ОШ МАМЛЕКЕТТИК УНИВЕРСИТЕТИНИН ЖАРЧЫСЫ. АЙЫЛ ЧАРБА: АГРОНОМИЯ, ВЕТЕРИНАРИЯ ЖАНА ЗООТЕХНИЯ

ВЕСТНИК ОШСКОГО ГОСУДАРСТВЕННОГО УНИВЕРСИТЕТА. СЕЛЬСКОЕ ХОЗЯЙСТВО: АГРОНОМИЯ, ВЕТЕРИНАРИЯ И ЗООТЕХНИЯ

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ENVIRONMENTALLY ACCEPTABLE NORMS OF MAN-MADE LOADS ON IRRIGATED LANDS DURING WASTEWATER DISPOSAL

ЭКОЛОГИЧЕСКИ ДОПУСТИМЫЕ НОРМАТИВЫ ТЕХНОГЕННЫХ НАГРУЗОК НА ОРОШАЕМЫЕ ЗЕМЛИ ПРИ ОТВЕДЕНИИ СТОЧНЫХ ВОД

САРКЫНДЫ СУУЛАРДЫ ЧЫГАРУУДА СУГАТ ЖЕРЛЕРГЕ ТЕХНОГЕНДИК ЖҮКТӨРДҮН ЭКОЛОГИЯЛЫК ЖАКТАН АЛГЫЛЫКТУУ ЧЕНЕМДЕРИ

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ENVIRONMENTALLY ACCEPTABLE NORMS OF MAN-MADE LOADS ON IRRIGATED LANDS DURING WASTEWATER DISPOSAL

Annotation

Nature management in a broad sense is considered as a combination of various forms of exploitation of the natural resource potential of natural and natural-man-made systems and measures to preserve it. Its most important component is the preservation, reproduction and rational change of the ecological balance of natural systems. It is from these positions that it seems necessary to determine environmentally acceptable norms of man-made loads on irrigated lands during the disposal of wastewater, widely used in the practice of water supply and sanitation. The use of wastewater from industrial and municipal facilities for irrigation of land is of fundamental importance from both ecological and economic positions. From an ecological point of view, the use of wastewater for irrigation of agricultural crops, in the presence and creation of waste-free and safe technologies for their disposal in irrigation fields, can serve as the basis for rational nature management, since at the same time the ecological sustainability of landscapes is ensured, which in turn makes possible the long-term exploitation of natural resources without their pollution and degradation. From an economic point of view, by creating agricultural landscapes in unproductive lands, using wastewater from industrial and municipal facilities, it is possible to ensure the production of a certain amount of agricultural products, provided that the damage caused to the natural system (S) will be less than the profit (S). Under these conditions, the object of wastewater disposal is the soil, which requires the need to determine a number of environmentally effective ways to optimize the soil-forming process, which would create, in an agroecological and economic sense, a perfect technology for their disposal, taking into account the laws of nature.

Keywords: wastewater, drainage, irrigation, water resources.

Экологически допустимые нормативы техногенных нагрузок на орошаемые земли при отведении сточных вод

Аннотация

Природопользование в широком смысле рассматривается как совокупность различных форм эксплуатации природно-ресурсного потенциала природных и природно-антропогенных систем и мер по его сохранению. Важнейшей его составляющей является сохранение, воспроизводство и рациональное изменение экологического равновесия природных систем. Именно с этих позиций представляется необходимым определение экологически приемлемых норм техногенных нагрузок на орошаемые земли при отведении сточных вод, широко применяемых в практике водоснабжения и водоотведения. Использование сточных вод промышленных и коммунальных объектов для орошения земель имеет принципиальное значение как с экологических, так и с экономических позиций. С экологической точки зрения использование сточных вод для орошения сельскохозяйственных культур при наличии и создании безотходных и безопасных технологий их утилизации на полях орошения может служить основой рационального природопользования, поскольку при этом обеспечивается экологическая устойчивость ландшафтов, что в свою очередь делает возможной длительную эксплуатацию природных ресурсов без их загрязнения и деградации. С экономической точки зрения, путем создания

Саркынды сууларды чыгарууда сугат жерлерге техногендик жүктөрдүн экологиялык жактан алгылыктуу ченемдери

Аннотация

Айлана-чөйрөнү башкаруу кеңири мааниде табигый жана табигый-антропогендик системалардын жаратылыш ресурстук потенциалын пайдалануунун ар кандай формаларынын жана аны сактоо боюнча чаралардын жыйындысы катары каралат. Анын эң маанилүү компоненти болуп жаратылыш системаларынын экологиялык балансын сактоо, көбөйтүү жана рационалдуу өзгөртүү саналат. Дал ушул позициялардан саркынды сууларды чыгарууда сугат жерлерге техногендик жүктөрдүн экологиялык жактан алгылыктуу ченемдерин аныктоо зарыл болуп турат, алар суу менен камсыздоо жана санитария практикасында кеңири колдонулат. Өндүрүштүк жана муниципалдык объекттердин саркынды сууларын жерди сугаруу үчүн пайдалануу экологиялык жактан да, экономикалык жактан да принципиалдуу мааниге ээ. Экологиялык көз караштан алганда, айыл чарба өсүмдүктөрүн сугаруу үчүн саркынды сууларды пайдалануу, аларды сугат талааларында калдыксыз жана коопсуз технологиялар болгондо жана түзүүдө экологияны сарамжалдуу башкаруунун негизи боло алат, анткени бул ландшафттардын экологиялык туруктуулугу, бул өз кезегинде жаратылыш ресурстарын булгануусуз жана деградациясыз узак мөөнөттүү эксплуатациялоого мүмкүндүк берет. Экономикалык көз караштан алганда, өндүрүштүк жана муниципалдык объектилердин саркынды агроландшафтов на малопродуктивных землях, используя сточные воды промышленных и коммунальных объектов, можно обеспечить производство определенного количества сельскохозяйственной продукции при условии, что ущерб, наносимый природной системе (S), будет меньше прибыли (S). В этих условиях объектом утилизации сточных вод является почва, что обусловливает необходимость определения ряда экологически эффективных способов оптимизации почвообразовательного процесса, которые позволили бы создать в агроэкологическом и экономическом смысле совершенную технологию их утилизации, учитывающую законы природы.

Ключевые слова: сточные воды, дренаж, орошение, водные ресурсы.

сууларын пайдалануу менен түшүмсүз жерлерге айыл чарба ландшафттарын түзүү менен табигый системага (S) зыян азыраак болгон шартта айыл чарба продукциясынын белгилүү бир көлөмүн өндүрүүнү камсыз кылууга болот. пайдадан (S) караганда. Мындай шарттарда саркынды сууларды жок кылуу объекти болуп кыртыш эсептелет, ал кыртыштын түзүлүүчү процессин оптималдаштыруунун бир катар экологиялык жактан эффективдүү ыкмаларын аныктоону талап кылат, бул агроэкологиялык жана экономикалык мааниде сууну агып чыгууну түзүүгө мүмкүндүк берет. жаратылыш закондорун эсепке алуу менен аларды утилдештирүү үчүн кемчиликсиз технология.

Ачкыч сөздөр: саркынды суулар, дренаждар, сугат, суу ресурстары.

Introduction

A systematic analysis of the results of studies on wastewater disposal in irrigation fields conducted in various countries has shown that the main factors hindering the expansion of agricultural irrigation fields are:

- the complexity of the chemical composition of wastewater, which have complex effects on the soil microflora and physiological processes in plants;

- the possibility of accumulation and decomposition in soil and plants of substances harmful to farm animals and humans that require strict control of sanitary and epidemiological services;

- insufficient knowledge of the medical and biological evaluation of crop and livestock products;

- lack of structural and functional integrity of irrigation fields with ecological systems;

- ecological non-safety of the irrigation field during wastewater disposal;

- lack of technological, economic, environmental and legal mechanisms for waste water disposal in irrigation fields.

With prolonged utilization of wastewater in irrigation fields, as the anthropogenic load increases, the intensification of moisture, mass, and heat transfer processes, the structural and functional integrity of the agricultural landscape is violated, and its bioproductivity decreases. Regulation of anthropogenic impacts, early diagnosis, localization and restoration of damaged environmental components during wastewater disposal in irrigation fields contribute to strengthening the internal regulation of the system, and restore the potential for optimal development of the soil-forming process in agricultural landscapes.

In this regard, there is a need to form an environmentally sound strategy for safe disposal and a fundamental concept for the use of wastewater, based on the following principles:

- maximum use of the evaporating capacity of the moisture of the natural system in the disposal of wastewater, using the principle of energy balance of heat, moisture and nutrients, taking into account natural regimes;

- preservation and reproduction of soil fertility, taking into account natural regimes that allow for the preservation of an environmentally friendly energy regime in the soil;

- prevention of contamination of soils, water, plants in the process of agricultural production, water consumption and sanitation;

- taking into account the diffuseness of wastewater, regulation of its chemical composition and, in the future, disposal in the places of their formation;

- on the basis of the principle of unity and integrity of nature management, the creation of a natural production complex for waste-free and safe disposal of wastewater.

Based on a systematic analysis of methods for regulating water, salt, heat and food regimes of soils as the basis of the soil-forming process and ensuring the needs of intensive agriculture in various agro-climatic zones of Kazakhstan, J.S. Mustafayev and S.S. Sadykov [1] proposed a simulation model of the soil-forming process based on the teachings of Dokuchaev-Williams-Kostyakov on the genesis and reclamation of soils, as a special natural body and Dokuchaev–

Grigoriev–Budyko on the law of evolution and geographical zonality of soils. When developing a simulation model of the soil-forming process, a special place was occupied by the doctrine of the evolution of soils, considering the soil in dynamics and development. At the same time, it was based on the position of P.S. Kossovich that every soil formation of this time reflects the entire past history [2].

The calculation of the elements of heat, water balances and other moisture indicators for some years makes it possible to obtain a variational series of these values. If the general law of probability distribution for each indicator of heat and water balance is known, then particular distributions for any particular series can be constructed according to empirical distribution parameters.

Materials and methods of research

The basic principle of the proposed environmentally safe and waste-free disposal of wastewater on irrigated lands is based on the properties of the geosystem:

- openness, that is, the possibility of the existence of a geosystem or soil, which are their components, only in the presence of a constant exchange of substances and energy with the environment;

- integrity – interconnection and interdependence of individual components of the geosystem;

- functioning – the process of mass and energy transfer, both within a geosystem and between coupled geosystems;

- dynamics – the ability of a geosystem to restore its properties under short-term impacts (reversible changes);

- stability – the ability of a geosystem to maintain its structure under changing external, including anthropogenic influences;

- evolution is an irreversible change in the geosystem associated with a change in its structure or individual components.

Thus, environmentally safe and waste-free disposal of wastewater is carried out on the basis of their periodic accumulation on soil layers, taking into account water-physical properties and preserving the energy balance of heat, moisture and nutrients within certain spatial and temporal limits. Therefore, the soil layer of irrigated lands can be considered as an open system that performs the functions of, on the one hand, an accumulating and evaporative reservoir for wastewater disposal, on the other hand, a production facility producing agricultural products [3].

In this regard, the main object of land reclamation that ensures the disposal of wastewater on irrigated lands is the soil, including vegetation, wildlife, ground and surface waters, that is, the agricultural landscape. Firstly, the soil is the habitat of the biota of microorganisms and invertebrates, algae, higher plants and other living organisms. Therefore, the properties of the soil and its regimes largely determine the characteristics of the soil cover as a habitat. Secondly, from an applied point of view, measures for the ecological protection of soils as a habitat for higher plants, in particular agricultural crops, are of particular interest and importance. Therefore, when disposing of wastewater on irrigated lands, the issues of soil reclamation and nature protection should be considered in two aspects: environmental protection of the landscape as an environment for the formation of soil cover and human habitation and environmental protection of soils as a habitat for biota, in particular agricultural crops [4].

Results and discussion

Before formulating environmental requirements for the parameters and modes of man-made loads during wastewater disposal on irrigated lands, it is necessary to consider in detail the relationship between the creation of an agricultural landscape and the corresponding transformation of nature.

Since the landscape components form an inseparable, stable, interconnected geosystem, it is practically impossible to manage or change one of them from the point of view of creating an environmentally safe and waste-free technology. This implies the need to carry out landscape protection measures aimed at protecting the natural environment as a whole, at protecting the landscape.

According to the ecological law of optimality, any natural system can function effectively only within certain spatial and temporal limits. The desire to intensify the utilization of wastewater on irrigated lands without due consideration of the laws of ecology and nature management always leads to energy overload, deterioration of physical and biochemical characteristics of soils.

Therefore, the principle of energy balance of heat, moisture and nutrients, taking into account natural regimes, allowing for the preservation of an environmentally favorable energy regime in the soil, was used to determine environmentally acceptable standards for the disposal of wastewater on irrigated lands [5].

The ratio of the radiation balance (R) to the heat costs for evaporation (L=590 cal.) of precipitation (Os) can be used to determine the environmentally acceptable rate of man-made loads (Op), during the disposal of wastewater on irrigated lands:

$$O_p = R/(\bar{R} L) - O_c$$

Where $\bar{R}$ is the hydrothermal coefficient.

To determine the variability of the heat and energy resource of irrigated lands, it is possible to use the sum of air temperatures accumulated during the growing season by agricultural crops or the biologically active period of the year, and on its basis determine photosynthetic active radiation (PhAR) for the year according to the following dependence (V.V. Shabanov, 1988):

$$R = 13.93 + 0.0079 \sum t^o C$$

Where $\sum t^o C$ is the integral sum of air temperatures for the growing season of agricultural crops or the biologically active period in that year.

The one-time soil-ecological norm of technogenic loads on irrigated lands (m) during wastewater disposal is determined taking into account the water-physical properties of the soil, the capacity of the moistened soil layer (H) and water density (d_{H_2O}) according to the formula:

$$т = 100 \cdot H \cdot d_n (\beta_{hb} - W_{оду}) / d_{H_2O},$$

Where β_{hb} is the lowest moisture capacity, % of the mass of absolutely dry soil, that is, the limit of accumulation of wastewater into the soil; d_n - soil density (volume mass), g/cm3; $W_{оду}$ is thesoil moisture corresponding to the optimal range of moisture, that is, the limit of evaporation of moisture from the soil [6].

The amount of irrigation for the biologically active period of the year is defined as the ratio of the ecologically permissible norm of man-made loads (Or) to the one-time soil-ecological norm of man-made loads (m), that is, n = Or/m.

The duration of the irrigation period is determined taking into account the thermal regime of the decade of the growing season:

T=(m·L)/R_i (t_cp/t_i)

Where Ri isthe average daily radiation balance for the growing season, kcal/cm2; tcpistheaverage daily air temperature during the growing season; ti- average daily air temperature of the i-th decade.

Thus, a certain regime is created on irrigated lands, the so-called hydrothermal regime of irrigated lands [7], which is based on the principle of energy balance of heat and moisture, which differs from the irrigation regime of agricultural crops, according to the object of reclamation and according to the principle of the purpose of the irrigation regime.

In relation to the zones of heat and moisture supply of the Kyzylorda region, the calculation of the environmentally safe norm of man–made irrigation loads during irrigation with wastewater according to the hydrothermal indicator, the results of which are shown in Table 1 [8].

Table1 - Environmentally safe rate of technogenic loads during irrigation with sewage in the conditions of Kyzylorda

Indicators	**Months**						**Irrigationperiod**
	04	05	06	07	08	09	
Natural andenergyresources							
t, ^oC	16.3	22.7	28.4	29.9	27.5	20.3	24.1
$\Sigma t_M, ^oC$	489	704	852	927	852	609	4433
$K_t=\Sigma t_M/\Sigma t$	0.11	0.16	0.19	0.21	0.19	0.14	1.00
$R_M=K_tR$, kcal/cm^2	5.40	7.80	9.30	10.3	9.30	6.80	48.9
Environmentallysafeirrigationstandards							
E, m^3/ha	913	1328	1577	1743	1577	1162	8300
Oc, m^3/ha	200	198	80	40	37	45	600
ΔW, m^3/ha	400	-	-	-	-	-	400
O_p, m^3/ha	313	1130	1497	1703	1577	1117	7337
t_{cp}/t_i	1.48	1.06	0.84	0.80	0.88	1.19	-
T, day	22	16	13	12	13	18	
n	1	1	2	2	1	1	8
$q = m/86.4 \cdot T$, *l/s*	0.12	0.42	0.58	0.64	0.59	0.43	-
W_{bo}, *thousand m3*	535.3	535.3	535.3	478.7	478.7	478.7	3069.0
F_C, *ha*	1710.0	474.0	358.0	281.0	303.6	428.6	592,5

As a criterion level of the radiation dryness index (‾R) for the period of air temperatures above 100C for average long-term conditions, a value of 1.0 is assumed.

Thus, as can be seen from Table 1, the maximum possible area of irrigated land with the use of wastewater in Kyzylorda is 1710.0 ha, and the minimum is 281.0 ha. Then, the total area of permanently irrigated lands, according to the condition of designing irrigation systems for the use of wastewater, is 562.0 hectares.

With environmentally safe and waste-free disposal of wastewater, the hydrothermal irrigation regime, taking into account natural regimes, performs certain functions on irrigated fields, which are the object of management of the main factors of the soil-forming process during the active biological period of the year. In this regard, regardless of the biological characteristics of agricultural crops, a single irrigation regime is observed in crop rotation fields, aimed at maximum utilization of wastewater. Against the background of these irrigation regimes, the cultivation of forage crops is carried out with full compliance with the basic principles of crop alternation and crop rotation. At the same time, the choice of the type of forage crops cultivated in irrigation fields is carried out taking into account their biological characteristics: the sum of active air temperatures (□toC), photosynthetically active radiation (R) and the duration of the growing season (T0) [9].

Theoretical substantiation of soil-ecological norms of irrigation of agricultural crops can be carried out on the basis of the law of conservation of energy, because consideration of the process of moisture exchange in the system "soil - plant - surface layer of air" is unthinkable without connection with the processes of heat exchange. Like any physical process of changes and transformations, the process of heat exchange based on the law of conservation of energy in a specific geographical space for a certain period of time is characterized by a balance of transition and energy consumption:

$$R=LE+B+S$$

Where LE is the heat costs for total evaporation; Ristheradiation balance; Listhelatent heat of vaporization –590 kal; Sistheheat exchange between the surface of the soil and the atmosphere; Bistheheat exchange between the soil layer and the underlying layers of the soil-forming rock; E – total evaporation.

In the works of a number of meteorologists, it is accepted that under irrigation conditions the values of B and S are close to zero. In this case, the formula for determining the radiation balance will take the form:

$$R=LE$$

or

$$E=R/L$$

In a simplified form, the water balance equation for the aeration zone has the following form:

$$W_k=O_c+O_p-E-C\pm q+W_н$$

where$O_c$is theprecipitation; $O_p$istheirrigation rate; Cistheresulting surface runoff; ±qisthe amount of water exchange between soil and groundwater; W_kи$W_н$isthefinal and initial moisture reserves of the soil of the aeration zone.

With a low groundwater level (below 3-4 m) and no closure of the capillary border with the root zone (± q = 0), provided that the periodic supply of irrigation water to the field does not exceed the water–holding capacity of the root layer of soils, and the intensity of water supply does not exceed the intensity of its infiltration into the depth of the soil, the equation of the water balance of the root the soil layer will take the form [10]:

$$W_k=O_c+O_p-E+W_н$$

The value in the equation can be expressed using the balance equation, in which, taking into account the relatively long period of drawing up the balance, it is possible to put due to the smallness of $\Delta W=W_k-W_н\cong 0$, so

$$E=O_c+O_p$$

Taking into account the above equation for determining the value of the total evaporation E, we get:

$$O_c+O_p=R/L$$

As is known, the ratio of the radiation balance to the heat costs for evaporation of precipitation is a hydrothermal coefficient (radiation dryness index):

$$\bar{R}=R/LO_c$$

that is, one of the most suitable criteria for assessing soil-reclamation conditions and the needs of the soil-forming process in water reclamation for modern practice of land reclamation design. At the same time, the hydrothermal coefficient ($\bar{R}$) based on the equation should be considered not so much as a natural characteristic of the terrain, but as an adjustable value:

$$\bar{R}=R/L(O_c+O_p)$$

As can be seen from the equations, $\bar{R}$characterizes the balance of energy and matter and determines the intensity of the geological and biological cycles of water and chemicals on earth, and therefore can be used to justify soil and environmentally acceptable water consumption standards of agricultural land. Having solved the last equation with respect to Op, we find the dependence for soil-ecological irrigation of agricultural land:

$$O_p=R/(\bar{R} L)-O_c$$

The value of the hydrothermal coefficient ($\bar{R}$), which characterizes the optimal ratio of heat and moisture on irrigated lands, is determined taking into account the orientation of the soil-forming process based on the law of evolution.

Conclusions

The calculation of the elements of heat, water balances and other moisture indicators for some years makes it possible to obtain a variational series of these values. If the general law of probability distribution for each indicator of heat and water balance is known, that particular distributions for any particular series can be constructed according to empirical distribution parameters.

Thus, the proposed methodology for substantiating the environmental norms of technogenic loads of the natural system with environmentally safe and waste-free disposal of wastewater, which is based on the principle of energy balance of heat and moisture, can be used in the creation of local natural-technogenic complexes intended for the disposal of wastewater from industrial and municipal facilities.

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