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CONTENTS

Regulation of water resources and operation of reservoir group in the Yangtze River basin.....	CHEN Jin (2)
Advances in hydro-meteorological forecast under changing environment	LEI Xiaohui WANG Hao LIAO Weihong YANG Mingxiang GUI Ziling (9)
Problems and challenges on flood control for large rivers	LIU Ning (19)
Review on service risk analysis of dam engineering ...	GU Chongshi SU Huaizhi LIU Hezhi (26)
Response mechanism of the river and lakes in the middle and lower reaches of the Yangtze River under the combined effect of reservoir groups.....	LU Jinyou YAO Shiming (36)
A review on flow analysis method for pumping stations	WANG Fujun TANG Xuelin CHEN Xin XIAO Ruofu YAO Zhifeng YANG Wei (47)
Theory and regulation of sediment turbidity current venting with high efficiency in Xiaolangdi Reservoir	ZHANG Junhua MA Huaibao XIA Junqiang LI Tao WANG Yuanjian (62)
The impact of channel-floodplain evolution on the flood release in the mouths of Pearl River Estuary	HE Yong LU Chen YANG Liuzhu YE Ronghui ZOU Zhihua WANG Hua (72)
Advances of ice hydraulics, ice regime observation and forecasting in rivers	YANG Kailin (81)
Review of probable maximum precipitation estimation	LIN Bingzhang LAN Ping ZHANG Yehui LIN Zhicheng CHEN Xiaoyang (92)
Research advances in drip irrigation emitter clogging mechanism and controlling methods	LI Yunkai ZHOU Bo YANG Peiling (103)
Research review and perspective of drought mitigation	QU Yanping LÜ Juan SU Zhicheng SUN Hongquan MA Miaomiao (115)
Review on water and salt transport and regulation in drip irrigated fields in arid regions	TIAN Fuqiang WEN Jie HU Hongchang NI Guangheng (126)
Cognition in the uncertainty and equifinality of hydrological model: a systematic review.....	YANG Xiaoliu WANG Yizhen (136)

水利学报

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第49卷 2018年 第1期(月刊)

目次

2018年新年献词：本末终始知先后，清渠活水源头来	(1)
长江流域水资源调控与水库群调度	陈 进 (2)
变化环境下气象水文预报研究进展	雷晓辉 王 浩 廖卫红 杨明祥 桂梓玲 (9)
大江大河防洪关键技术问题与挑战	刘 宁 (19)
大坝服役风险分析与管理研究述评	顾冲时 苏怀智 刘何稚 (26)
水库群联合作用下长江中下游江湖关系响应机制	卢金友 姚仕明 (36)
泵站内部流动分析方法研究进展	王福军 唐学林 陈 鑫 肖若富 姚志峰 杨 魏 (47)
小浪底水库异重流高效输沙理论与调控	张俊华 马怀宝 夏军强 李 涛 王远见 (62)
珠江河口口门区滩槽演变及对泄洪的影响研究	
..... 何 用 卢 陈 杨留柱 叶荣辉 邹华志 王 华 (72)	
河渠冰水力学、冰情观测与预报研究进展	杨开林 (81)
可能最大降水估算研究综述	林炳章 兰 平 张叶晖 林智琛 陈晓昉 (92)
滴灌系统灌水器堵塞机理与控制方法研究进展	李云开 周 博 杨培岭 (103)
抗旱减灾研究综述及展望	屈艳萍 吕 娟 苏志诚 孙洪泉 马苗苗 (115)
滴灌条件下干旱区农田水盐运移及调控研究进展与展望	
..... 田富强 温 洁 胡宏昌 倪广恒 (126)	
水文模型的不确定性和异因同果性：认知的回顾	杨小柳 王艺臻 (136)
2017年优秀审稿专家表彰名单	(143)
对2017年《水利学报》审稿专家的致谢	(144)

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Regulation of water resources and operation of reservoir group in the Yangtze River basin

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Abstract: The Yangtze River basin is facing severe issues such as shortage of water resources, degradation of water quality and water ecology. It is urgent to strengthen the strict water resources management and the optimal regulation of water conservancy system. The Large-scale water conservancy project, such as the Three Gorges, the mid-route and east-route of South-to-North Water Transfer Projects, have provided essential engineering measures for water resources allocation. Furthermore, the Three Red Lines of Water Resources Management, and other measures have improved managerial level of water resources and regulatory level of hydraulic engineering in the Yangtze River Basin. Firstly, this study reviewed the change of water resources supply and demand relationship in the context of socio-economic development, the progress of reservoir construction, water resources regulation. Secondly, the research progress and problems in the synthetic regulation technique of water resources of the Yangtze River basin have been introduced based on the water diversion project from Yangtze River to Tai Lake basin and the operation of controlled reservoirs such as Danjiangkou Reservoir on the Han River and Three Gorges on the Yangtze. Finally, the scientific, technical and administrative research which should be taken in the further comprehensive water resources regulation has been discussed.

Keywords: Yangtze River basin; water resources regulation; reservoir group; multiple target regulation

Advances in hydro–meteorological forecast under changing environment

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Abstract: With the change of global climate and underlying surface characteristics, and increasing human activities, hydro–meteorological factors such as precipitation, evaporation, and runoff, etc., are directly affected, therefore the assumption of stationarity may no longer exist. In a changing environment, the conventional runoff predicting methods become invalid, which brings challenges to accurate hydro–meteorological forecast. A review of hydro–meteorological forecast research under a changing environment is presented from the aspects of precipitation data fusion, numerical weather forecast, watershed hydrological model, parameterization, data assimilation and ensemble forecast. Much relevant research has been studied, and a lot of achievements have been achieved. The future research on hydrological forecast under changing environment will mainly focus on the following direction: (1) to further improve the accuracy and spatial resolution of precipitation forecast; (2) structure improvement and uncertainty analysis of hydrological models; (3) description methods of hydrological forecast error and reliability.

Keywords: non–stationarity; hydro–meteorological forecast; numerical weather forecast; watershed hydrological model; parameterization; data assimilation; ensemble forecast

Problems and challenges on flood control for large rivers

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Abstract: Climate change combined with more frequent human activities have strongly disturbed the natural water cycle. In addition, the increasing population and social wealth in flood protection zone caused new challenges for flood control for large rivers under the changing environment. This article reviewed the challenges that the flood control for large rivers is facing the two key challenges as “retain or release” and “protect or abandon” problems. Furthermore, some key techniques utilized for decision making were presented, including: building of optimization model, multi-objective problem solving, balance decision-making techniques, as well as high precision prediction of basin runoff and sediment dynamical simulation supported by dynamic calculation of flood “retain or release”. In the end, the application of related technologies was further verified with typical case studies.

Keywords: large river; decision making of flood control; retain or release; protect or abandon; multi-objective

Review on service risk analysis of dam engineering

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Abstract: With the rapid development of dam construction and the continuous improvement of the productivity level, China's dam safety management is transmitting from the traditional engineering safety management to the risk management nowadays. Based on the analysis of the current situation of dam risk analysis and management in China, the research status of dam risk criteria establishment, risk identification, risk assessment and risk treatment was discussed in this paper. In order to perfect the dam risk analysis and management system in China, it should be highlighted in the future to study the dams risk criteria, social and environmental impact caused by dam-break, quantitative model of dam risk identification, dam risk calculation under multiple failure modes, non-probabilistic and time-dependent reliability analysis methods, and the risk analysis methods for dam group system and so on, which may help to ensure the long-term performance of hydraulic structures.

Keywords: dam; service risk; criterion; identification; assessment; treatment

Response mechanism of the river and lakes in the middle and lower reaches of the Yangtze River under the combined effect of reservoir groups

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Abstract: The total capacity of group reservoirs along the Yangtze River and its tributaries is about 37.6 % of the annual runoff of the Yangtze River. The combination of the group reservoirs has changed the water and sediment conditions of the rivers and lakes in the middle and lower reaches of the Yangtze River. This has in turn changed the water flow and sediment transport, erosion and deposition and the relationship between rivers and lakes, which are the focus of this study. The results show that, under the combined effect of group reservoirs, the runoff and the proportion of the middle and lower reaches of the rivers and lakes has no significant change, however, the sedimentation rate and proportion composition has significantly changed, particularly in Yichang station. The middle and lower reaches of the Yangtze River transfer from high sediment concentration under natural conditions to low sediment concentration, while the deposition in rivers and lakes transfers from cumulative under the natural condition to continuous erosion and it will undergo adjustment in a longer period. The combined effect of the group reservoirs on water flow and sediment exchange, scouring and deposition in lakes causes the earlier arrival of the dry season in the Dongting Lake and Poyang Lake, great decrease of the sediment deposition rate in lakes and the overall relationship between the rivers and lakes tending towards to improvement. Due to the uncertainty of the changes of flow and sediment conditions in the Yangtze River, the human activities and the complexity of the evolution of the rivers and lakes system, it is necessary to further investigate the response mechanism of the middle and lower reaches of the rivers and lakes in the future.

Keywords: group reservoirs; flow and sediment conditions; the relationship between the river and lakes; the evolution of the river and lakes

Theory and regulation of sediment turbidity current venting with high efficiency in Xiaolangdi Reservoir

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Abstract: Efficient sediment releasing is the key operation to prolong the project life for the Xiaolangdi Reservoir. Under the condition of impoundment, high release efficiency can be achieved by increasing the ratio of output to input sediment load during turbidity current events and reducing the deposition from the stagnant layers created by turbidity currents. Combining the methods of theoretical study, flume experiments and field data analyses, this paper investigates the dynamic conversion between different flow regimes for sediment transport in reservoirs, the hydrodynamics for sediment transport of turbidity currents, the variations in physical parameters of the stagnant layers and their response to flow conditions. A momentum equation for turbidity currents was proposed, with the correction factors of pressure and momentum being included, and a plunge criterion was derived for turbidity currents under complex flow conditions. Moreover, the formulas were proposed for calculating the velocity and discharge of turbidity currents intruding the tributaries, and multiple regression analyses were conducted for the estuary sandbar elevation and deposition volume of the tributaries. The responsive characteristics of the stagnant layers to subsequent floods were investigated. Finally, the operation principles for efficient sediment releasing were also provided.

Keywords: turbidity current plunging; intrusion into tributary; stagnant layer; efficient sediment release; Xiaolangdi Reservoir

A review on flow analysis method for pumping stations

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Abstract: Pumping stations are the important infrastructures of water diversion, water supply, irrigation or drainage projects. The hydraulic performance of pumping station directly affects the operation safety, stability and benefits of a project. The flow analysis of pumping station involves several disciplines such as pumping station, fluid dynamics and numerical theory. The analysis method has been developed from traditional one-dimensional semi-empirical, semi-theoretical stage to modern three-dimensional viscous stage based on computational fluid dynamics. This paper reviews the turbulence model, geometric model, grid model, numerical discretization model and solution model involved in the flow analysis of pumping station. The methods and procedures used for investigating sump surface vortex, sediment and cavitation, flow-induced vibration, hydraulic transient, and hydraulic design in pumping stations are discussed. The latest research achievements for flow analysis methods in pumping stations are summarized. The future development trend and main research topics are put forward.

Keywords: pumping station; hydraulic performance; CFD; multiphase flow; numerical method

The impact of channel–floodplain evolution on the flood release in the mouths of Pearl River Estuary

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Abstract: Regional security of flood control is highly related to the clearness of estuarine mouth. Due to the impact of variable flow and sediment load and intensive human activities, the rule of channel–floodplain evolution is complicated in the Pearl River Estuary. Hence, regional security of flood control should be further explored. This paper characterizes the evolution of channel–floodplain in the Pearl River Estuary and reveals the hydrodynamic mechanism of river mouth bar evolution. Besides, the influence of multiple large-scale wading projects on flood release is evaluated. The classification of estuarine sensitive region under the control of runoff and tide is presented and the influential factor of flood control is quantified. It is found that: (1) with significantly decreasing sediment load, the floodplain has the potential of erosion, which may provide advantage for flood release; (2) alongshore current driven by monsoon and flood flow are the main influential factors of east and west channel evolution of river mouth bar, and the interaction of flood and wave leads to the erosion of inner and outer slope and siltation of crest for river mouth bar; (3) wading projects exert group effect on the water level, flow division ratio, the load of flood release and tidal prism, and the variation of water level is more sensitive to bridge constructions than reclamation projects in the four eastern mouths while it is reverse in the four western mouths; (4) according to the ratio of runoff and tide, unit discharge and the effect of water block, regional classification is proposed to distinguish the flood risk of different channels; (5) the height of water block in the sensitive part of channel is calculated. Base on the transverse hydraulic geometry, the decrease of tidal prism caused by wading projects should be less than 1%–2%.

Keywords: channel–floodplain evolution; river mouth bar evolution; engineering group effect; sensitive region with flood risk; controlling indexes

Advances of ice hydraulics, ice regime observation and forecasting in rivers

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Abstract: The ice regime forecasting is an important scientific basis for conducting prevention, dispatching and decision-making for ice flood. It is also a complicated systematic project involving the ice hydraulics, thermodynamics, meteorology and artificial intelligence. In this paper are reviewed the advances of the ice hydraulics theory, the model experiment and prototype observation, and ice regime forecasting in recent decades, including the ice roughness coefficient calculation, the numerical simulation of the formation and evolution of ice covers, ice jams and ice dams, the typical results of the model experiments and prototype observations, as well as the application of the ground penetrating radar (GPR), ultrasonic, photographing, video-taping, remote sensing and aerial drone technics et al to the ice regime observation. At last, some scientific problems needed to resolve are presented.

Keywords: ice regime forecasting; ice hydraulics; model experiment; prototype observation

Research advances in drip irrigation emitter clogging mechanism and controlling methods

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Abstract: Drip irrigation emitter clogging issue directly affects irrigation uniformity, operating benefits and service life of the whole irrigation system, and has become one of the most worldwide challenges of the drip irrigation studying area. Especially in the subsurface drip irrigation(SDI)system, the additional negative pressure suction and root invasion effects made the emitter clogging mechanism more complicated. Besides, both water shortage and water pollution forced us to apply multiple water sources in drip irrigation system, and meanwhile the system gradually transferred from merely irrigation to multifunction (including irrigation and fertilization etc.). Using drip irrigation in high value-added perennial crops also raised higher requirements in emitter anti-clogging ability. In this paper, the studying process of drip irrigation emitter clogging issue was reviewed. The types of emitter clogging, the testing and evaluating methods, as well as emitter clogging characteristics and prediction methods were systematically summarized at first. Then, based on how to analyze the clogging substances, the coupled-inducing mechanism and continuously growing mechanism were revealed, from the aspects of growth kinetics of clogging substances and transportation of multiple substances within emitters, respectively. Thus came up with the emitter clogging controlling methods, including controlling the sources of clogging substances, improving anti-clogging ability and effectively clearing clogging substances. Finally proposed the aspects needed to be studied in the future, aiming to provide references to solving emitter clogging issue completely and enhancing its large-scale promotions.

Keywords: drip irrigation; emitter; clogging characteristics; clogging substances; mechanism; controlling

Review of probable maximum precipitation estimation

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Abstract: Probable maximum precipitation (PMP) has been used to calculate the probable maximum flood (PMF) in design of important water conservancy and hydropower project, nuclear power project and urban flood prevention planning. A review of PMP estimation methods of statistical method, in-situ storm maximization, storm transposition and generalized method, storm model, numerical modeling, multifractals method, etc. are systematically stated. The frontier and hot issues of PMP estimation are briefly addressed in five topics, including the storm transposition in mountainous areas, short duration PMP estimation, uncertainties associated with PMP estimation, the impact of climate change on PMP and the probability of PMP. The research emphasis and directions of PMP estimation are discussed as well.

Keyword: Probable Maximum Precipitation (PMP); hydrometeorological approach; numerical modeling; short duration; uncertainties; climate change

Research review and perspective of drought mitigation

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Abstract: Drought and its disaster occurs frequently throughout the world in recent decades. More and more researchers are aware of the significance of drought mitigation research, and carry out a series of fruitful research. In this paper, the research progress on drought mitigation will be elaborated systematically, mainly focusing on following four aspects, drought assessment, drought forecasting, drought disaster risk assessment and drought disaster management strategy. The future trends and main technical difficulties in the drought mitigation research are also put forward. Drought assessment shows tendencies from single-indicator analysis to comprehensive analysis of multi-indicators, and from single intensity analysis to comprehensive analysis of intensity-time-range. In respect of drought forecast technology development, there is a trend from forecast based on statistical methods to forecast based on a coupled atmospheric-hydrological modeling method. The drought risk assessment presents the transitions from evaluation model based on mathematical methods to evaluation model based on physical mechanism, and from static risk assessment to static and dynamic combined risk assessment.

Keywords: drought mitigation; drought assessment; drought forecasting; drought disaster risk assessment; drought disaster management strategy

Review on water and salt transport and regulation in drip irrigated fields in arid regions

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Abstract: Drip irrigation, one of advanced water-saving irrigation technologies, has been widely applied in the arid regions of China. It can enhance the efficient use of water and fertilizer and therefore increases crop yield. However, it also changes the distribution and accumulation pattern of salt. On one hand, the phreatic evaporation can be reduced due to dropping down of groundwater table and thus soil salinization is alleviated. On the other hand, few water is applied with irrigation and thus salt tends to accumulate in the surface soil layer due to lack of leaching water. To address this emerging issue of soil salinization, an attempt was made in this paper to rigorously review: (1) water and salt migration and especially soil salt accumulation under drip irrigation, (2) features of crop responses to water and salt stress, (3) numerical models of soil water and salt movement, and (4) measures for soil water and salt regulation. Based on the extensive literature review, several research tasks associated with drip irrigation were identified: (1) to further explore characteristics of water and salt migration and accumulation and to develop sustainable operation schemes for field water and salt management under varied climatic and geologic settings, (2) to explore coupled responses to water and salt stress for different crops and corresponding threshold values for management, (3) to develop the numerical software for coupled water/salt movement and crop growth, and (4) to develop ecological pattern based modes on farmland drainage and regional salinity disposal.

Keywords: drip irrigation; water-salt transport; simulation model; crop response; regulation

Cognition in the uncertainty and equifinality of hydrological model: a systematic review

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Abstract: This paper reviews the cognitive processes of uncertainty and equifinality to understand the idea debates on hydrological models. It briefs various doctrines on uncertainty sources, summarizes the supporting and opposing views of the discussion and analyzes the hotspots and trends of relevant research work. It also conducts an analysis on the equifinality of hydrological model in terms of academic background, research progress, main achievements and challenges faced. In the regards of the four-source doctrines, hydrology marginalization, minority views and equifinality, it comments on different points of view concerning uncertainty and equifinality and gives some reflections on the epistemology and methodology adopted by different research schools.

Keywords: hydrological model; uncertainty; equifinality