УДК: 614.79+556.5

СИРДАРЁ ГИДРОКИМЁВИЙ РЕЖИМИНИНГ МАКОН ВА ВАҚТ БЎЙИЧА УЧ ЎЛЧАМЛИ (3-D) ТАҲЛИЛИ

Мягков Сергей Владимирович,
техника фанлари доктори, «Гидрологик моделлаштириш» бўлими мудири

Гидрометеорология илмий-текшириш институти, Ўзгидромет

Аннотация. *Ер ва сув ресурсларидан оқилона фойдаланиш бўйича илмий асосланган таклифларни ишлаб чиқишда қишлоқ хўжалиги ерларининг суғориладиган ҳудудларидан ҳамда дарё ҳавзасидан тўйинадиган дарёларнинг гидрокимёвий режимини таҳлил этиш зарур. Дарёлар ҳавзаларидаги ер ва сув ресурсларига антропоген омиллар таъсири, ўз навбатида, юза сувларнинг сифати ўзгаришига олиб келади. Мақолада асосий дарёнинг узунлиги бўйича минерализация миқдорининг макон ва вақт бўйича тарқалишини уч ўлчамли модель асосида дарёларнинг гидрокимёвий режимини таҳлил қилишнинг янги методи таклиф этилади. Мазкур метод дарёларга ифлослантирувчи моддаларнинг келиб тушишини таҳлил қилиш, дарёлар гидрокимёвий режимининг шаклланиши ва ифлосланишининг асосий сабабларини аниқлаш имконини беради.*

Таянч тушунчалар: *минерализация, гидрокимёвий режим, моделлаштириш, суғориш, ифлосланиш, дарё ҳавзаси.*

ТРЕХМЕРНЫЙ (3-D) ПРОСТРАНСТВЕННО-ВРЕМЕННОЙ АНАЛИЗ ГИДРОХИМИЧЕСКОГО РЕЖИМА РЕКИ СЫРДАРЬЯ

Мягков Сергей Владимирович,
доктор технических наук,
заведующий отделом «Гидрологическое моделирование»

Научно-исследовательский гидрометеорологический институт, Узгидромет

Аннотация. *Для разработки научно обоснованных рекомендаций по рациональному использованию водных и земельных ресурсов необходимо проводить анализ гидрохимического режима рек, питающих орошаемые территории сельскохозяйственных земель в бассейне реки. Антропогенное влияние на водные и земельные ресурсы в бассейнах рек неизбежно влияет на изменение качества поверхностных вод. В статье предлагается новый метод анализа гидрохимического режима рек на основе трехмерного (3-D) моделирования пространственно-временного распространения минерализации воды по длине основной реки. Данный метод позволяет проводить анализ поступления загрязняющих веществ в реку, выявлять основные причины поступления загрязнений и формирования гидрохимического режима рек.*

Ключевые слова: *минерализация, гидрохимический режим, моделирование, орошение, загрязнение, бассейн реки.*

THREE-DIMENSIONAL (3-D) SPATIAL-TEMPORAL ANALYSIS OF THE HYDROCHEMICAL MODE OF THE SYRDARIA RIVER

Myagkov Sergey Vladimirovich,
Doctor of Technical Sciences

Head of the Department of Hydrological Modeling, Uzhydromet

Abstract. *The analysis of the hydrochemical regime of the rivers feeding the irrigated territories of agricultural land in the river basin is essential to develop scientifically based recommendations on the rational use of water and land resources. Anthropogenic influence on water and land resources in the basins of the rivers inevitably affects the change of surface water quality. A new method is proposed for analyzing the hydrochemical regime of the rivers based on three-dimensional (3-D) modelling of the spatio-temporal distribution of water mineralization along the length of the main river. This method allows to analyze the flow of pollutants into the river, identify the main causes of pollution and the formation of the hydrochemical regime of rivers.*

Keywords: *mineralization, hydrochemical regime, modeling, irrigation, pollution, river basin.*

Introduction

A change in the system of agro-industrial use of irrigated land inevitably leads to a change in the water intake regime and volume of drainage discharged collector - drainage water hydrological regime of return water and the amount of substances dissolved in the water. The hydrochemical regime of the main watercourse used in the irrigation system inevitably changes, since water is taken in to produce better water and the discharge of collector-drainage water has a higher salinity [9].

The used methods of water balance and their statistical processing are used in the analysis of water regime irrigated areas to ensure efficient use of land and water resources. These studies and their application in practice create conditions for increasing the fertility of irrigated tracts. The scientific study of the elements of the water balance of irrigated territories and their expression in the form of a balance equation, as well as the improvement of methods for the quantitative assessment of the constituents, is of great scientific and practical importance [10].

For hydrological calculations and calculations of the irrigation regime, it is necessary to take into account the hydrochemical regime of the main river bed, the mineralization of which determines the calculation system for water consumption.

The application of the analysis of the spatial and temporal distribution of salinity in the river, based on the construction of three-dimensional (3D) surface in which the axis «X» defer space consisting of a line n -OPERATION, or distance from the top of the hydrological alignment to the lower, axially «Y» to delay time and the axis “Z” values of mineralization, the resulting surface can serve as a basis for the analysis of the development of the hydrochemical process in the river.

The model of the formation of the hydrochemical regime

In general terms, the water balance equation for an irrigated area can be written as follows:

$$X+V+G\,p+P=+Go+E+K\pm\Delta B \quad (1)$$

where X is precipitation, V is water intake for irrigation, Gp is groundwater inflow, P is surface water inflow (streams, slope runoff, etc.), Go - underground outflow from this territory, E is total evaporation from the surface and transpiration by plants, K is water used for industrial and domestic needs, ± ΔB is the discrepancy of balance.

In the work of Vandewiele Gl and Elias [12], a detailed formula of the salt balance of the irrigated area is given:

$$Viw * Ciw + Vgw * Cgw + Sm + Sf - Vdw * Cdw - Sp - Sc = Saw \quad (2)$$

where Viw, Vgw, Vdw – volumes of irrigation, groundwater, drainage water; Ciw, Cgw, Cdw – salt concentrations. Vgw is not groundwater, but water, which is in the root zone and where it comes from groundwater. Sm - salts formed from weathering of minerals, the value is negligible and neglected.

W salts which are already present as a solid precipitate in the soil and the soil, are described by the general salt balance formula:

$$\Delta S = Sz + Suw - suw + Siw - Sv, \quad (3)$$

where ΔS is the change in the total salt reserve; Sz is the total salt reserve at the beginning of the balance period; Suw is the input of salts from groundwater into the soil; suw is the outflow of salts from groundwater into drains; Siw is the input of salts with irrigation water; Sv is the removal of salts with the crop, can be neglected by irrigation.

Scheme of the relationship between water and salt balance:

$$J * C = Q * C1 + Qdr * C2, \qquad (4)$$

where J is all kinds of irrigation water inflow, C is the concentration of salts in the irrigation water, Q is natural outflow of groundwater, C1 is the concentration of salts in naturally flowing groundwater, C2 is average actual groundwater salinity in the soil area, Qdr is drainage outflow without waste water, Ck is critical concentration of salts in groundwater.

Capacitive model of water-salt balance dynamics

Imagine the river in the form of elementary sections connected in series, and some elementary section of the river when used and irrigation water in the form of a diagram (Fig. 1). The water intake is performed upstream and discharge of return water occurs downstream. Then for each element of the river section, we give a simplification of the equation of water balance.

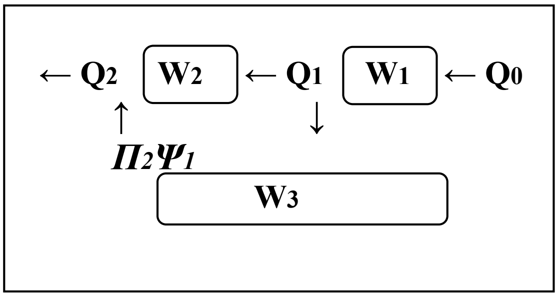

Figure 1: Balance sheet of a river section with water intake and discharge of return water.

The equations for each elementary volume are written as follows:

$$\begin{aligned} dW_1 / dt &= Q_0 - Q_1 - \Psi_1 \\ dW_2 / dt &= Q_1 - Q_2 + \Pi_2 \\ dW_3 / dt &= \Psi_1 - \Pi_2 \end{aligned} \qquad (5)$$

where W_j - number and honors water in a volume element, Q_j - water flow between the elements, Ψ - volumes of water per unit time, Π - return water volume per unit time.

The change in the concentration of a substance in each element is written by the equation

$$\begin{aligned} d(C_1W_1)/dt &= C_0Q_0 - C_1Q_1 - C_1\Psi_1 \\ d(C_2W_2)/dt &= C_1Q_1 - C_2Q_2 + C_2\Pi_2 \\ d(C_3W_3)/dt &= C_1\Psi_1 - C_2\Pi_2 \end{aligned} \qquad (6)$$

where C j is the concentration of a substance dissolved in water.

The volume of return water depends on the volume of water intake, for example, according to Ganiev A.M. [2], the functional dependence of drainage runoff from the water intake of administrative districts of Syrdarya river basin in annual terms represent a linear dependence of the form:

$$Dkds = \lambda * V + \mu \qquad (7)$$

or exponential form:

$$Dkds = \lambda * EXP(\mu * V) \qquad (8)$$

where: Dkds - the volume of drainage and discharge flow, mln. m3, B - water intake for irrigation, mln. m 3, "λ" and "μ" are some empirical coefficients. In all cases, the correlation coefficient is in the range from 0.86 to 0.93.

Earlier, we obtained the dependence of the volumes of return water entering the river on the amount of water supplied for irrigation (water intake for irrigation) in the decade context [6]:

$$\Pi_2(\tau)=\alpha\Pi_2(\tau-1)+\beta[\Psi_1(\tau)+\Psi_1(\tau-n)] \qquad (9)$$

Where «τ» is a certain point in time, n is the time taken by the passage of irrigation water through the water delivery system to the field, filtration into groundwater, drainage system (in decades), "α" and "β" are the coefficients, the numerical values of which are obtained by the least squares method based on hydrological observations for the main water management areas of the Syrdarya river basin.

Then the volume of the return water from a certain territory is determined by a certain functional dependence: Π j = ƒ (Ψ j) therefore, the total mineralization of water in the river is determined by the volume of water withdrawal for irrigation.

In Fig.2. the hydrograph of the average annual salinity of water along sections of the Syrdarya river and the main components: the Naryn and Karadarya rivers is presented.

We note the increase in the total mineralization of water in the Syrdarya river from the upper alignment to the bottom of the

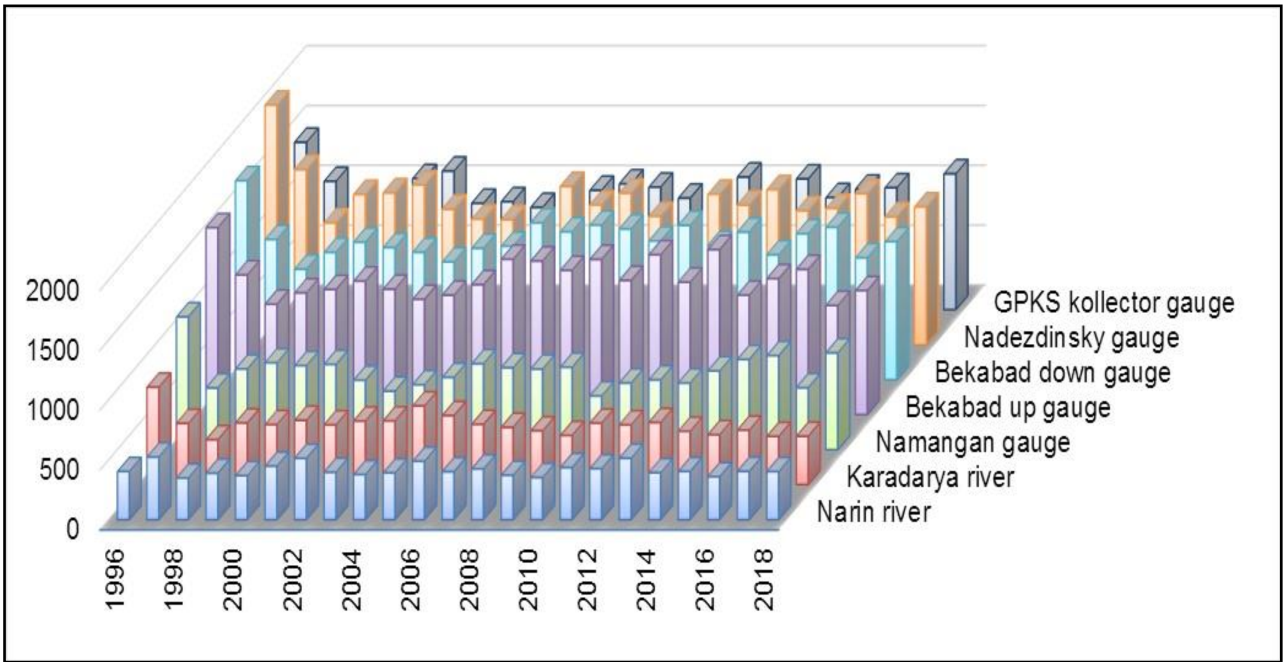

Fig. 2. The diagram of the distribution of water mineralization (mg / l) is the vertical axis, years are the horizontal axis and names of the observation lines, the lower line is the upper course of the Syrdarya River, the upper line is the lower stream of the Syrdarya.

flow. The change in the temporal dynamics of mineralization from year to year is clearly visible. However, in this diagram it is difficult to isolate and analyze the spatial-temporal dynamics of mineralization.

In this regard, it is proposed to present these observational materials in the form of a three-dimensional (3-D) surface (Fig. 3.).

In Fig. 3. a noticeable decrease in total mineralization in the period from 1996 to 2018 was observed in almost all sections of the Syrdarya river. An increase in mineralization in the middle reaches of the river and a decrease in mineralization to the lower reaches are noticeable as well.

The reason for the increase in water mineralization in the middle reaches of the river is a large discharge of industrial and return waters formed in irrigated areas.

The subsequent decrease in water salinity in the middle reaches is explained by the flow of more fresh water from the lateral tributaries of the rivers of the basin, which are formed in territories without anthropogenic impact.

However, in the subsequent growth of mineralization is observed again, which is explained by the flow of water from the Chirchik and Akhangaran rivers basins, since they experience a significant anthropogenic pressure, that is many industrial enterprises, vast areas of agricultural production, urban agglomerations, industrial facilities of the cities of Tashkent, Chirchik, Angren, Akhangaran and others.

Thus, the analysis of the spatial and territorial distribution of the mineralization of the Syrdarya river using the three-dimensional (3-D) representation of the observed values becomes simpler and clearer, therefore, the development of recommendations on water use and water consumption is more justified and scientifically substantiated.

Three-dimensional analysis allows to identify the main sources of pollution and salts, thereby increasing mineralization in the main channel of the Syrdarya river.

The vertical axis is the values of total mineralization (mg / l), the observation period by year, the distance from the upper section to the lower Syrdarya river.

Conclusions

The use of the three-dimensional (3-D) method of analyzing the spatiotemporal distribution of mineralization values allows to improve the whole practice of designing irrigation systems.

This approach will improve the compilation

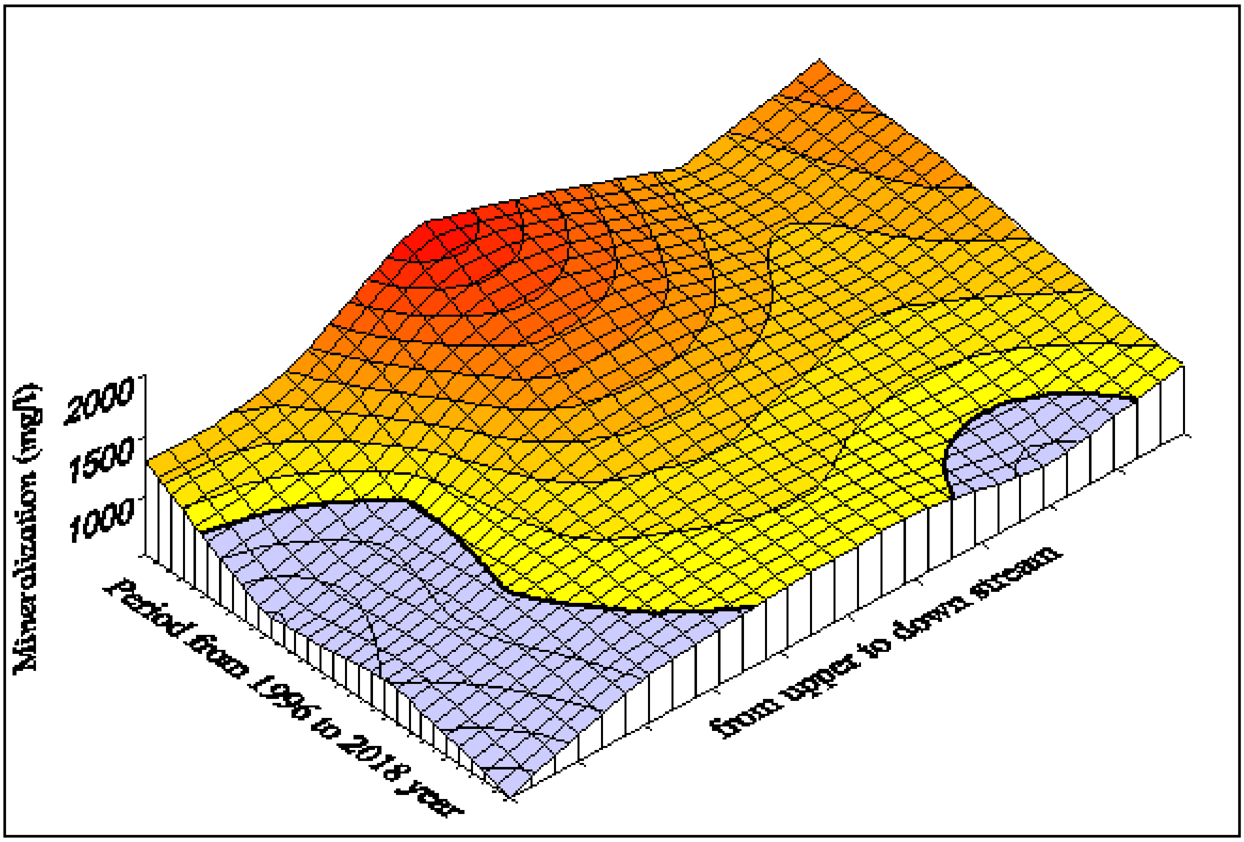

Fig. 3. Spatial-temporal distribution of water mineralization in the Syrdarya River, presented in the form of a three-dimensional (3-D) surface.

of detailed maps: soil, physical-lithological, and chemical properties of soil, soil, groundwater, maps of bundle inventory salts.

Since the water and salt balance of territories can be very different from the previous ones, when changing the irrigation systems over time, it is necessary to draw up a working - control (information) water-salt balance, based on the use of a 3-D salinity analysis in the main river irrigated areas.

References

1. Drainage Manual: A Guide to Integrating Plant, Soil, and Water Relationships for Drainage of Irrigated Lands // Interior Dept., Bureau of Reclamation. – 1993. – ISBN 978-0-16-061623-5.

2. Ganiev A.M. Graph-analytical method for assessing and predicting the interaction of the irrigated territory with the river // On Sat articles of the conference AuzIUWR. – T., 2000. – Pp. 41-42.

3. Hukkinen J., Roe E., Rochlin G.I. A salt on the land: A narrative analysis of the controversy over irrigation-related salinity and toxicity in California's San Joaquin Valley // Policy Sciences 23.4. – 1990. – Pp. 307–329.

4. Konovalov V.G., Karandaeva L.M. Methods and Experience of forecasting of an annual runoff on the basic rivers of Central Asia until year 2000 // Proceedings of the International Conference on World Water Resources at the Beginning of the 21-st Century. – UNESCO, Paris, France. – 3-6 June, 1998. – IHP-V Technical Documents in Hydrology. – No 18.

5. Merchant C. American Environmental History: An Introduction // Columbia University Press. – 2007. – ISBN 978-0231140355.

6. Myagkov S.V., Sokolov V.I. Features of the formation of drainage and waste waters and the methodology for their prediction in the Syrdarya river basin. – Tr. SANIIRI, 1986. – Pp. 114-123.

7. Nijland H.J., Guindy S.E. Crop production and topsoil // surface-water salinity in farmer's rice-fields,

the Nile Delta // Smith, KVH and DW Rycroft (eds.), Hydraulic Design in Water Resources. Engineering: Land Drainage. Proceedings of the 2nd International Conference. – Southampton University. – Springer Verlag, Berlin. – 1986. – Pp. 75-84.

8. Oosterbaan R.J. The study of effects of drainage on agriculture // International Institute for Land Reclamation and Improvement. – 2009.

9. Rodda J.C; Ubertini L. The Basis of Civilization – water Science // International Association of Hydrological Science. – 2004. – ISBN 9781901502572.

10. Snedecor G.W., Cochran W.G. Statistical methods // Lowa State University Press. – 8-th ed. – 1986. – 593 p.

11. Vandewiele G.l., Elias A. Monthly water balance model including deep infiltration and canal losses // HydrolSci. Bull. – No 22 (3). – Pp. 341-351.

12. Williamson R.E.. Kriz G.J. Response of agricultural crops to flooding, depth of water table, and soil gaseous composition. – 1970.

13. Yakubov M.A. Features of reclamation-hydrological processes in the river basins of the Syrdarya and Amudarya rivers and regulation of their water quality: Abstract of a DSc dissertation. – T.: NPO SANIIRI, 1997. – 49 p.

Reviewer:

Rakhimov Sh. Kh., Doctor of Engineering Sciences, Professor, Head of the Department of Irrigation, Central Asian Irrigation Research Institute.