



COMPREHENSIVE CONTROL OF
DROUGHT, WATERLOGGING AND SALINITY AND ITS
TECHNOLOGICAL AND ECONOMIC EFFECTS

旱涝盐碱综合治理 与技术经济效益

方生 陈秀玲 编著

Written by Fang Sheng and Chen Xiuling

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丰收在望

经过综合治理，盐碱地已改好。“东庄户”地的四成盐斑完全消失，小麦单产6000kg/hm²。后营以年递增14%的速度，十年实现人均生产500kg粮。20年粮食总产翻两番。

A good harvest is in sight. The saline-alkali land had reclaimed, salt plots in iDongzhuanghui all eliminated. The wheat yields was 6000 kg/hm². The grain output increased to 500 kg per capita in 10 years. The total yields increased by 3-fold in 20 years.



花生遍地

刘松林、胡双年等一班人估算旱涝盐碱综合治理的增产效益。20年来，人均占有粮食增加2.7倍，棉花增加7倍，油料增加6倍。

Peanut spread all over the farmland. Liu Songlin and Hu Shuangniang et al. are estimating the yield increase benefits of comprehensive control of drought, waterlogging and salinity. For the 20 years, the occupation of grain per capita increased by 2.7-fold, 7-fold for cotton and 6-fold for oil crops.

喜摘新棉

燕河开挖后，昔日村北盐碱荒地，今日粮棉成方。后营年均贡献粮食14 × 10⁴kg，棉花2.4 × 10⁴kg。

Picking new cotton. After Yanhe River had excavated, the saline-alkali wasteland to the north of village had reclaimed into nice farmland. Houying had provided annual commodity grain of 140 thousand kg, commodity cotton of 24000 kg.



SB288/02

硕果累累

后营发展果园 13hm², 片林 7hm²。种树 20 × 10⁴ 棵, 其中苹果 4000 棵。

Fruit hanging heavy. Houying developed orchard 13 hm² and afforested area of 7hm². Planted 200 thousand trees, in which apple trees was 4000 pear.



安居乐业

1984 年后营人均收入 410 元。比综合治理前翻了三番。80% 的村民住进新房, 建了电网, 使上自来水, 办起了合作医疗和托儿所。

Live and work in contentment. The income per capita of Houying was 410 yuan in 1984, increased by 7-fold than that before controlled. 80 % of the peasant have had their own new house. Electric network was set up, using running water, set up the cooperative medical service and kindergarten.

采摘蓖麻

后营利用闲散荒地种植苜蓿、田菁、紫穗槐、向日葵、蓖麻, 改土肥田, 增加收入。

Picking Castor-oil seed. Houying village utilized the wasteland planning false indigo, sunflower, castor-oil, alfalfa etc. Reclaiming saline-alkali land, fertilizing farmland and increasing income.



生态环境良性循环

燕河两岸的林带。全村植树 20 万棵，营造片林 7hm^2 ，建成农田防护林网。能防沟渠坍塌，改善小气候，减少蒸发返盐，防干热风危害。

Good circulation of eco-environment. The forest belt in both banks of Yanhe River. Planting Trees 200 thousand in whole village, tract of forest 7hm^2 , set up the shelter belt in farmland. Preventing landslip for canals and ditches, improving microclimate, decreasing salt accumulation by evaporation and preventing dry hot wind.



排涝排咸出路—龙治河和燕河

从后营村北穿过的燕河，河深 4m，排水流量 $28\text{m}^3/\text{s}$ 。燕河入龙治河最后入滏阳河、子牙河、海河入海。

Yanhe River--drainage outlet for excessive rainwater and saline groundwater. Yanhe River across the north of village, depth 4 m, discharge $28\text{m}^3/\text{s}$. Yanhe River flow to Longzhihe River, Fuyanghe River, Ziyahe River and Haihe River, at last to the sea.

国际交流与合作

1986 年美国农业部考察团霍夫曼博士等参观访问后营，与省水利厅侯陆总工程师、刘松林、王凤仪等进行交流。霍夫曼邀方生参加编著《Management of Farm Irrigation Systems》(1990 年 ASAE 出版)

International exchange and cooperation. Dr. Hoffman et al. of Investigation Group of USDA had visited Houying in 1986. Exchanged with Chief Engineer Houlu and Liu Songlin, Wang Fengyi, Fang Sheng, Chen Xiuling. Hofman invited Fang Sheng in the writing of iManagement of Farm Irrigation Systems (published by ASAE in 1990).



接待外宾来访

丹麦(1972)、阿尔巴尼亚(1974)、墨西哥(1976)、美国(1986)考察团先后访问后营。刘松林向阿尔巴尼亚盐碱地改良考察团作介绍。

Received foreign guests. Investigation Groups of Danmark (1972), Albania (1974), Mexico (1976) and America (1986) had visited Houying Pilot Area. The picture shows that Liu Songlin is passing on introduction for Albania Saline-alkali land Reclamation Investigation Group.



铁姑娘

后营修渠挖沟，平整土地动土百万方，当年17岁的王凤仪一天挖土 18m^3 。

Iron Girl. The excavation of earth achieved million m^3 for construction of canals and ditches in Houying Pilot Area. The picture shows that Wang Fengyi excavated earth 18m^3 each day, while she was 17 years old.

国家支持与科学指导

省水利厅规划实施龙治河、燕河工程，组建后营试区和龙治河实验站，指导旱涝盐碱综合治理。戴哲夫副厅长到后营检查工作，与刘松林、王凤仪等同志合影。

State support and scientific guiding. The Hebei Water Resources Bureau has planned and implemented the projects of Longzhihe and Yanhe Rivers, organizing and set up the Houying Pilot Area and Experimental Station, guiding the comprehensive control of drought, waterlogging and salinity. The picture shows Dai Zhefu, the vice bureau director is check up on work of Houying Pilot Area and taken a group photo with Lin Songlin and Wang Fengyi etcal.



摄影：李光辉 王鹏远 刘孟贵

内 容 提 要

《旱涝盐碱综合治理与技术经济效益》一书，是对华北平原河北省石津渠灌区深县后营试区旱涝盐碱综合治理、防治灌区盐碱化、促进农业可持续发展的实践经验与科研成果的总结。该书揭示了华北平原季节性干旱半湿润季风气候区旱涝盐碱的发生规律与特性；提出了旱涝盐碱综合治理的途径、综合措施与防治盐碱灌排工程有关设计参数；总结了历经 20 年不同水文年灌排结合综合治理旱涝盐碱的实践效果；分析了经济效益、社会效益与生态环境效益。可对干旱、半干旱、半湿润地区灌区、南水北调引水、输水、蓄水、灌水过程，防治土壤次生盐碱化提供借鉴。该书可供水利、农业、土壤、水文地质、林业、环境保护、农业经济等生产、管理与科研单位领导和科技人员及有关大专、中专院校师生参阅。

ABSTRACT

The book “Comprehensive Control of Drought, Waterlogging and Salinity and Its Technological and Economic Effects” summarizes the practice experience and research results of the comprehensive control of drought, waterlogging and salinity, the prevention and control of secondary salinization in irrigation district, which has promoted the sustainable development of agriculture in Houying Pilot Area of Shijin Canal Irrigation District in North China Plain. The book reveals the laws of occurrence of drought, waterlogging and salinity and their characteristics; Puts forward the way of comprehensive control, related technological measures and design parameters of irrigation and drainage project for salinity control; Summarizes the practical effects of integrating irrigation with drainage to comprehensive control of drought, waterlogging and salinity in different water years experienced 20 years; Analyzes the benefits of economy, society and eco – environment. The book can be used for reference in the project of prevention and control of secondary salinization of soil in similar irrigated area in arid, semi – arid and semi – humid regions in the world, and in the process of water diversion, transportation, storage and irrigation of the South – to – North Water Transfers Project. The book is fit to read for reference by leaders and personnel of science and technology of production, administration and scientific research organization in the field of water resources, agriculture, soil, hydrogeology, forestry, environment protection and agricultural economy etc. , and also by teachers and students in relevant university, college and technological school.

序

1958 年随着海河流域水利建设的迅速发展，山区河流大部分都修建了水库拦洪蓄水，平原区为解决春夏季节的干旱问题，利用当地河水及引黄发展灌溉，还在平原河道上建闸，或利用洼地修筑平原水库蓄水，增加灌溉水源。那个时期山谷水库工程，为当地防洪和工农业供水，发挥了重要作用；而平原区兴建的蓄水和灌溉工程，却曾一度酿成严重的渍涝和土壤次生盐碱化灾害。当时海河平原土壤次生盐碱化大发展有其自然的和历史的原因。从自然条件上看，平原幅员辽阔，地势低平，微地貌岗坡洼交错，排水不畅；气候方面，降水量年际变化大，而且由于季风影响，全年降水量 70% 集中在 7~8 月份，其他月份干旱少雨。以致旱涝交替，旱涝盐碱并存。形成高地旱、洼地涝、坡地盐碱的分布规律。深县后营所处的地理位置就在滹沱河冲积平原的缓平坡地上，地下水矿化度高，多在 5~10 g/L 以上，历来土地盐碱严重。历史的原因是全国解放初期，缺乏大规模农田灌溉经验，只注意引水蓄水抗旱灌溉，而未料到会引发渍涝盐碱灾害。1963 年海河流域发生特大暴雨洪水，造成一场严重的洪涝灾害。此后，海河平原各地区广大群众，为了根治海河开挖了骨干排水河道，增辟了行洪排涝入海尾间，为综合治理洪涝旱碱灾害奠定了基础。

后营村防治灌区盐碱化正反两方面的经验，在华北平原很有代表性。后营村自 1952 年合作化以后，依靠集体的力量，开始改造利用盐碱地。曾采用围埂刮盐，挖坑换土，苦水压盐，修建台田等办法改造盐碱，但水盐没有出路，有的一时有效，最后终归失败。1958 年开始引石津渠水灌溉，由于

有灌无排，抬高了地下水位，又加重了土壤的次生盐碱化。1963 年遭受特大洪水灾害后，河北省水科所与后营村总结历史教训，吸取国内外经验，依据季节性干旱半湿润地区旱涝盐碱的发生规律，提出了旱涝盐碱综合治理的思想。不是单一的土壤盐碱化防治，而是与抗旱灌溉、排涝防渍结合起来；不是单一的灌水压盐，而是与利用伏雨洗盐、排涝排盐结合起来；不是单一的灌溉排水，而是水利措施与农业措施结合起来，综合治理。经过反复实践，不断完善，形成了“四结合”的综合治理措施：水利措施与农业措施相结合，灌溉与排水相结合，深沟与浅沟排水相结合，地表水与地下水灌溉相结合。排水方面，结合根治海河开挖骨干排水河道——龙治河和燕河，解决了排水排盐出路，在田间开挖支、斗、农、毛排水沟配套工程。灌溉方面，1970 年以前，主要用石津渠水灌溉，以后由于大旱时渠水没有保证，又打井开发地下水灌溉。由于措施得当，经过十年治理，后营村生态环境发生了重大变化，粮食产量每年以 14% 的速度递增，到 1974 年达到人均占有粮食 500kg；又过十年，到 1984 年粮食总产较综合治理前翻两番。

后营村取得防治灌区土壤盐碱化的突出成就，首先应归功于后营村有一个坚强、实干、尊重科学的领导班子。第二是有国家支持与科学指导。后营村排水排盐出路，是在国家根治海河统一规划安排下，才得到了解决。河北省水科所和试验站的科技工作者，坚持理论与实践结合、科技人员与群众结合的技术路线。“文化大革命”中试验站被撤消，科技人员遭受冲击批判，但仍然坚持科学实验，指导群众生产实践。忍辱负重，矢志不移，锲而不舍，无私奉献，终于取得科研与生产的双胜利。第三是多部门、多学科的不计名利的协作精神，拓宽了科学研究的思路，各种专业技术互帮互补，取得科学技术、经济社会、生态环境的综合效益。

方生、陈秀玲教授编写的《旱涝盐碱综合治理与技术经济效益》一书不仅系统地总结了后营综合治理的经验和科研成果，也是对 20 世纪 60~80 年代华北平原防治灌区盐碱化走过的道路所进行的历史回顾。后营村是华北

平原旱涝盐碱综合治理、促进农业生产可持续发展的一个杰出典型。后营村干部群众经过艰苦奋斗，反复实践，实现了旱涝盐碱综合治理的科学设想。后营村治理了旱涝盐碱，粮棉生产迅速发展，生态环境良性循环，证明综合治理是符合自然规律的正确途径，是防治灌区土壤次生盐碱化在实践认识上的一次飞跃。后营村综合治理旱涝盐碱的经验，不仅对我国北方由于缺乏排水设施引起地下水高水位、存在着土壤次生盐碱化的河水灌区，可以提供借鉴；而且对世界上干旱、半干旱、半湿润地区存在着渍涝和盐碱问题的类似灌区，也有重要参考价值。目前渍涝和盐碱化问题对海河平原大部分地区虽然已不是主要威胁，但华北平原尚有 69% 的面积仍属地下水咸水区，随着南水北调工程的实施，在大量引水、输水、蓄水、灌水的过程中，如处理不当，土壤次生盐碱化仍有发展的可能。《旱涝盐碱综合治理与技术经济效益》一书的出版，所介绍的后营村旱涝盐碱综合治理的经验，对南水北调受水区防治土壤次生盐碱化，仍具有重要的现实意义。

张蔚榛

2003 年 7 月 19 日

张蔚榛：武汉大学教授，中国工程院院士

Foreword

With the rapid development of the hydraulic engineering construction in Hai River Basin in 1958, in most of the mountainous areas of its tributaries storage reservoirs for retarding flood water were constructed, for alleviating drought in spring and summer seasons in plain areas, local runoff in rivers and water diverted from Yellow River were used for irrigation, check gates on river channels and plain reservoirs in low-lying lands were also constructed for water storage in order to increase irrigation water supply. In this period the reservoirs in mountainous valleys played important role for flood control and industrial and agricultural water supply, while the water storage and irrigation projects constructed in plain area caused for a time serious problems of water logging and soil salinity. The rapid development of the secondary soil salinization in a large scale in the Hai River Plain at that time had its natural and historical reasons. The extensive territory of the plain area, the mildness of the slope of low-lying lands, the micro geomorphology with the crisscross of gentle mound, Inclined lands and depressions are the unfavorable natural conditions for land drainage. The intensive variation of perennial precipitation and the concentration of annual rainfall in July – August up to 70% of the yearly total due to the influence of monsoons lead to alternating drought and waterlogging, as well as soil salinity. Usually drought occurs in the gentle mound, waterlogging threatens depressions, and in inclined lands the soil salinization is widely developed. The Houying Village of the Shen County is just located on the mild inclined lands of the alluvial plain of the Hutuo River, the farmlands there, under which the groundwater mineralization is as high as 5 ~ 10 g/L, suffers from high soil salinity all through the ages. The historical reason for the rapid development of secondary soil salinization was lacking experience for land irrigation in a large scale and paying attention only to diverting and storing water for combating drought and irrigation, not foreseeing the risk of inducing waterlogging and soil salinity at the beginning of the People's Republic. In 1963 an extraordinary torrential rain and extreme flood occurred in the Hai River basin, which caused serious waterlogging and flood disasters. After that, in order to permanently harness the Hai River, people in Hai River Plain excavated main drainage rivers and outlets for disposing storm and flood water to the sea, which laid sound foundations for the comprehensive control of disasters of flood, waterlogging, drought and soil salinity.

The experiences and lessons for salinity control accumulated in Houying Village are representative in North China Plain. After the establishment of the agricultural cooperatives, the major measures taken for salinity control were scraping the surface saline soil and construction of

dykes enclosing the field for increasing rainfall infiltration, excavation pits for changing the top soil, leaching of salt by saline groundwater and construction of platform land, and so on, but due to lack of outlets for removing drainage water and salt, although these measures were effective for a short period of time, the soil salinity could not be brought under radical control. Since 1958, the Houying Village began to divert water from the Shijin Canal for irrigation, due to lacking drainage system, irrigation caused the rising of groundwater level, which led to the aggravation of the secondary soil salinization. After the extreme flood in 1963, the Hebei Institute of Hydrotechnics together with the Houying Village summarized the historical lessons and adopted the experience for salinity control both in China and foreign countries, based on the rule of occurrence of drought, waterlogging and salinization in seasonal arid and semi-humid areas, put forward an idea of comprehensive control of drought, waterlogging and salinity. The measures of the salinity control were combined with those for combating drought and prevention of waterlogging; leaching of salt was carried out not only by irrigation with river water, but also by rainfall water in rainy seasons and combined with removing storm water and disposing excessive salt; the engineering measures of irrigation and drainage are combined with agricultural techniques. After repeated experiments and tests and continuous improvements, the "four combined" comprehensive measures were formulated, namely: hydraulic engineering measures combined with agricultural ones, irrigation combined with drainage, deep drainage ditches combined with shallow field ditches, surface water irrigation combined with groundwater irrigation. For removing excessive water and salt, along with radical harnessing the Hai River the main drainage ditches, Longzhihe and Yanhe Rivers were excavated as drainage outlets, in the farm lands the branch, lateral and farm, as well as field drainage ditches were also constructed as infrastructures. Before 1970's the surface water from the Shijin Canal was used as the major water source for irrigation, since in extreme dry period the canal water could not be guaranteed, after 1970's wells were constructed and groundwater was also developed for irrigation. Thanks to the comprehensive measures after 10 years of efforts the ecological environment in the Houying Village had experienced tremendous changes, the cereal production had been increasing by 14% each year, up to 1974 the average cereal production per capita was increased to 500kg/a, and another 10 years afterwards in 1984 the total cereal output was increased to 4 times of that before the comprehensive control.

The outstanding achievement in Houying Village was attributed, firstly to a firm and hard working leading group of the village, which valued scientific proposal for comprehensive control of drought, waterlogging and salinity. Secondly to the support of the government and the guidance by the scientific institutions, the scientific research and technical personnel of the Hebei Institute of Hydrotechnics and the Houying Experimental Station led by Prof. Fang Sheng adhered to the technical route of combination of theory with practice and technical personnel with masses, continued their experimentation, even in the hard time of the "Cultural

Revolution” when the Experimental Station was dismissed, until the full success in scientific research, increase of crop production and improvement of ecological environment was achieved. Thirdly to the spirit of close cooperation between different units and specialities, acquiring each other’s strong points to overcome one’s weakness, thus to obtain the comprehensive benefits of technology, social economy and eco – environment.

The book “Comprehensive Control of Drought, Waterlogging and Salinity and Its Technological and Economic Effects” written by Professors Fang Sheng and Chen Xiuling not only systematically summarized the experience of comprehensive control of the Houying Village and the results of scientific research, it is also a historical review of the process of prevention of soil salinization and reclamation of saline lands in the North China Plain in the period of sixties through eighties of the 20th century. Houying Village is an outstanding example of comprehensive control of drought, waterlogging and salinity in North China Plain, it has realized the scientific consideration of comprehensive control, rapid increase of cereal and cotton production and improvement of ecological environment. The experience of Houying Village not only can be used in surface water irrigated areas of North China, where there is high standing of water table and soil salinization due to lacking drainage facilities, but also could be of important value of reference for similar irrigated areas suffering from waterlogging and soil salinization in arid, semi – arid and semi – humid regions in the other parts of the world. Although at the present time waterlogging and soil salinization are no longer the major threat to most part of the Hai River Plain, still the groundwater in 69% of the total area of the North China Plain is saline, with the implementation of the South – to – North Water Transfers Project, in the process of water diversion, transportation, storage and irrigation in a huge scale, there is still the risk of development of secondary soil salinization in case of mismanagement. The publication of the book “Comprehensive Control of Drought, Waterlogging and Salinity and Its Technological and Economic benefits” and the experience of Houying Village to be introduced therein are still of important actual significance for water receiving areas of the South to North Water Transfers Project.

ZhangWeizhen

2003. 7. 19

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1963年11月17日毛泽东主席亲笔题词“一定要根治海河”。这一伟大号召，充分表达了海河流域人民战胜自然灾害的迫切愿望，指明了除水害、兴水利、改变这一地区农业生产面貌的根本方向，极大地调动了广大人民群众建设社会主义的积极性，迅速掀起了声势浩大的根治海河的群众运动。在实践中采取了开挖疏浚骨干排水河道，大搞配套工程，挖深沟，打机井，排沥涝，治盐碱，河渠相通，沟渠相连，排灌结合，调节用水，平整土地，植树造林，进行了洪涝旱碱的综合治理。通过十多年的艰苦奋战、科学治理，终于实现了“遇旱有水，遇涝排水”的理想，彻底扭转了“南粮北调”的被动局面，开创了历史上千百年来从未有过的伟大业绩。

河北省深县后营村是华北平原旱涝盐碱综合治理、促进农业生产可持续发展的一个杰出典型。20世纪50年代末，我国为了克服干旱对农业生产的威胁，大规模发展灌溉。开发了引黄灌区，平原洼地大量蓄水，河库灌区扩大浇地面积。由于有灌无排，抬高地下水位，引发了大面积严重的土壤次生盐碱化。黄淮海平原耕地中盐碱地面积由1958年的 $273 \times 10^4 \text{hm}^2$ 扩展到1961年的 $413 \times 10^4 \text{hm}^2$ 。土壤生态环境遭到破坏，给农业生产带来严重损失。1963年海河流域发生了特大洪水灾害，大面积农田淹没，更加重了平原渍涝和盐碱。在毛主席“一定要根治海河”的伟大号召指引下，国家开始对黄淮海平原洪涝旱碱实行综合治理。海河下游增辟了入海尾间，开挖疏浚骨干排水河道，解决了洪水、沥水和咸水的排水出路，广阔农田实行灌溉排水配套，开发利用地下水，发展井灌井排、井渠结合，不但使土壤次生盐碱化得到制止，而且也改好了大面积原有的盐碱地。到1980年，黄淮海平原盐碱地较过去改好了一半，减少到 $207 \times 10^4 \text{hm}^2$ 。后营村就是引石津渠水灌溉发生土壤次生盐碱化后，又经旱涝盐碱综合治理，促进了农业生产力大发展。后营自1964年开始综合治

理，以年递增 14% 的速度 10 年实现人均占有千斤粮，20 年粮食总产翻两番。后营是华北平原旱涝盐碱综合治理的一个缩影。

灌区土壤次生盐碱化是一个世界性问题。不仅在我国宁夏、内蒙古引黄灌区，新疆大部河水灌区，在没有排水或排水设施不完善、也没有开发利用地下水的渠灌区，地下水位居高不下，次生盐碱化的问题依然存在，而且世界上还有一半灌区存在着渍涝和盐碱。一些国家跨流域调水工程带来的渍涝和盐碱，至今还在艰难地进行治理。后营采用水利与农业措施相结合、灌溉排水相结合、深浅排水沟相结合、地上水地下水灌溉相结合，综合治理旱涝盐碱的经验，不仅对我国北方而且对世界上干旱、半干旱、半湿润地区解决灌区渍涝和盐碱问题，仍有现实应用价值。

为了纪念毛主席“一定要根治海河”题词发表 40 周年，为了使后营的经验得到进一步推广应用，为了把这个具有中国特色的治水改土经验留给后人，河北省水利科学研究院方生、陈秀玲教授重新编写了后营的经验和研究成果。本书选辑了后营大队长刘松林 1982 年在黄淮海平原农业发展学术讨论会上的发言《改造利用盐碱地三十年》和方生、陈秀玲教授 1986 年接待美国农业部考察团时有关后营研究成果的介绍《旱涝盐碱综合治理与技术经济效益》两篇文章。使人们不要忘记今天已经改好的盐碱地，过去曾是盐碱严重的低产田，因为苦水红荆的后营村现在连红荆都没有了。不要忘记我国北方地区还有大面积浅层地下咸水，后营至今大部地下水矿化度还在 5~10g/L 以上，旱季地下水埋深不过 3~5 m，一旦引黄引江大量蓄水，过量灌溉，再抬高地下水位，发生土壤次生盐碱化将是随时可能的。不要好了疮疤忘了痛，丢掉经过反复实践付出沉重代价才取得的综合治理旱涝盐碱的经验，重蹈历史上大引水大浪费大盐碱的复辙。此话讲在南水北调工程开工之际，绝非是耸人听闻。我认为这也是编写此书的现实意义。

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