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EXPLOITATION OF WASTEWATER IRRIGATION SYSTEM (WWIS)

Abstract. This article discusses the method of exploitation of wastewater irrigation systems (WWIS).Presented WWIS exploitation activities - selection of sites for irrigation with wastewater, tillage in irrigated fields, sowing, planting and harvesting, fertilizer system.

Key words: wastewater, irrigation system, groundwater, fertilizer system, irrigation norm, salt balance, irrigation regime.

Introduction. *Selection of sites for irrigation with wastewater.* Before irrigation with wastewater, land should be selected.

Selection of sites for the construction of wastewater irrigation system (WWIS) should be carried out by a special commission of the district or regional akimats, which should include representatives of water users, water operators, sanitary inspection, designers, public organizations and the committee for nature protection.

In areas where irrigation with wastewater is planned, it is necessary to ensure the conditions of groundwater protection, the depth of which must be at least 3.5 m from the surface.

WWIS should be located, generally, downstream of the groundwater flow from the underground water intake facilities for centralized water supply in accordance with the requirements.

It is not allowed to install WWIS on the territory of 1 and 2 zones of sanitary protection, sources of centralized drinking water supply, on the territory of pinching out of aquifers within the district of sanitary protection of resorts.

From the edge of irrigation fields to the nearest settlement should be 200 m when it is surface irrigation and 300 m when it is sprinkling, and to inter-farm roads - 100 m [1-3].

Sanitary protection zones from the irrigated area to the main roads must be at least 100 m, including the stripe of disposal.

When selecting a territory, the need to ensure the depth of the groundwater level during irrigation should be taken into account at least 1.0 m for loamy and 1,25 m for sandy-loamy soils. The need for a drainage device for regulating the depth of groundwater and its design, as well as a system for reuse of drainage flow will install during designing which is based on surveys, predicted hydrogeological calculations taking into account the protection of water resources.

It is advisable to arrange the storage of wastewater on lands unsuitable for agriculture and on poorly permeable soils, in coordination with the territorial geological and sanitary services.

Wastewater storage reservoirs and irrigated arrays will be rational if they are located close to each other and using self-flowing wastewater supply. At the same time, irrigation fields may consist of several independent plots depending on the adopted water supply scheme.

Soils with good filtration properties are primarily suitable for the WWIS device. For utilization of wastewaters of cities of the southern region, the most favorable soil and climatic conditions for the

construction of WWIS are in Almaty region: farm lands "Burundai", "Kaskelen", "Ili"; the best conditions are around the "Sorbulak" storage reservoir; in the South Kazakhstan region: lands in the interfluve of the Badam and Arys rivers, in the Zhambyl region - lands of the CC "TasTobe", "Assa"; in the Kyzylorda region of the land of the Uchkhoz; near Taldykorgan land of LLP "Tazhiribe" [4-8].

Hydrogeological conditions of these areas are distinguished by good permeable soils and soils of the aeration zone (K - 0.3–10 m/day), deep groundwater (6–7 m), reliable insulation between soils and artesian waters.

Soil cultivation on irrigated fields. When tilling the soil, it is necessary to give the arable layer a lumpy structure with the simultaneous creation of the most favorable water-air regime in the soil, with the predominance of oxidative processes over reducing.

Tillage should begin with the annual current field planning, which in the area under consideration is carried out in the autumn - after harvest. At the same time, it is necessary to level the soil microrelief, otherwise wastewater will accumulate in certain depressions, which is completely undesirable.

The main and mandatory method of autumn processing is autumn plowing. It is carried out to the same depth by all the bodies of the plow, level the surface with a harrow or harrowwith float.

Spring presowing treatment depends on whether winter fertilizer irrigation was carried out or not performed in a given area. If such watering was carried out, then spring work begins with a deep, rootless loosening with plows and chisels. Before sowing, early spring harrowing and loosening, early cultivation to a depth of 10-12 cm are necessary.

On soils where winter irrigation was not carried out, spring work begins with harrowing in 1-2 tracks. All spring work is carried out to achieve maturity of the soil.

Sowing, caring for crops and harvesting. Sowing of crops is carried out according to all established rules of the adopted agricultural technology.

To ensure uniform moistening over the entire area in this zone of the culture of continuous sowing, it is recommended to sow with cutting of the furrows inside the lanes (watering on the sown furrows), and tilled crops - on the furrows. Furrows are cut before the first watering; soil - rolled after sowing.

Arrangement of the stripes for vegetative irrigation is most appropriate to carry out with border disks. The most common width of the stripes is 3,6 and 4,2 m, which corresponds to modern harvesters. Currently, there are many designs of various types of border disks.

In the south of Kazakhstan, are widely used border disks - rider-type planners of various designs developed by KazNIIVH. Such border disks simultaneously with the device of the rollers eliminate the irregularities of the field relief formed during plowing.

The height of the rollers reaches 18-20, and the width at the bottom is 35-40 cm. Border disks work in the unit with a seeder. To reduce land losses, it is recommended to sow the rollers, for which it is necessary to raise the plowshare of the seeder working on the roller. At the same time, seeding productivity decreases by 1,1 and 1,2 times. At cultivation of alfalfa, the sowing rollers in the second year of operation practically do not collapse or deform.

When cultivating such tall stem crops as corn, there is an opportunity to carry out only one or two cultivations, i.e. before the second watering. On soils with heavy mechanical structure, the furrows are usually not deformed. On soils with a heavy mechanical structure, the deformation of the furrows is significant and this interferes with further quality irrigation.

The device of deep furrows between rows of 1.0 m reduces the deformation. In this case, the corn seeds should be sown in a dotted manner through a 10 cm.

Care of sowing is mainly to keep the soil loose and weed-free. After each irrigation, a small crust remains on its surface, blocking the access of air deep into the arable layer. This crust must be destroyed by cultivating between the rows.

Watering with wastewater causes increased weed growth, therefore it is necessary to systematically carry out the following agronomic measures: sowing of crops in optimal time with high-quality seeds; conducting provocative irrigation, layer-by-layer processing of loosening and undercutting tools; destruction of weeds along roads, canals and hydrants. Chemical treatment is prohibited.

In the fields it is very important to harvest in time. Watering of forage crops must stop at least 14-15 days before harvesting. Quarantine terms between the last watering and harvesting should be coordinated with the authorities of the sanitary-epidemiological service and veterinary supervision.

At harvest should eliminate product contamination and infection of workers.

When harvesting hay, mowed grass should remain on the site only until it is dried in rollers. Its further processing, drying, accumulation and storage should be carried out outside the field.

Delay with the start of harvesting and delaying the harvesting period of harvesting causes not only crop losses, but also worsens its quality.

With strong winds, the bottom sediment of the accumulators is mixed to some extent with the upper clarified part of the wastewater. It is established that in 2-3 days after the wind subsides the water takes on its former form. Therefore, while strong winds it is recommended to suspend water intake from storage tanks during 3-4 days. This does not have a significant impact on the water consumption of agricultural crops [9, 10].

Methods. *Fertilizer system.* The system of fertilizers is accepted recommended for this zone, taking into account their content in the waste water. The amount of fertilizer applied to the soil is determined as follows.

1. Determine the expected intake of mineral fertilizers with wastewater:

$$N = \frac{a \cdot M}{1000}; \quad PO = \frac{b \cdot M}{1000}; \quad KO = \frac{c \cdot M}{1000},$$

where N, P_2O_5, K_2O – the amount of expected intake of nitrogen, phosphorus and potassium, kg/ha; a, в, c – content of nitrogen, phosphorus and potassium in wastewater mg/l; M – irrigation norm cubic m/ha.

2. Amount of needed fertilizer: if $A \cdot N > N^1$; $Б \cdot P_20_5 < P_20_5^1$ and $B \cdot K_2O > K_2O^1$, then mineral fertilizers can not run-off, if $A \cdot N < N^1$

B. $P_2O_5 < P_2O_5^1$ and $V \cdot K_2O > K_2O^1$, it is necessary to supplement the difference by making the appropriate mineral fertilizers.

In this formulas A, Band V - coefficients of use of mineral nutrition elements: nitrogen A - 0,7, phosphorus B - 0,7, potassium V - 0,6 N^1, K_20^1, $P_2O_5^1$ recommended dose of mineral fertilizers for this zone.

The pace and quality of all crop care work on WWIS is primarily determined by timely and high-quality irrigation. Watering should be carried out at scheduled times with calculated norms for the entire area of crops according to the principle of a water management plan, consisting, as a rule, of an application for water, calendar and operational plans-schedules for watering and processing for the whole year. Requests for water should include the required volume of wastewater and the timing of their collection.

The water use plan is drawn up in the usual ways adopted in irrigation. To facilitate the calculation, we propose a nomogram presented in figure 1.

According to the nomogram (figure 1), it is possible to determine the required net water consumption in l/s for irrigation of crops, depending on the area and irrigation norm with the duration of irrigation at

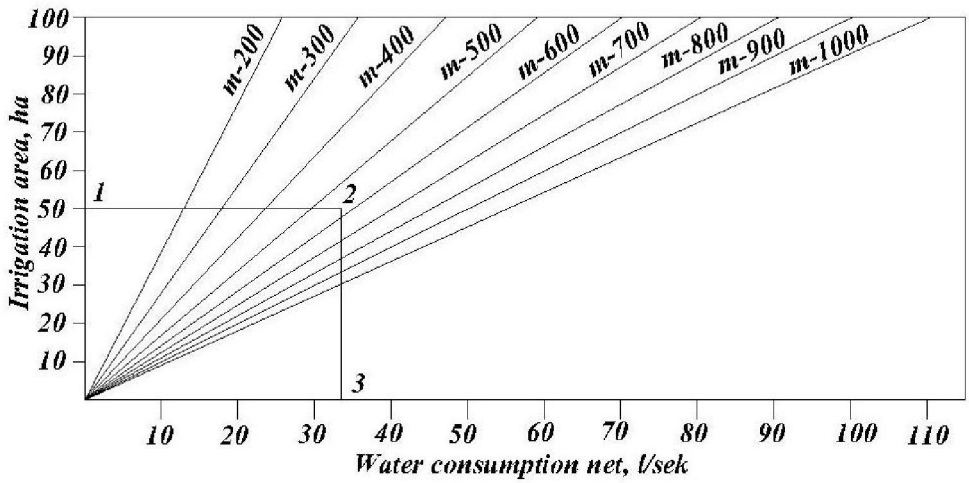

Figure 1 – Nomogram to determine the net discharge depending on the area and irrigation norm

10 days. If the duration of irrigation is different from 10 days, the required flow discharge is determined by dividing the flow discharge when the duration of irrigation is 10 days by 10 and multiplying by the corresponding duration of irrigation per day. According to the second nomogram (figure 2), the daily irrigation area is determined depending on the irrigation norm and water discharge.

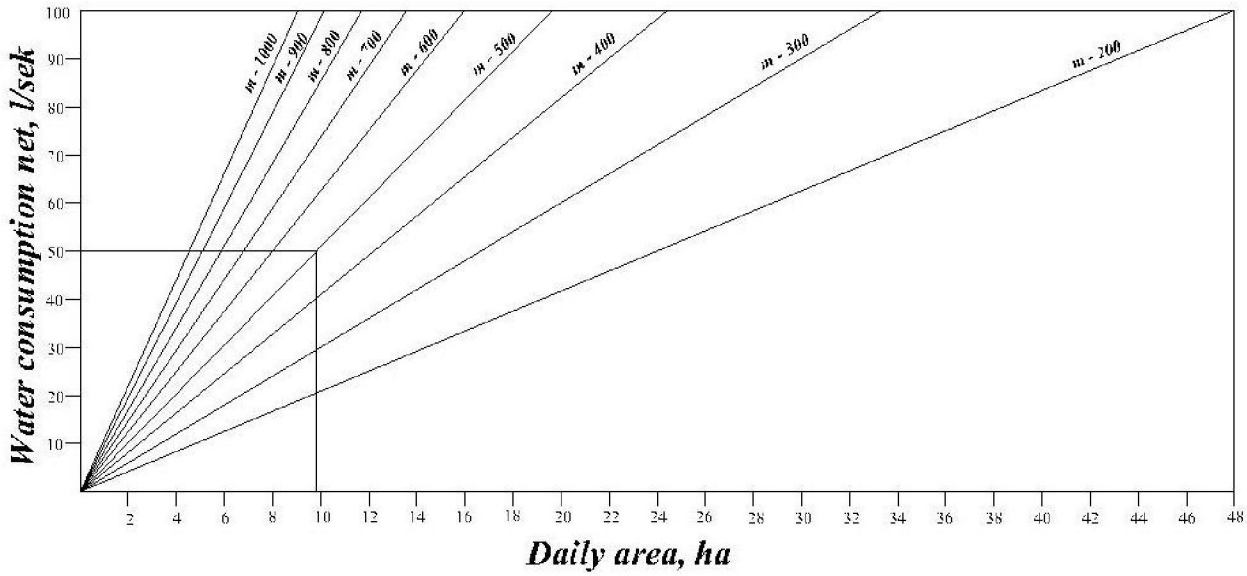

Figure 2 – Nomogram to determine the daily irrigated area depending on the irrigation norm and water discharge

Irrigation with waste water requires compliance with a number of rules: uniform distribution of water throughout the territory, water withdrawal strictly according to plan, elimination of run-off from fields, etc. Since irrigation with sewage is a new direction, which differs somewhat from irrigation with clean water, a special treatment of WWIS service personnel is necessary taking into account sanitary and hygienic rules. It is also necessary to consider the issue of remuneration of irrigators, stimulating the increase in labor productivity. In order to receive qualified assistance, it is necessary to constantly maintain close contact with project and research institutes dealing with this problem. General guidance for ensuring the normal operation of WWIS is responsible the hydraulic engineering specialist of farms using wastewater.

The main irrigation work should be carried out in the daytime. It is necessary to control the irrigation process, especially at night, to prevent unproductive discharges outside the irrigated area. It is forbidden to artificially increase irrigation norms. This significantly reduces the degree of soil post-treatment of wastewater. In this regard, it is necessary to keep strict accounts of incoming water to the irrigated area. To account and regulate the flow of incoming water, it is necessary to use various recording water meters, spillways and regulating machines. On large agricultural irrigation fields, special sanitary-field camps should be created, and on small ones - points. They should have a shower room, a medical check-up point, a room for drying overalls, dining room and trash can, etc.

When irrigating with wastewater, it is necessary to strictly observe a number of agrotechnical measures (deep autumn plowing, after irrigation treatment before the last irrigation, non-growing irrigation at a norm of 1200 cubic m/ha, cutting deep furrows, careful testing of the surface, etc.) the amount of leaching mineral fertilizers in each case is determined depending on the composition of the wastewater.

Calculations are carried out as follows:

1. Determination of the expected intake of mineral fertilizers with wastewater:

$$N = \frac{a \cdot M}{1000}; P_2O_5 = \frac{B \cdot M}{1000}; K_2O = \frac{r \cdot M}{1000};$$

where N, P_2O_5, K_2O – the amount of expected intake of mineral fertilizers at appropriate irrigation norms, kg/ha; a, B, r – the content of an ingredient in the wastewater, ml / l (determined by laboratory); M – irrigation norm, cubic m/ha.

2. Amount of needed fertilizer, if $_{0.7}N > N^{/}$, $_{0.7}P_2O_5 > P_2O_5^{/}$ and $_{0.6}K_2O > K_2O^{/}$, then mineral fertilizers can not be contribute, if $_{0.7}N < N^{/}$, $_{0.7}P_2O_5 < P_2O_5^{/}$ and $_{0.6}K_2O < K_2O^{/}$, it is necessary to supplement these differences by applying appropriate fertilizer. In this formulas $N^{/}$, $P_2O_5^{/}$ and $P_2O_5^{/}$ – recommended dose of mineral fertilizers for specific zones and for specific crops. To facilitate calculations to determine the expected release of mineral nutrients with wastewater into the soil, we proposed a nomogram (figure 3).

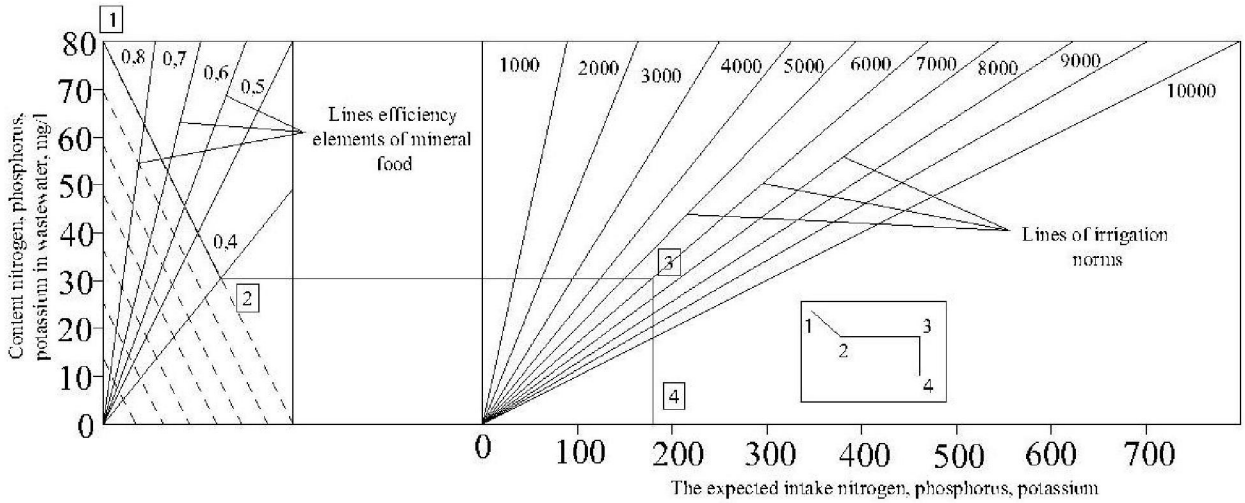

Figure 3 – Nomogram of determining the expected intake into the soil of nitrogen, phosphorus and potassium with wastewater

One of the important elements in irrigation with wastewater is the constant monitoring of salt accumulation in the soil. To do this, in irrigated areas it is necessary to determine the consumption and incoming amount of salts as a percentage. In General, they can be defined by the following formula:

$$C_K = C_K - C_O;$$

where $C_K = 100\gamma \times H \times S_K$ – salt content in the calculated soil layer; $C_H = 100\gamma \times H \times S_H$ – respectively, at the end and beginning of the period, t/ha; $C_B = 10^{-3} \times M \times K$ – flow of salts with irrigation norm, t/ha; $C_O = C_H + C_B + C_K$ – removal of salts (including desalinization) beyond the calculated layer, t/ha.

In these formulas: γ – volumetric weight of the calculated soil layer, t/cubic m; S_k and S_n – the salt content in the calculated layer (in% by weight of dry soil), respectively, at the end and beginning of the period (determined by laboratory); M –irrigation norm, cubic m/ha; K – salt content in irrigation water, g/l; H – calculated layer, m.

To determine the components of the salt balance can be used nomogram (figure 4).

They are defined as follows. The lower axis of the ordinate is the value S_k and S_n in % by weight of dry soil (point 1) through it draw a line parallel to the x abscissa axis to the intersection with the line of the calculated soil layers (point 2), then a perpendicular line to the abscissa axis is drawn until the intersection with the line of the volumetric weights of the calculated soil layer (point 3) and, after drawing a horizontal line, we find point 4 on the ordinate axis, which corresponds to the salt content in the calculated layer, t/ha. According to the nomogram, it is also possible to determine the expected flow of salts with wastewater into the soil in % by weight of dry soil. The determination is made in the opposite direction.

It has been established that under the conditions of Zhambyl and Aktobe regions, when irrigating with wastewater, about 60-70% of the incoming salts with irrigation water are washed out of the root-occupied soil layer, and about 30-40% remain in this layer. Under optimal irrigation, the annual accumulation of salts in the root zone of the soil amounted to 0,0088% of the weight of dry soil. With a long nomogram (figure 5), it is possible to predict for how many years the soil salinity of various degrees will appear.

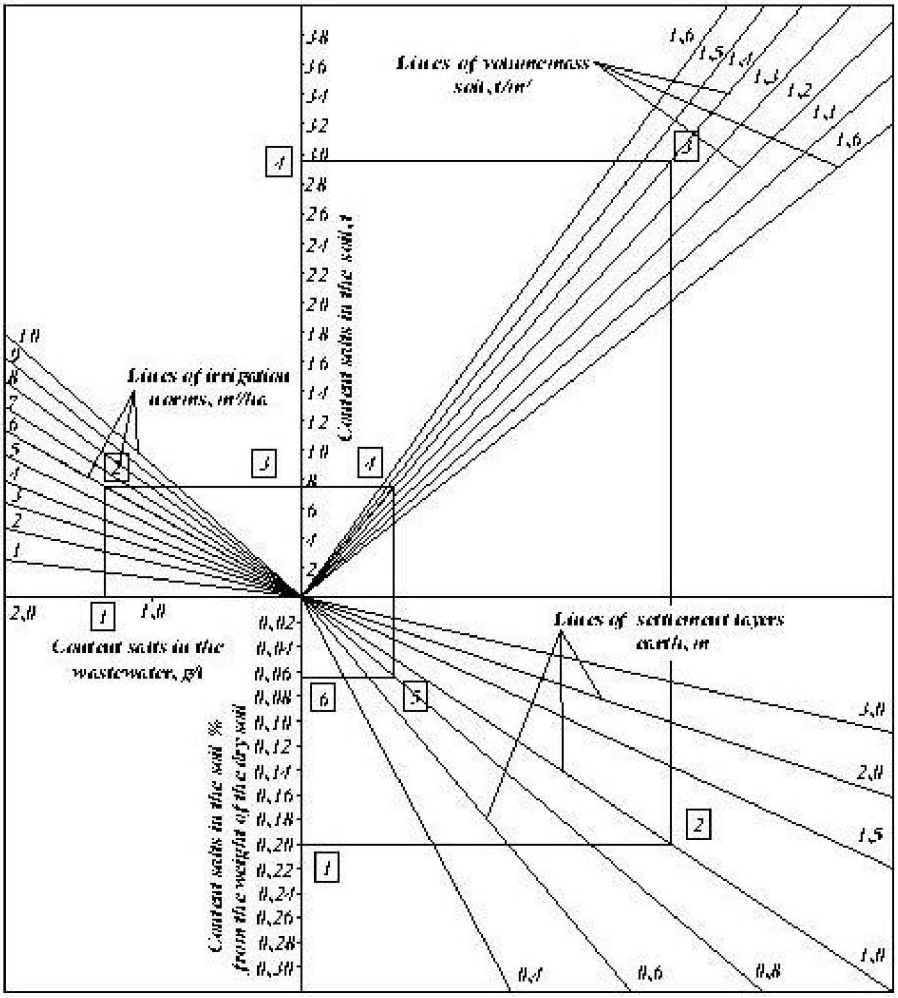

Figure 4 – Nomogram of calculation of salt balance of the soil

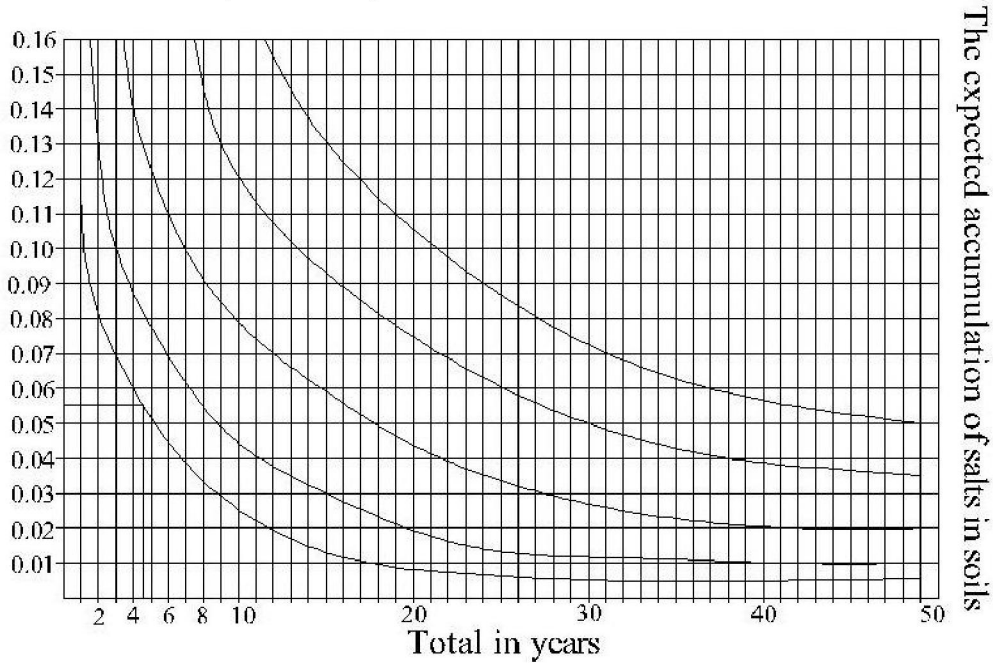

Figure 5 – Nomogram for determining the threshold of critical soil salinity

Results. In this regard, when irrigation with wastewater, it is necessary to constantly monitor the salt accumulation and take timely measures to reduce it. One of such activities is to conduct autumn-winter irrigation with clean water at a norm of 1200 cubic m/ha. At the same time, it is necessary to strictly observe the irrigation regime and all agrotechnical measures aimed at improving thesoil - reclamation conditions of the irrigated area [11-13].

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ТӨГІНДІ СУЛАРДЫҢ СУҒАРУ ЖҮЙЕСІН ПАЙДАЛАНУ

Аннотация. Мақалада төгінді сулардың суғару жүйесін пайдалану тәсілі қарастырылады. Сонымен қатар осы төгінді сулардың суғару жүйесін пайдалану тәсілі бойынша нақты іс-шаралар беріледі – төгінді сулармен суғару үшін учаскілерді таңдау, суғару алқаптарындағы топырақты өңдеу, егу, дәрілеу жүйесі, егін алқабын баптау және егінді жинау.

Түйін сөздер: сточные воды, оросительная система, грунтовые воды, система удобрения, оросительная норма, солевой баланс, режим орошения.

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ЭКСПЛУАТАЦИЯ ОРОСИТЕЛЬНЫХ СИСТЕМ СТОЧНЫХ ВОД

Аннотация. В данной статье рассматривается метод эксплуатации оросительных систем сточных вод (ОССВ). Представлены мероприятии по эксплуатации ОССВ – выбор участков для орошения сточными водами, обработка почвы на полях орошения, посев, уход за посевами и уборка урожая, система удобрения.

Ключевые слова: сточные воды, оросительная система, грунтовые воды, система удобрения, оросительная норма, солевой баланс, режим орошения.

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