluids 69(2):255-272

Application of shallow water equations to analyze runoff processes in hilly farmlands
Ishida K, Yangyuoru M, Unami K, and Kawachi T (2011)
Paddy and Water Environment 9(4):393-401

A hydro-environmental watershed model improved in canal-aquifer water exchange process
Imagawa C, Takeuchi J, Kawachi T, Ishida K, Chono S, Buma N (2011)
Paddy and Water Environment 9(4):425-439

A stochastic model for behaviour of fish ascending an agricultural drainage system
Unami K, Ishida K, Kawachi T, Maeda S, and Takeuchi J (2010)
Paddy and Water Environment 8(2):105-111

A physically based FVM watershed model fully coupling surface and subsurface water flows
Takeuchi J, Kawachi T, Imagawa C, Buma N, Unami K, and Maeda S (2010)
Paddy and Water Environment 8(2):145-156

A refined hydro-environmental watershed model with field-plot-scale resolution
Takeuchi J, Imagawa C, Kawachi T, Unami K, Maeda S, and Izumi T (2010)
Paddy and Water Environment 8(2):175-187

A stochastic differential equation model for assessing drought and flood risks
Unami K, Abagale FK, Yangyuoru M, Alam AHMB, Kranjac-Berisavljevic G (2010)
Stochastic Environmental Research and Risk Assessment 24(5):725-733