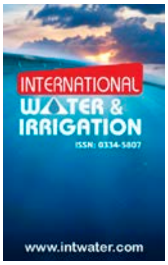

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Test study on water and salt transport in soil transition layer under water storage irrigation based on big data technology and its mechanism

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Abstract At present, it is necessary to vigorously transform saline-alkali wasteland, dry land and coastal tidal flat to realize the balance of cultivated land occupation and compensation. In this paper, the experiment and mechanism of water and salt transport in soil transition layer under water storage irrigation are studied by combining big data technology. Moreover, based on the basic principle of water and salt balance, the numerical model of water and salt transport in vadose zone of study area under brackish water irrigation is constructed on the basis of existing data. The model is a set of numerical models for simulating water transport, heat transport, solute transport and root water uptake in one-dimensional variable saturated media. The model analysis shows that soil water and salt transport is a complex natural phenomenon under the joint action of a large number of natural factors and human factors. In addition, this paper uses normal test analysis to find out whether the salt content of each soil layer conforms to the normal distribution, and combines with big data technology to perform mechanism analysis and verify the effectiveness of this method.

Keywords: big data; water storage irrigation; soil transition layer; water and salt transport.

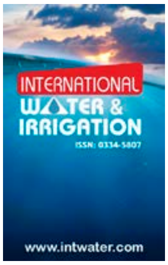
1 INTRODUCTION

Appropriate irrigation mode is the key to control salt accumulation in crop root zone and realize safe utilization of salt water. Among them, salt concentration and ion composition of salt water are the main factors that determine the utilization mode of salt water, and selecting appropriate utilization mode and irrigation technology is the first prerequisite for formulating the utilization mode of salt water. Commonly used saline water utilization methods include direct irrigation of saline water, alternate irrigation of saline and fresh water and mixed irrigation of saline and fresh water. Moreover, salt water irrigation technology mainly includes flood irrigation, furrow irrigation, spring irrigation and drip irrigation[1].

In order to fully and effectively utilize limited water resources and improve land use efficiency, many experts and scholars have done a lot of work on the utilization and improvement of saline alkali land. How to scientifically utilize salinized land is not only an important way to improve the utilization rate of land resources, but also directly affects human survival and development with the growth of population and urbanization. In irrigation areas, excessive irrigation leads to soil salt accumulation, causing soil salinization or secondary salinization, slow or unsustainable crop growth, withering and decay of wild vegetation, soil hardening and hardening, reduction of organic matter, decline in agricultural product quality, and even affecting human health. The study of water and salt movement provides scientific basis for protecting arable land and improving soil [2]; Provide basic data for scientific prediction and benefit evaluation of water conservancy engineering construction; To improve the growth environment of crops and achieve stable and high yield services. The key to solving the problem is to develop a reasonable water use plan, improve the effective utilization rate of water resources, and achieve a balance between soil and water environment based on scientific analysis of soil water and salt transport laws. How to improve and utilize saline alkali soil for agricultural production has become one of the severe problems faced by sustainable agricultural development[3].

The basic theory of water and salt migration in soil is the hydrodynamic dispersion theory, which is a macroscopic quantitative description of the phenomenon of soluble fluid displacement in porous media. By observing, analyzing, and abstracting the dispersion phenomenon, one can gain an understanding of the hydrodynamic dispersion mechanism [4]. Hydrodynamic dispersion occurs due to the thermodynamic effects of particles and the mechanical mixing effect of fluids on solute molecules. By applying different theoretical methods and mathematical tools, mathematical equations can be derived to describe the hydrodynamic dispersion process. The proposal of hydrodynamic dispersion theory was accompanied by the proposal of the theory of easy mixing and displacement in porous media [5]. Reference [6] proposed a mechanism model similar to the convection diffusion equation based on the phenomenon of easy mixing and displacement of solutes in porous media.

Studying the impact of soil physical heterogeneity on salt transport is a concern for many scholars. Most researchers believe that the ratio of the water content in the moving water zone to the total water content decreases with the decrease of the medium water content in the study of the influence of stagnant water on salt transport. The material transfer and exchange coefficient between the two intervals is a parameter that characterizes the solute diffusion range in the stationary and movable regions during salt transport, and can only be determined by the slope of the delayed part of the penetration curve in the experiment, with little fluctuation with changes in water content [7]. Reference [8] fitted a linear relationship between the mass transfer coefficient a



and the average pore water flow velocity in the movable water zone. Laboratory research on the effects of stagnant water on salt transport is gradually decreasing, with a focus on field experiments in order to apply the research results to practical applications. The field experimental work mainly focuses on using a pressure disc permeameter to measure the content of stagnant water and the mass exchange coefficient. The research results show that field experiments are an important way to obtain these two parameters [9]. The mechanism of chemical and biological reactions that occur during the migration of salt in porous media has been a widely studied field by many scholars in recent decades. Due to the different types of salt, the reactions between salt and medium, salt and salt, as well as the salt itself, vary during the migration process. Based on various research results, the reactions that occur during salt migration can be divided into adsorption and desorption, exchange, precipitation, degradation, dissolution, etc. The magnitude and degree of these reactions are related to many factors such as the water content, water flux, and clay content of the medium [10].

In recent years, with the rapid development of economy, the situation of shortage of fresh water resources and insufficient cultivated land area has become increasingly apparent. In order to realize the sustainable utilization of agricultural water resources, it is necessary to seek and develop alternative resources of fresh water resources. Therefore, it is necessary to vigorously transform saline-alkali wasteland, dry land and coastal tidal flat to realize the balance of cultivated land occupation and compensation. In this paper, combined with big data technology, the experiment of water and salt transport in soil transition layer under water storage irrigation and its mechanism are studied, which provides reference for the further utilization of water resources.

2 BASIC PRINCIPLE OF MODEL

Based on the basic principle of water and salt balance, the model can simulate and analyze the interannual dynamic changes of water and salt in regional cultivated land and wasteland. The model has been successfully used in many areas and different soil conditions, and achieved good simulation results.

The main principle of the model can be summarized as simulating crop seasoning, dividing the tillage area, carrying out soil stratification, simulating the water and salt movement of each layer, and outputting the annual water and salt changes after integration. Simulated seasons are mainly based on irrigation and crop planting, and can generally be divided into 1-4 simulated seasons. Meanwhile, different crop zoning can be divided according to the water demand of crops, which is generally divided into general water consumption area, large water consumption area and non-irrigated area, and then the crops in the area are divided according to the area ratio. After the actual investigation and study of this study area, the study area is divided into two areas, namely, the general water consumption area and the non-irrigation area for simulation analysis. The schematic diagram of hydrological elements in three different types of crops is shown in Figure 1.

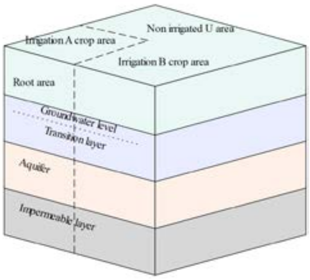


Figure 1 Schematic diagram of seasonal zoning and stratification of model crops

2.1 Water balance equation

The model roughly divides the soil into four layers according to the regional geological conditions, which are surface layer, root zone layer, transition layer and aquifer, and then simulates the water quantity of each layer respectively. Figure 2 shows the layered calculation of water balance.

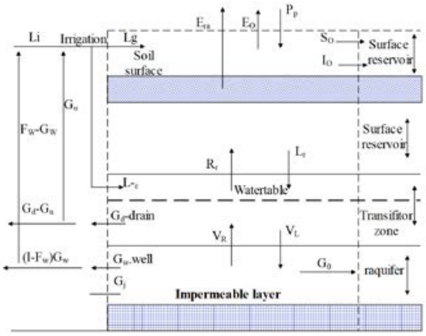


Figure 2 Schematic diagram of water balance elements of model

Note: *Pp:* represents the amount of water falling vertically to the sur***face;*** *Ig*: represents the total irrigation amount (natural water flow and well water and drainage for irrigation, but excluding the amount of canal leakage); λo: represents the amount of water infiltrating into the surface layer from the root layer; *Eo*: represents water surface e*vaporat*ion; λi: represents the amount of water infiltrating into the root zone from the surface; *Io*: represents the amount of water withdrawn from cultivated land; *So*: represents surface runoff; *Rr:* represents the amount of capillary water infiltrating into the root zone; *Era:* represents actua*l evapot*ranspiration in root zone; *Lr:* represents root zone leakage; *Lc:* represents the leakage of the channel; *Vr:* represents the amount of infiltration from the aquifer into th*e transit*ion layer; *VL:* represents the amount of infiltration from the transition layer into the aquifer; *Gd:* represents displacement.

The surface water balance equation is:

$$Pp + Ig + \lambda o = Eo + \lambda i + Io + So + \Delta Ws \quad (1)$$

In the formula, Pp represents the amount of water falling vertically to the surface, m^3 /season$\cdot m^2$; Ig represents total irrigation (including natural water flow and well water and drainage for irrigation, but excluding canal leakage), m^3 /season$\cdot m^2$; λo represents the amount of water infiltrated into the soil surface from the root layer (which only occurs when the underground water level is above the surface), m^3 /season$\cdot m^2$; Eo represents water surface evaporation, m^3 /season$\cdot m^2$; λi represents the amount of water infiltrating into the root zone from the surface, m^3 /season $\cdot m^2$; I_o represents the amount of water withdrawn from cultivated land, m^3 /season$\cdot m^2$; So represents runoff, m^3 /season$\cdot m^2$; ΔWs represents the change of water storage, m^3 /season$\cdot m^2$.

For the study area, because the study area is in a dry area with little rain and strong evaporation, the surface runoff cannot be considered. The variation of water quantity in root zone, transition zone and aquifer is mainly considered.

The water balance equation of root layer is:

$$\lambda i + Rr = \lambda o + Era + Lr + \Delta W_f + \Delta Wr \quad (2)$$

In the formula, Rr is the capillary rising water volume, m^3 /season$\cdot m^2$; Era is root zone evapotranspiration, m^3 /season$\cdot m^2$; Lr is leakage, m^3 /season$\cdot m^2$; ΔW_f is the effective water holding capacity, m^3 /season$\cdot m^2$; ΔWr is soil water holding capacity, m^3 /season$\cdot m^2$. According to the actual situation, Rr and Lr are opposite processes, that is, when Rr > 0, Lr=0, and when Lr > 0, Rr=0. When the calculation period is long, it is usually negligible. The equation expression becomes:

$$\lambda i + Rr = \lambda o + Era + Lr + \Delta Wr \quad (3)$$

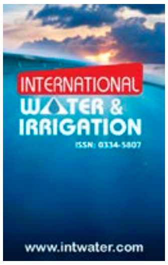
The calculation method of Rr is as follows:

$$Rr = Ea - Vs \quad (4)$$

$$Ea = FsVs + Ra \quad (5)$$

$$Ra = FcMd \quad (6)$$

$$\begin{cases} Fc = 1 & \left(Dw < \frac{1}{2}Dr\right) \\ Fc = 0 & (Dw > Dc) \\ Fc = 1 - \left(Dw - \frac{1}{2}Dr\right)\left(Dc - \frac{1}{2}Dr\right) & \left(\frac{1}{2}Dr < Dw < Dc\right) \end{cases} \quad (7)$$



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In the formula, Dw is the groundwater value, $\mathrm{m}; Dr$ is the root layer thickness, $\mathrm{m}; Dc$ is the critical groundwater depth of capillary rising water, $\mathrm{m}; Fc$ is the capillary rising factor; Fs is water storage efficiency; Vs is the total water quantity, m^3 /season $\cdot \mathrm{m}^2$; Md is the amount of water deficit, m^3 /season $\cdot \mathrm{m}^2$, and other symbols are the same as above.

The water balance equation of the transition layer is:

$$Lr + Lc + Vr + Gti = Rr + V_l + Gd + Gto + \Delta Wx \quad (8)$$

In the formula, Lc is the amount of channel leakage, m^3 /season $\cdot \mathrm{m}^2$, Gti is the amount of water flowing into aquifer, m^3 /season $\cdot \mathrm{m}^2$, V_l is the amount of water infiltrating into aquifer, m^3 /season $\cdot \mathrm{m}^2$. Gd is the total discharge, m^3 /season $\cdot \mathrm{m}^2$, Gto is the amount of water flowing out of the aquifer, m^3 /season $\cdot \mathrm{m}^2$, and other symbols are the same as above.

The water balance equation of aquifer is:

$$Gi + Qi + V_l = Go + Qo + Vr + Gw + \Delta Wq \quad (9)$$

In the formula, Gi is the amount of water entering the aquifer, m^3 /season $\cdot \mathrm{m}^2$, Qi is the inflow condition of the aquifer, m^3 /season $\cdot \mathrm{m}^2$, Go is the amount of water flowing out of the aquifer, m^3 /season $\cdot \mathrm{m}^2$, Qo is the outflow condition of the aquifer, m^3 /season $\cdot \mathrm{m}^2$; Gw is the amount of water pumped in the well, m^3 /season $\cdot \mathrm{m}^2$, and other symbols are the same as above. Among them, the terms Gi, Go and ΔWq are based on the value of V_l, Vr, Gw and are determined by the groundwater model.

The water balance equation entering the field is:

$$I_i = I_f + I_o + L_c - F_w G_w - G_u \quad (10)$$

In the formula, F_w is the percentage of irrigation well water in total water, G_u is the underground drainage of irrigation, m^3 /season $\cdot \mathrm{m}^2$, and I_f is the water applied in the field, m^3 /season $\cdot \mathrm{m}^2$, and it is calculated by the following formula:

$$I_f = I_{aA} A + I_{aB} B \quad (11)$$

In the formula, I_{aA}, I_{aB} is the amount of irrigation in fields A and B, m^3 /season $\cdot \mathrm{m}^2$, $\cdot A, B$ is the area of irrigated land for field crops, hm^2 , and other symbols are the same as above.

The water balance equation of root layer leakage is:

$L_{r燭} = L_{rA}A + L_{rB}B + L_{rU}U$ (12)

In the formula, L_{rA}, L_{rB}, L_{rU} is the water leakage of root layer of crops in A, B and U irrigated lands respectively, m^3 /season $\cdot \mathrm{m}^2$.

$L_{r爛} = V_A - E_{aA}$ (13)

$L_{r烟} = V_B - E_{aB}$ (14)

$L_{rU} = V_U - E_{aU}$ (15)

In the formula, V_A,V_B,V_U is the surface water resources of A, B and U irrigated land respectively, m^3 /season $\cdot \mathrm{m}^2$;E_{aA}, E_{aB}, E_{aU} is the actual evapotranspiration of A, B and U irrigated land respectively.

$V_A = P_p + I_{iA} - S_{OA}$ (16)

$V_B = P_p + I_{iB} - S_{oB}$ (17)

$V_U = P_p + I_{iU} - S_{OU}$ (18)

In the formula, P_p is rainfall, m^3 /season $\cdot \mathrm{m}^2$;I_{iA}, I_{iB}, I_iU is irrigation amount of irrigated land of A, B and U, m^3 /season $\cdot \mathrm{m}^2$;S_{OA}, S_{OB}, S_{OU} is surface runoff of irrigated land of A, B and U, m^3 /season $\cdot \mathrm{m}^2$.

The water balance equations of water deficit, capillary rising water and actual transpiration are as follows:

$Md = Ep - FsVs \quad M_d > 0$ (19)

In the formula, Md is water deficit, m^3 /season $\cdot \mathrm{m}^2$;Ep is potential evapotranspiration, m^3 /season $\cdot \mathrm{m}^2$;Fs is surface water storage rate, m^3 /season $\cdot \mathrm{m}^2$;Vs is surface water resources, m^3 /season $\cdot \mathrm{m}^2$.

$E_a = F_S V_s + F_c M_d$ (20)

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$$\begin{cases} Fc = 1 & \left(Dw < \frac{1}{2}Dr\right) \\ Fc = 0 & (Dw > Dc) \\ Fc = 1 - \left(Dw - \frac{1}{2}Dr\right)\left(Dc - \frac{1}{2}Dr\right) & \left(\frac{1}{2}Dr < Dw < Dc\right) \end{cases} \quad (21)$$

In the formula, E_a is the actual transpiration, m^3 /season$\cdot\mathrm{m}^2$, and F_c is the capillary rise factor, which is determined by groundwater level Dw, root layer depth Dr and critical depth Dc.

$$Rr = Ea - Vs \quad (22)$$

$$Ea = FsVs + Ra \quad (23)$$

$$Ra = FcMd \quad (24)$$

In the formula, Rr is capillary rising water quantity, m^3 /season$\cdot\mathrm{m}^2$, and other symbols are the same as those above.

The balance equation of underground displacement is:

The underground layout of the exhaust pipe is shown in Figure 3.

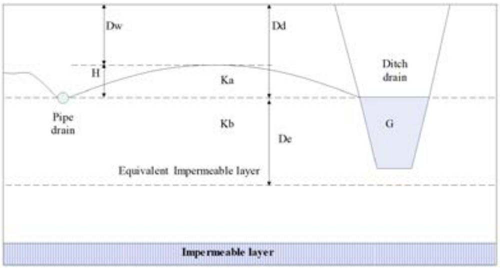


Figure 3 Layout of underground drainage pipe

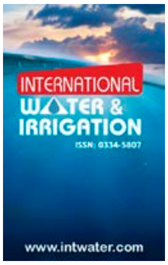
According to Hooghoudt's, the basic equation of drainage is:

$$G_{\mathrm{dt}} = G_{da} + G_{db} = \frac{4K_aH^2}{Y^2} + \frac{8K_bD_eH}{Y^2} \quad (25)$$

$$\mathrm{H} = D_d - D_w \quad (D_d \geq D_w) \quad (26)$$

In the formula, G_{da} is the displacement above the drain pipe, m^3 /season $\cdot\mathrm{m}^2$; G_{db} is the displacement below the drain pipe, m^3 /season$\cdot\mathrm{m}^2$.

The groundwater level is calculated as follows:



$$\Delta W = Pp + Ig + L_{rT} + Gi - Ea - Io - So - Gd - Go - G_W \quad (27)$$

$$Dw = Dwi - \frac{\Delta W}{Pei} \quad (28)$$

The irrigation efficiency is calculated as follows:

$$F_{fA} = \frac{\left(E_{aA} - R_{rA}\right)}{\left(I_{aA} + P_p\right)} \quad (29)$$

$$F_{fB} = \frac{E_{aB} - R_{rB}}{I_{aB} + P_p} \quad (30)$$

$$F_{ft} = \frac{A\left(E_{aA} - R_{rA}\right) + B\left(E_{aB} - R_{rB}\right)}{It + Pp} \quad (31)$$

The total water balance equation is:

$$\mathrm{Pp + Ig + Lc + Gti + Gi + Qi = Ea + Io + So + Gto + Gqo + Qo + Gd + Gw + \Delta W} \quad (32)$$

2.2 Salt equilibrium equation

The surface salt balance equation is:

The salt Zse introduced by various surface waters is:

$$\mathrm{Zse = Ci\left(I_a A + I_b B + SuU\right) + CpPp + \left(Ca + C_b + Cu\right)\lambda_o} \quad (33)$$

The salt Zso discharged from irrigation area by surface drainage facilities is:

$$\mathrm{Zso = Csi\left(Io + S_{oa} + S_{ob} + S_{ou}U + \lambda i\right)} \quad (34)$$

The total surface salt Zsf is:

$$\mathrm{Zsf = Zsi + Zse + Zso} \quad (35)$$

The salt balance equation of root layer is:

When the underground depth is below the surface in the last season, the salt equation of root zone is:

$$\begin{aligned}\mathrm{\Delta Zra} &= \mathrm{CpPp + CiIa + RraCxki} \\ &\mathrm{- Sa(0.2Crai + Ci) - LraCla}\end{aligned} \quad (36)$$

$$\begin{aligned}\mathrm{\Delta Zrb} &= \mathrm{CpPp + CiIb + RrbCxki} \\ &\mathrm{- Sa(0.2Crbi + Ci) - LrbClb}\end{aligned} \quad (37)$$

$$\begin{aligned}\Delta \mathrm{Zru} &= \mathrm{CpPp} + \mathrm{CiSu} + \mathrm{RruCxki} \\ &- \mathrm{Su}(0.2\mathrm{Crui} + \mathrm{Ci}) - \mathrm{LruClu}\end{aligned} \quad (38)$$

When the underground depth is above the surface in the current season and the previous season,

$$\Delta \mathrm{Zra} = \lambda \mathrm{i}(\mathrm{Csi} - \mathrm{Cla}) - \lambda \mathrm{o}(\mathrm{Cla} - \mathrm{Cxki}) \quad (39)$$

$$\Delta \mathrm{Zrb} = \lambda \mathrm{i}(\mathrm{Csi} - \mathrm{Clb}) - \lambda \mathrm{o}(\mathrm{Clb} - \mathrm{Cxki}) \quad (40)$$

$$\Delta \mathrm{Zru} = \lambda \mathrm{i}(\mathrm{Csi} - \mathrm{Clu}) - \lambda \mathrm{o}(\mathrm{Clu} - \mathrm{Cxki}) \quad (41)$$

When the groundwater depth is below the surface in the current season and above the surface in the previous season,

$$\Delta \mathrm{Zra} = \lambda \mathrm{i}(\mathrm{Csti} - \mathrm{Cla}) - \lambda \mathrm{o}(\mathrm{Cla} - \mathrm{Cxki}) + \mathrm{Zsi} \quad (42)$$

$$\Delta \mathrm{Zrb} = \lambda \mathrm{i}(\mathrm{Cst} - \mathrm{Cl}) - \lambda \mathrm{o}(\mathrm{Clb} - \mathrm{Cxki}) + \mathrm{Zsi} \quad (43)$$

$$\Delta \mathrm{Zru} = \lambda \mathrm{i}(\mathrm{Cst} - \mathrm{Clu}) - \lambda \mathrm{o}(\mathrm{Clu} - \mathrm{Cxki}) + \mathrm{Zsi} \quad (44)$$

The salt concentration expression of leakage water at the end of last season is:

$$\mathrm{Cla} = \mathrm{F}_{\mathrm{lr}}\mathrm{C}_{\mathrm{ra}} \quad (45)$$

$$\mathrm{Clb} = \mathrm{F}_{\mathrm{lr}}\mathrm{C}_{\mathrm{rb}} \quad (46)$$

$$\mathrm{Clu} = \mathrm{F}_{\mathrm{lr}}\mathrm{C}_{\mathrm{ru}} \quad (47)$$

Then, the expression of salt concentration Cr in root layer is:

$$\mathrm{Cra} = \mathrm{Crai} + \frac{\Delta Zra}{P_{tr}D_{r}} \quad (48)$$

$$\mathrm{Crb} = \mathrm{Crbi} + \frac{\Delta Zrb}{P_{tr}D_{r}} \quad (49)$$

$$\mathrm{Cru} = \mathrm{Crui} + \frac{\Delta Zru}{P_{tr}D_{r}} \quad (50)$$

The salt balance equation of transition layer is:

When there is no drainage facility, the salt content of transition layer is:

$$\begin{aligned}\Delta \mathrm{Zx} &= \mathrm{LrTClo} + \mathrm{LcCic} + \mathrm{VrCqi} + \delta \mathrm{i} \\ &- \mathrm{RrtCx} - \mathrm{FlxGx}(\mathrm{Vl} + \mathrm{Gto})\end{aligned} \quad (51)$$

When drainage facilities exist and the transition layer is above the water level of drainage ditch (pipe),

$$\Delta Zxa = Lrt Clo + Lc Cic + (Vr - Vl - Gb) Flx Cxbi - Rr T Cxa - Flx Ga Cxa \quad (52)$$

$$\Delta Zxb = Fl(Lrt + Lc - Rrt - Ga) Cxa + Vr Cqi - Flx(Vl + Gb) Cxb \quad (53)$$

$$C_{xxf} = C_{xi} + \frac{\Delta Z_x}{P_{tx} D_x} \quad (54)$$

$$C_{xaf} = C_{xai} + \frac{\Delta Z_{xa}}{P_{tx}\left(D_d - D_r\right)} \quad (55)$$

When the transition layer is at the water level of the drainage ditch (pipe),

$$C_{xbf} = C_{xbi} + \frac{\Delta Z_{xb}}{P_{tx}\left(D_r + D_x - D_d\right)} \quad (56)$$

In the formula, Cic is the salt concentration of irrigation water, $dS/m; Cqi$ is the saturated salt concentration of aquifer, $dS/m; C_{xi}$ is the saturated salt concentration of transition layer, dS/m.

The salt balance equation of aquifer is:

The salt of an aquifer can be expressed as:

$$\Delta Zq = Gqi Ch + Vl Cxx - (Gqo + Vr + Gw) Cov \quad (57)$$

$$C_{qf} = C_{qi} + \frac{\Delta Z_q}{P_{tq} D_q} \quad (58)$$

In the formula, Ch is the salt concentration entering the aquifer, $dS/m; Cov$ is the salt concentration leaving the aquifer, $dS/m; Ptq$ is the total porosity, and Dq is the thickness.

2.3 Other Equation

(1) The salt concentration of irrigation water is:

$$C_i = \frac{\left(I_i C_{ic} + D_d C_{di} + F_w G_w C_{qi}\right)}{I_i + D_d + F_w G_w} \quad (59)$$

In the formula, F_w is the groundwater utilization factor $\left(0 < F_w < 1\right)$.

(2)The initial salt content of drainage is:

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$$C_{di} = \frac{F_{lx}\left(G_{db}C_{xbi} + G_{da}C_{xai}\right)}{G_d} \quad (60)$$

In the formula, F_{lx} is the elution rate of transition layer.

(3)The salt concentration of leaking water is:

$$C_{lo} = \left[\frac{L_{ra}C_{ra}A + L_{rb}C_{rb}B + L_{ru}C_{ru}U}{L_{ra}A + L_{rb}B + L_{ru}U}\right] \quad (61)$$

In the formula, C_{lo} is the salt concentration of leakage water, dS/m.

(4) The salt concentration of pumped well water is:

3 TEST DESIGN AND BIG DATA TEST PLATFORM

3.1 Test design

On the basis of the existing data, the numerical model of water and salt transport in the unsaturated zone of the study area under irrigation is constructed. The model is a set of numerical models for simulating water transport, heat transport, solute transport and root water uptake in one-dimensional variable saturated media. The flow of water transport system in atmosphere-soil-plant in this model is shown in Figure 4.

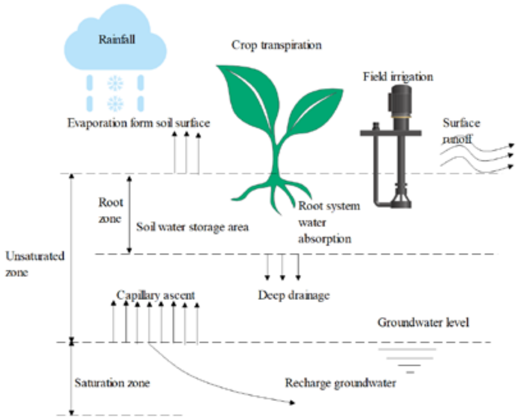

Figure 4 Generalization of water transport process

Soil water and salt transport is a complex natural phenomenon under the combined action of a large number of natural factors and human factors. Among them, natural factors include: geology and geomorphology, hydrogeology, hydrology, hydrochemistry, soil, vegetation and climate, etc.,

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while human factors include: irrigation, drainage, fertilization and farming management, etc. Moreover, various factors and their different combinations determine different dynamic changes of soil water and salt. This paper combines big data technology to process the data of this model, and then builds a big data model.

3.2 Data processing platform of big data test

When the cluster is created, the normal configuration of big data components needs the support of specific virtualized networks, and the cluster operation also needs the correct network environment. If the network is not designed well in advance, users need to learn the use steps of OpenStack virtualization network before deploying clusters, and create corresponding networks for their experimental clusters, which increases the cost of learning OpenStack and is not beneficial to the experiment. Therefore, the pre-design of virtual network can pave the way for students to quickly obtain experimental clusters. When monitoring virtual machines and users' experimental behaviors at the same time, it is also necessary to obtain data through virtual networks. The virtual network structure is shown in Figure 5. The virtual network on the platform needs to manage the following types of network traffic: Management, API, VM and External. Moreover, the control node and the computation node merge the Management, API and VM network, and are managed by the network card 1. The network card 2 of the control node is connected to an external network, and the external network address pool serves as a floating ip pool of the virtual machine. From LinuxBridge and OpenVswitch two kinds of VM network agents, we choose LinuxBridge, which is more mature and efficient, as the virtual network manager of the platform. In addition, vxlan is selected as the type of VM network.

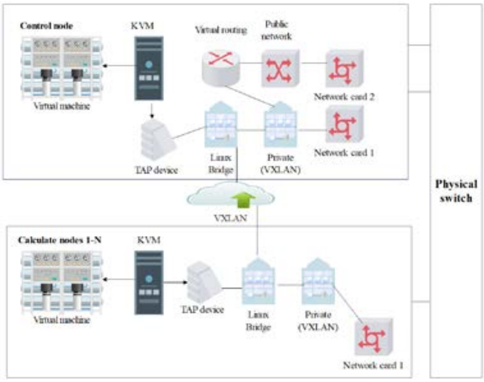


Figure 5 Virtual network structure diagram

Platform monitoring is shown in Figure 6. There are mainly the following points to be achieved. First, the granularity of monitoring is refined, and monitoring is carried out from three aspects: physical machine, virtual machine and user experimental behavior. The second is monitoring information processing, which saves the resource monitoring information to the database, saves the historical warning records, and saves the users in the form of log files after classification. The third is to isolate the monitoring information between users and show it to users.

Considering that Ceilometer, a monitoring project of OpenStack, needs to be deployed on the control node, the CPU consumption of the control node is high after testing, and it is suitable for large-scale situations. Therefore, according to the requirements of the experimental platform, the physical resource monitoring is equally divided into each machine, and only the necessary information is collected. Finally, the resources are classified by the classifier on the control node.

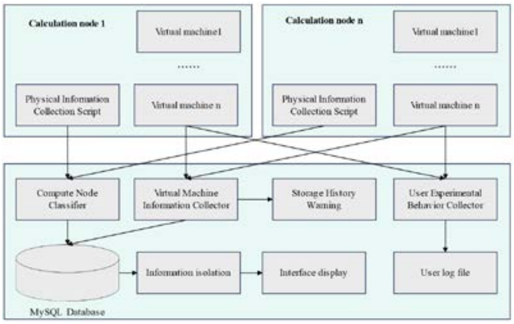
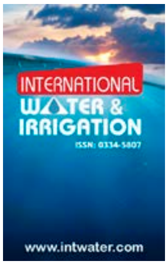


Figure 6 Platform monitoring structure diagram.

4 TEST RESULTS AND DISCUSSION

According to the general classical statistical method, the statistical characteristic values of soil salt content in different soil layers are listed in Table 1. It can be seen from the contents of the table that the salt content of soil is generally higher at different levels. Because the average salt content of each soil layer ranges from 4.16 g/kg to 7.50 g/kg, according to the classification standard of saline soil, it belongs to the type of heavy saline soil (> 4.0 g/kg), which also shows that severe salinization in this area is an important factor affecting the ecological environment in this area. In addition, the average difference of salt content in different soil layers is not very large, which also shows that the variation of soil salt content in the vertical profile direction in the study area is very small, but it can be seen that the accumulation of salt content in 80 ~ 100cm soil layer is very obvious, so the study area is roughly in a distribution state of "bottom aggregation type".

From the aspect of variation coefficient, the variation coefficients of salt content in each soil layer are 60.00%, 52.32%, 55.03%, 54.15% and 58.97% respectively. According to the coefficient of variation reflecting the degree of dispersion, the variability of soil salt content is classified into simple grades, that is, when the coefficient of variation is less than 10%, it is classified as weak variability, when the coefficient of variation is between 10% and 100%, it is classified as medium variability, and when the coefficient of variation is greater than 100%, it is strong variability. According to the above classification criteria, it is found that the salt content of each soil layer also shows moderate variation intensity in horizontal direction. With the increase of soil depth, the



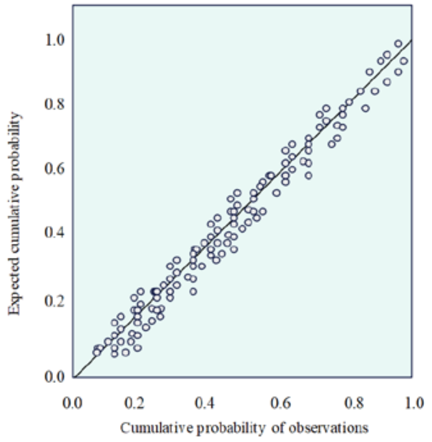
coefficient of variation basically belongs to a downward trend, which also shows that with the increase of soil depth, the change of horizontal salt content gradually weakens.

Table 1 Statistical characteristic values of soil salt content in different soil layers in the study area

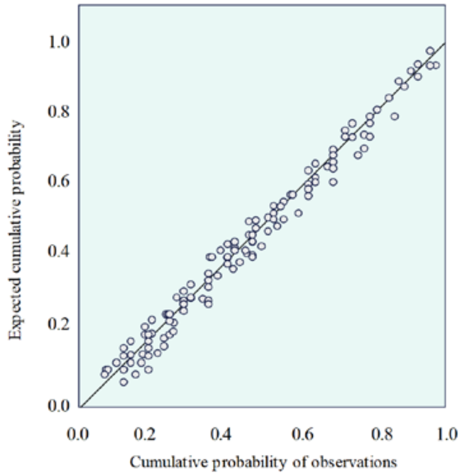
Soil layer cm	Minimum value g/kg	Maximum value g/kg	Average g/kg	Standard deviation	Skewness coefficient	Kurtosis coefficient	Variation coefficient
0~20	0.8282	10.3222	4.2016	2.5149	0.4545	0.6868	60.60%
20~40	1.212	10.4333	4.3733	2.2927	0.5353	0.3333	52.84%
40~60	0.9999	11.6554	5.0904	2.7977	0.4949	0.6868	55.58%
60~80	1.4544	11.3524	5.7873	3.131	0.2323	1.3332	54.69%
80~100	1.414	16.5034	7.575	4.4642	0.3838	1.0807	59.56%

However, although the classical statistical analysis of soil salt content generalizes the whole picture of soil salt content, it often cannot reflect some local variation characteristics, that is, it only reflects the overall situation within a certain range, but cannot quantitatively and fully show the randomness, structure, independence and correlation of soil salt distribution. In order to solve these problems, it is necessary to further use geostatistical methods to analyze and discuss the spatial variation structure.

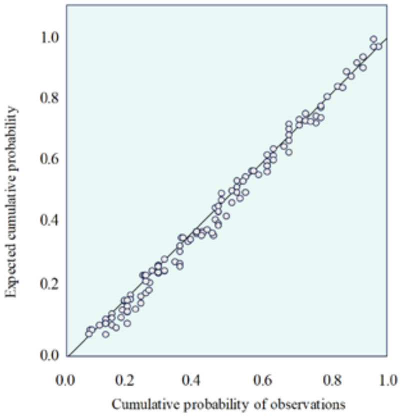
In this study, the P-P normal probability graph of SPSS 18.0 software is used to test the normal distribution, which is a graph generated according to the cumulative ratio of variable distribution and the cumulative ratio of normal distribution. If the data is normal distribution, the tested data is basically straight. Then the normal distribution test of soil salt content in soil layer is shown in Figure 7. The data layer of soil salt content is checked by normal analysis to find out whether the salt content of each soil layer conforms to the normal distribution, and the data used to calculate the variogram is the original data.



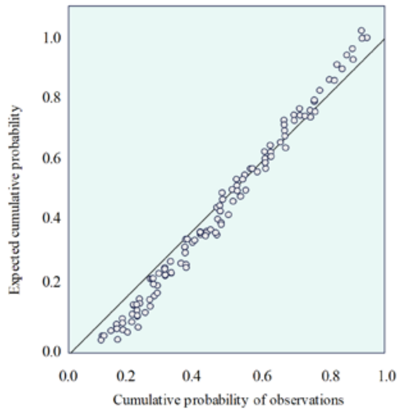
(a) 0-20cm



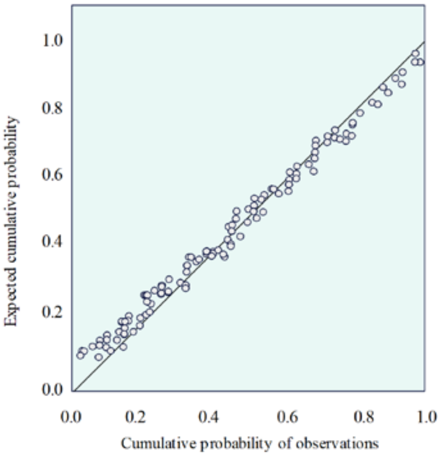
(b) 20-40cm



(c) 40-60cm



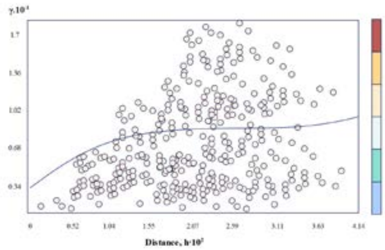
(d) 60-80cm



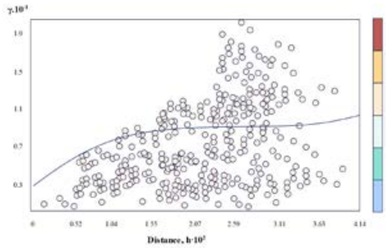
(e) 80-100cm

Figure 7 Normal distribution test of soil salt content in soil layer

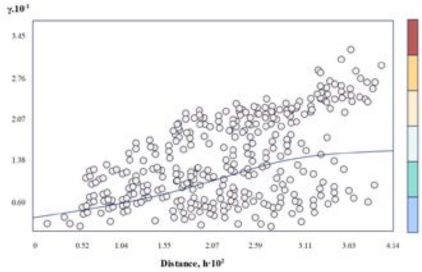
The spatial variability of soil salt content in each layer is studied, and the semi-variance function diagram is drawn. Then, the semi-variance function graph takes the semi-variance as the ordinate and the sampling distance as the abscissa, and draws the graph of the variance function, and obtains Figure 8.



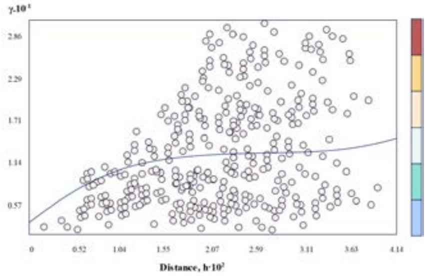
(a)0-20cm



(b)20-40cm



(c)40-600cm



(d)60-80cm

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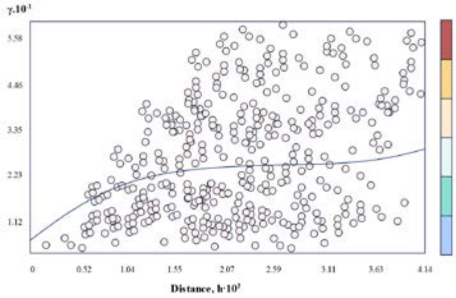

(e)80-100cm

Figure 8 Theoretical model and semi-variance diagram of soil salt content in soil layer

With the increase of soil depth, the influence of external factors continues to weaken, thus strengthening the influence of internal factors caused by strong autocorrelation function. In other words, the strong spatial correlation of soil salt content is influenced by structural factors (topography, soil type and soil parent material, climate). Therefore, the salinization of soil in the study area is mainly due to seawater intrusion and strong evaporation. Although there are human factors in the study area, the salt accumulation type in the soil layer is "bottom accumulation type", which shows that this phenomenon is dominated by natural factors.

Combined with big data technology, the mechanism analysis is carried out, and the laws of daily change, long-term change and rainfall period of water and salt migration are obtained from field observation. It is concluded that the law of water and salt migration is relatively stable in one day, and the distribution of salt content in the vertical direction is not a single change, but the salt content in different soil layers is different under various influencing factors. During rainfall, it is found that the peak value of soil profile resistivity (except the surface change) began to move to the lower layer with the passage of time, so the peak value moves down, and the law that the migration rate of soil water and salt gradually slowed down with the passage of time after this rainfall is obtained.

5 CONCLUSION

In the course of exploitation and utilization of saline-alkali land, we need to master the law of soil water and salt movement, so that through reasonable planning of crop irrigation system, adjustment and control of soil water and salt dynamics, it can adapt to the requirements of sustainable and stable development of agricultural production, and make water-saving irrigation achieve the best economic and ecological benefits. This has important practical significance for developing water-saving irrigation, protecting fresh water resources, improving the production capacity of water and soil resources and realizing the sustainable development of agriculture. In this paper, combined with big data technology, the test of water and salt transport in soil transition layer under the condition of water storage irrigation and its mechanism are studied. The model is based on the basic principle of water and salt balance, and can simulate and analyze the interannual dynamic changes of water and salt in regional cultivated land and wasteland. Moreover, the model has been successfully used in many areas and different soil conditions, and achieved good simulation results. In addition, this paper combines big data technology to process the model data, and uses normal test analysis to find out whether the salt content of each soil layer conforms to the normal distribution, and combines with big data technology to perform mechanism analysis and verify the effectiveness of this method:

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3.The key R&D and promotion project of Henan Province, "Water and nitrogen coupling mechanism and key technologies for water conservation and efficiency enhancement of maize alternative irrigation".

REFERENCES

[1] Rathi, S. (2021). S-PLACE GA for optimal water quality sensor locations in water distribution network for dual purpose: regular monitoring and early contamination detection–a software tool for academia and practitioner. *Water Supply*, *21*(2), 615-634.

[2] Ballen, S. C., Ostrowski, G. M., Steffens, J., & Steffens, C. (2021). Graphene oxide/urease nanobiosensor applied for cadmium detection in river water. *IEEE Sensors Journal*, *21*(8), 9626-9633.

[3] Tshamala, A. K., Musala, M. K., Kalenga, G. K., & wa Mumapanda, H. D. (2021). Assessment of Surface Water Quality in Kakanda: Detection of Pollution from Mining Activities. *Journal of Environmental Protection*, *12*(9), 561-570.

[4] Santonastaso, G. F., Di Nardo, A., Creaco, E., Musmarra, D., & Greco, R. (2021). Comparison of topological, empirical and optimization-based approaches for locating quality detection points in water distribution networks. *Environmental Science and Pollution Research*, *28*(26), 33844-33853.

[5] Mabvouna Biguioh, R., Adogaye, S. B. B., Pete, N., Martial, P., Sanou Sobze, M., Kemogne, J. B., & Colizzi, V. (2020). Microbiological quality of water sources in the West region of Cameroon: quantitative detection of total coliforms using Micro Biological Survey method. *BMC public health*, *20*(1), 1-7.

[6] Jongman, M., Carmichael, P. C., & Bill, M. (2020). Technological advances in phytopathogen detection and metagenome profiling techniques. *Current Microbiology*, *77*(4), 675-681.

[7] Bayat, F., Didar, T. F., & Hosseinidoust, Z. (2021). Emerging investigator series: bacteriophages as nano engineering tools for quality monitoring and pathogen detection in water and wastewater. *Environmental Science: Nano*, *8*(2), 367-389.

[8] Motlagh, A. M., & Yang, Z. (2019). Detection and occurrence of indicator organisms and pathogens. *Water Environment Research*, *91*(10), 1402-1408.

[9] Kitajima, M., Sassi, H. P., & Torrey, J. R. (2018). Pepper mild mottle virus as a water quality indicator. *NPJ Clean Water*, *1*(1), 1-9.

[10] Song, H., Zhou, Y., Li, Z., Zhou, H., Sun, F., Yuan, Z., ... & Hu, J. (2021). Inner filter effect between upconversion nanoparticles and Fe (ii)–1, 10-phenanthroline complex for the detection of Sn (ii) and ascorbic acid (AA). *RSC Advances*, *11*(28), 17212-17221.