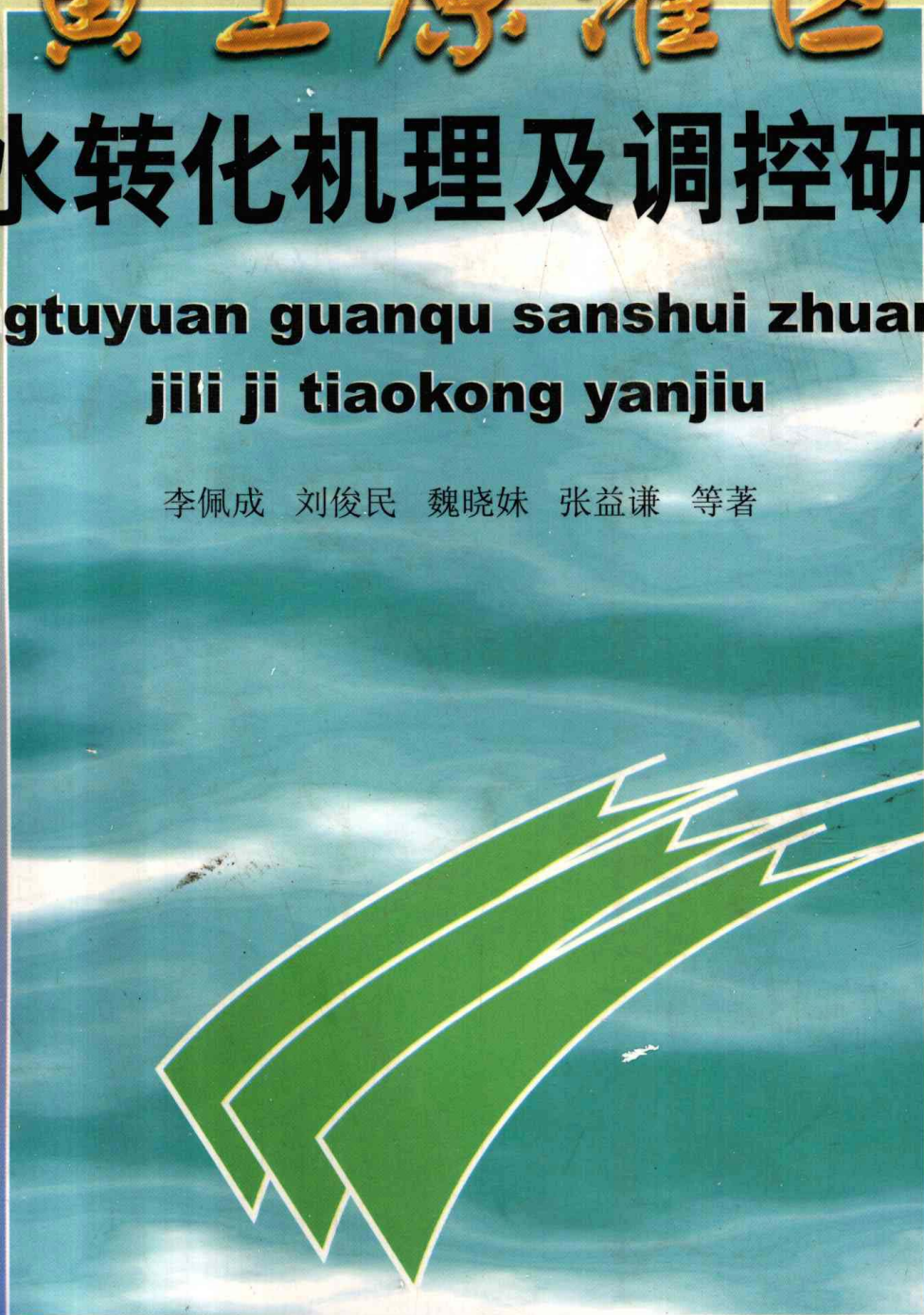


黄土原灌区

三水转化机理及调控研究

huangtuyuan guanqu sanshui zhuanhua
jili ji tiaokong yanjiu

李佩成 刘俊民 魏晓妹 张益谦 等著

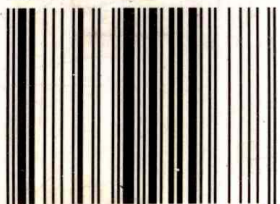


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黄土原灌区 三水转化机理及调控研究

李佩成 刘俊民 魏晓妹 张益谦
马耀光 张讲文 王晓霞 著



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内 容 简 介

本书是以高等学校博士点基金项目和陕西省自然科学基金项目研究成果为基础编写的专著。全书共分10章,分述了三水——降水、地面水(主要是灌溉水)、地下水(包括土壤水)的入渗、饱水、释水机理和转化机理的试验研究成果;介绍了灌区地下水动态研究以及灌溉水资源调控方式途径、数学模型和求解方法。内容特点是取材于实地试验,立足于观测资料的理论分析,以及将理论用于指导实践的举示。

本书可作为从事水文、水资源、水文地质、农田水利以及黄土高原治理开发等领域的研究人员和实际工作者的参考。

黄土原灌区三水转化机理及调控研究

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前言

中国黄土高原面积约 62 万 km^2 ，辽阔广大，资源丰富，具有成为农业、林业、牧业和能源基地的光、热、土地及油、气、煤等自然资源条件，在中国的未来发展中具有十分重要的地位。但是，在这个绝大部分属于半干旱的地区，发展国民经济的最大障碍是水土流失和干旱缺水。

千百年来，为了防旱、抗旱，发展农业生产，在黄土地上修建了许多灌溉工程，发挥了巨大效益。但是，由于自然条件的限制，这些工程越来越严重地遭受着河源水量不足的制约，特别是在春旱和伏旱期间，有些地方不是河源缺水，便是河水含沙量过大而不能引用，致使旱象无法解除，庄稼受损致灾；另一些地方由于不合理的灌溉，致使灌区内地下水补排失调，水位大幅度上升，引发渍涝、盐碱灾害；还有的地方因过量开采引起地下水位过分下降，造成井的出水量减小或使已有机井大量报废。黄土原灌区出现的这种既干旱缺水，又涝碱成灾的矛盾局面，反映出当地水循环的明显失调，这种失调的后果，已在陕、甘、宁、蒙、晋、豫等省区严重地妨碍着国民经济的发展，危害着生态环境的改善。

上述发生在灌溉地上的旱涝矛盾和渍碱灾害，在黄土高原以外的广大干旱半干旱地域，无论是在国内还是在外国均较普遍地存在着。在水资源日显短缺的形势下，如何想方设法，解决上述矛盾，增大水源保证，改善灌溉条件，从而实现灌区的可持续发展，在决定性的程度上取决于人们能否遵循水循环规律，运用先进的科学技术，对三水——天上（降）水、地面（河）水和地下水（包括土壤水）实现有利的转化和调控。

有关三水转化和调控的理论探讨，早在 40 年前便有论文发表；可以看作三水转化的生产实践更为久远，60 年代初我国便在一些大型自流灌区打井，实现井渠结合，两水并用；70 年代以来，三水统观统管和三水转化理论便被明确提出，从而推动了水利事业的发展。如在引黄济卫和泾惠渠灌区都在实现地面水地下水两水并用、井渠结合，在防治旱涝碱方面作出显著成绩。

近 40 年来，美国、前苏联、日本、德国、印度、巴基斯坦等国也都在利用地面水补给地下水，在实施地下水、地面水联合运用方面开展了大量研究和生产实践活动，积累了值得借鉴的经验，获得了可贵的成果。

但是，这些国内外成果，大多集中在工程技术和计算模型的求解方面，而对三水转化的机理本身揭示不够，因而影响着调控工程的正确设计，妨碍着水资源包括灌区水资源的正确评价，在黄土地区尤其如此。例如，在水资源评价中常常需用给水度 μ 值，但却因取值不准而导致严重差错，之所以如此，是因为对给水度反映的含水层释水机理研究尚欠充分，因而对 μ 的取值

前言

缺乏有力的理论指导，正如本书第 6 章中将要论及的那样。

因此，水科学和水利建设、水文地质事业发展到今天，形势要求开展三水转化机理的深化研究，以便为水资源的准确评价，合理调控、高效开发和科学管理提供理论依据。

本专著反映的正是这方面的最新研究成果，这些成果是作者们在完成两个基金项目的过程中获得的，这两个项目是高等学校科学技术基金办公室批准的“黄土原灌区三水转化机理及水资源最佳调控方式研究”（1991），和陕西省科学技术委员会资助的基金项目——“半干旱黄土原灌区三水转化机理及调控模式研究”。

上述主要以黄土台原灌区为代表取得的研究成果，在书中分 10 章予以介绍。具有创新的内容包括：对降水入渗、灌溉入渗的田间试验以及有关机理的深化认识；对含水层释水过程的揭示，对测定给水度的理论和方法推进；对灌区“新含水层”概念的确立和系统研究；以及对灌区“三水”调控计算新模型的建立和求解等。书中介绍的这些来源于实地研究的理论推进、机理揭示、实践创新乃至研究方法的选用等，将会推进水资源优化调控事业，丰富水科学宝库，充实水文学、水文地质学、水资源学的学科内容，深化人们对黄土地下水的认识，促进黄土地区的水利建设和灌溉事业的发展。

本书共分 10 章，其撰写人分别是：第 1 章李佩成、刘俊民；第 2 章马耀光；第 3 章魏晓妹；第 4 章张讲文；第 5 章王晓霞；第 6 章李佩成；第 7 章、第 8 章刘俊民；第 9 章魏晓妹；第 10 章张益谦。在刘俊民、魏晓妹、张益谦同志的协同下，李佩成完成了对全书的统稿编著工作。

除上述撰写者外，初扬瑞高级实验师、郭建青副教授也都是作为成书基础的基金项目的参加者。

书中的全部图件是由张惠琴女士精心清绘的，作者十分感激。

作者还要特别感谢的是西安工程学院学报编辑李燕明女士，她在炎热暑天，帮助校稿，设计版面，促成本书的早日问世。

在国庆 50 周年和 21 世纪到来前夕，拙著出版了，著者感到十分高兴，但由于水平所限，还因为有些工作尚需深入，差错之处一定会有，恳望专家学者朋友们不吝赐教。

著者

1998 年 8 月于古城西安

PREFACE

The Loess Plateau in China enjoys a vast land with an area of 0.62 million km² and rich natural resources such as light, heat, land, petroleum, gas and coal, which are favourable for the creation of agricultural, forestry, livestock and energy resources producing bases, occupying an important strategical place in the future development in China. However, water and soil erosion, droughts and water deficiency are the major constraints in developing national economy in most part of this region falling into the semi-arid and arid area.

For more than thousand years, many irrigation works have been constructed in order to prevent and resist droughts and develop agricultural production over the vast loess land, which have brought about great benefits. Nevertheless, largely owing to the natural condition constraints, these irrigation works are gradually suffering from serious shortage of river water resources. Particularly, during the spring and summer droughts, either there is water shortage in the river or the river water with heavy sediments can not be used in irrigation, thus, further intensifying droughts so that crops fail to harvest, with the disasters caused. On the one hand, the irrational irrigation has resulted in imbalance between supplement and drainage of groundwater so that groundwater table rises by a wide margin, resulting in water-logging and alkaline disaster. On the other hand, Over-exploration of groundwater has led to overdrop of groundwater level, causing a reduction in the outflow of wells or making some pumping wells lay wasted in great numbers. The occurrence of the contradictory situation of either droughts and water deficiency or water-logging and alkaline disaster in the irrigation district over the loess plateau has reflected the obvious imbalance of groundwater circulation. The consequences of this imbalance have seriously hindered the development of national economy in Shaanxi, Gansu, Ningxia, Inner Mongolia, and Shanxi and also harmed the ecoenvironmental improvement.

The occurrence of contradiction between droughts and water-loggings as well as alkaline disasters over the irrigated land mentioned above widely exists both at home and abroad apart from the vast arid and semi-arid areas on the loess plateau. In the case of the increasing shortage of water resources, how to try every means possible

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to solve the above mentioned contradictions and enlarge water resource guarantee and improve irrigation conditions, thereby to achieve the sustainable development in the irrigation districts, depends on to a decisive extent whether people are able to conform to the laws of water cycle and to use the advanced science and technology to achieve the favourable conversion, regulation and control of three waters rainfall water, surface water (river water), and groundwater (including soil water).

Early in 40 years ago there were papers published to deal with the conversion, regulation and control of three waters, which could be considered as the conversion of three waters in production practice with a long history. Early in the 60s, China dug wells in some large-sized gravity flow irrigation districts to realize the combination of wells with irrigation canals so as to achieve simultaneous use of two waters since the 70s, over all view and unified management of three waters and theory of conversion of three waters have been definitely presented whereby boosting the development of cause of water conservancy. For instance, diverting the waters from the Yellow River for irrigation in Henan and Jinhui irrigation district have made significant achievements in realizing the simultaneous use of surface water and groundwater, the combination of wells with canals and control over droughts, water-loggings and alkalinization.

In recent 40 years, the United States, the former USSR, Japan, German, India and Pakistan, etc have carried out much research work on the use of surface water to supplement groundwater and the united utilization of ground water and surface water as well as practical production activities and accumulated much experience which should be worth borrowing and obtained the valuable achievements.

However, these foreign achievements have focused on engineering technology and solutions to computation models, and revealed little on the conversion mechanism of three waters perse, as a result of which the correct design of regulating and controlling engineering is affected; and the correct evaluation of water resources including water resources in irrigation district is hindered; and so is the case particularly in the loess region. For instance, in evaluating water resources, water supply degree, a value is always given at random. It is just because of inaccurate value

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taking that results in serious error. why is to be in this case is that there is little research on water supply degree which can reflect water release mechanism of water-bearing layer. Therefore, there is short of the definite theoretical guidance in deciding a values just as chapter 6 in this book will deal with it in details. Accordingly the progress in the enterprises of water science, water resource construction, hydrology and geology is further required nowadays by the new situations to carry out indepth study of conversion mechanism of three waters with the corresponding results obtained so as to provide theoretical bases for the accurate evaluation, rational regulation and control, effective exploration of water resources and scientific management.

This monography is just the reflection of the latest research achievements in this respect. The achievements have been obtained by the Authors in the course of completing two projects financed by the Foundation. The two projects—《Research on Conversion Mechanism of Three Waters and Optimal Regulation and Control Patterns of Water Resources in the Irrigation Districts Over the Loess Plateau》was approved by The office of Science and Technology Foundation of Shaanxi Institutions of Higher Learning, and 《Research on Conversion Mechanism of Three Waters and Regulation and Control Patterns in the Irrigation Districts on the Semiarid Loess Tableland》was financed as the corollary project by shaanxi science and Technology commission.

The above achievements are obtained mainly from the irrigation districts in the loess tableland areas as the representative, which are introduced in 10 chapters in this book. The main creative contents include the indepth realization of rainfall water infiltration, field experiment of irrigation water infiltration and some related mechanism, the indication of water releasing in water-bearing layer, the promotion of accurate measurement of water supply degree theory and method, the establishment and systematic research of the concept of “new aquifers” in the irrigation districts, and the establishment and solutions of new models for regulation and control computation of three waters in the irrigation districts. What have been introduced in the book come from the theoretical promotion of practical study , mechanism

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indication, new creation in practice and selection of research methods, etc. Accordingly, this book is bound to push forward the enterprise of optimal regulation and control of water resources, to enrich the treasury of water science, to fill out the discipline contents of hydrology, hydrogeology, and water resource science, to deepen the realization of the loess groundwater by the people and to boost the development of water conservancy construction and irrigation enterprises over the loess plateau.

The book consists of 10 chapters, whose contributors are chapter 1 by Li Peicheng, Liu Junmin, chapter 2 by Ma Yaoguang, chapter 3 by Wei Xiaomei; chapter 4 by Zhang Jiangwen; chapter 5 by Wang Xiaoxia; chapter 6 by Li Peicheng; chapters 7 and 8 by Liu Junmin; chapter 9 by Wei Xiaomei and chapter 10 by Zhang Yiqian. Assisted by comrades Liu Junmin, Wei Xiaomei and Zhang Yiqian, Professor Li Peicheng has completed all the compilation of this book.

The authors would like to extend their profound gratitude to Miss Zhang Huiqin who has prepared all the drawings and maps, senior Experimentor Chu Yangrui, associate professor Guo Jianqing who have devoted their efforts and wisdoms to basic research work on this book.

Profound gratitudes are also extended to Miss Li Yanmin who has made an important contribution to the publication of this book.

On the eve of the coming of the 21st century and the 50th anniversary of national day of the founding of the peoples Republic of China, the book has been published. The authors are feeling specially very happy and also sincerely expect to have criticisms and suggestions from the experts, scholars and friends, for there must have been some errors because of Lack of experience and detailed work.

Li Peicheng
In the ancient City- Xi'an
August. 1998

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