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ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
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Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

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ENVIRONMENTAL LOAD NORMA OF IRRIGATION FIELDS WITH SEWAGE WATER

Abstract. The article provides materials of field lysimetric studies on the degree of soil purification of wastewater. In order to study the interaction of irrigation wastewater with the soil in the conditions of Almaty region, we carried out field experiments using E. I. Shilova's scoop shape lysimeters.

Keywords: waste water, lysimeters, cleaning, gray soil, ingredients, filtrate.

Introduction. Lysimeters were installed in a hole 1.2 m deep in a previously prepared niche with depth from the surface of the hole wall to a depth of 0,30, 0,60, 0,90 m. The niche free space after installing the lysimeters was tamped with moist soil. The walls of the pit concreted. The filtrate enters the rubber tubes in the vessels (tubes).

On the surface of the lysimeters there is a platform of size 1,00x1,20 m, outlined by a wooden side 0,20 m high.

For irrigation, wastewater from the city of Almaty was used, which is characterized by an alkaline reaction (pH = 7,80), a hydrocarbonate-chloride-sulphate composition with a total mineralization of 0,90–1,10 g/l.

The research results are presented in the table, which show that wastewater, penetrating into the soil, leaves various substances contained in it from top to bottom, that is, soil cleaning takes place. In this case, the degree of wastewater treatment by one or another layer of soil is different in nature and depends primarily on the load rate.

The main wastewater treatment occurs in the soil horizon 0-30 cm. Here, the degree of purification of water-soluble salts reaches 76%, and nitrogen and phosphorus up to 90%. As the load rate increases, it appears to a lesser extent. A high degree of purification is noted in a layer of 0-90 cm with a load of 1000 m^3/ha. Bringing the rate of load to 1500 m^3/ha slightly reduces the degree of purification in each of the soil layers under consideration. The migration of calcium and magnesium in the underlying layers is not a desirable phenomenon. Their significant migration was established at a one-time irrigation rate of 1,500 m^3/ha. Therefore, such a value of a one-time norm for irrigation fields in conditions of dark chestnut soil is not acceptable.

We found that when passing through a certain layer of serozem soils (0,90 m), the wastewater bleached, the amount of all chemical components decreased. Lysimetric waters had no odor, which indicates the cleaning ability of the soil. The final treatment of wastewater does not end at a layer of 0-90 cm. It can be assumed that it will flow in the layer below 0-90 cm and there is such a thickness of the soil layer where the filtrate will be practically clean. Many researchers have argued that at a depth of 1,5 meters, the wastewater is completely free from any impurities, if the irrigation regime is observed [1].

However, in order to protect groundwater from pollution, it is recommended to arrange irrigation fields where groundwater lies at a depth of 3 meters or more. Analyzing the data in the table, it should be noted that the absorption of mineral elements by the soil layer, such as nitrogen, phosphorus, potassium, does not fall below 82-85% even with a load of up to 1500 m^3/ha. However, the loss of nitrogen from wastewater increases with increasing irrigation rates. German scientists have shown that with an increase in the water supply rate, nitrogen absorption by the soil stops: on sandy soils with an increase in water supply from 60 to 150 mm, on sandy soils - up to 400 mm, on clayey - even higher [2].

Apparently, the colloidal composition of the soil is of particular importance for reducing the nitrogen content of wastewater in the process of their purification and use in agriculture.

The main absorption of nitrogen occurs in the upper layers of the soil profile. For example, the absorption of nitrogen to a depth of 30 cm ranged from 40 to 60%, depending on the load norms, and to a depth of 60 cm to 80-87%. Nitrogen uptake will continue. According to I. F. Thomas, it ends at a depth of 3 m [3].

Table 1 – The degree of soil tertiary treatment of wastewater at different load norms (initial water supply)

Indicators	Content of ingredients, mg/l								
	HCO_3	Cl	SO_4	Ca	Mg	Na+K	P_2O_5	N	K_2O
With a load rate of 600 m^3/ha									
Sourcewater	480	160	320	80	40	306	11	30	19
In a layer of 0-30 cm									
Filtrate	270	106	118	50	21	160	5	12	3,8
Absorbedin, %	42	34	63	34	47	48	54	60	80
In a layer of 0-60 cm									
Filtrate	114	60	80	35	10	85	2	4	–
Absorbedin, %	76	62	75	56	75	72	81	87	100
With a load rate of 1000 m^3/ha									
In a layer of 0-30 cm									
Filtrate	240	111	145	60	24	150	6	16	4,8
Absorbedin, %	50	31	55	25	40	51	46	47	75
In a layer of 0-60 cm									
Filtrate	126	80	90	42	12	80	1	6	1
Absorbedin, %	74	50	72	47	70	74	91	80	95
In a layer of 0-90 cm									
Filtrate	91	51	45	29	9	43	–	1	–
Absorbedin, %	81	68	86	64	78	86	100	98	100
With a load rate of 1500 m^3/ha									
In a layer of 0-30 cm									
Filtrate	280	115	160	30	35	149	6	18	7,2
Absorbedin, %	42	29	50	12	12	51	45	40	62
In a layer of 0-60 cm									
Filtrate	166	96	95	58	16	92	2	6	5,1
Absorbedin, %	75	40	70	28	60	70	82	80	76
In a layer of 0-90 cm									
Filtrate	108	67	90	54	22	86	2	6	0,4
Absorbedin, %	78	58	72	33	45	72	83	81	98

Phosphorus absorption is higher than nitrogen. In 58% of the experimental results showed that the maximum absorption of phosphorus is observed up to a depth of 60 cm. In this layer, depending on the water supply rate, phosphorus absorbed up to 82-91%. Similar trends were noted in the studies of M. Schultz [2].

As it is known, mineral substances such as nitrogen, phosphorus and potassium in waste water are mainly in a dissolved form (nitrogen 85%, phosphorus 50% and potassium 95%). Absorbing in the upper soil layer, they become more accessible to crops.

Calcium absorption by the arable layer of soil 0,30 m did not exceed 37%. With a normal load of 50 mm, and with a load of 150 mm, calcium absorption did not exceed 12%. As the depth of the soil horizons increases, its absorption is somewhat increased. Magnesium has the same pattern, although it is absorbed more than calcium. Apparently they go to the underlying layers of the soil. Therefore, the possible outflow of calcium from the soil must be compensated by liming [4-6].

A number of scientists propose a major role in the significant enrichment of the soil, as noted in our experiments, plays a large absorbing energy of the K-cation, which primarily occupies all the free valences of the surface layers. Huge cations, primarily sodium and calcium, whose absorption energy is much lower than that of potassium, therefore, is carried into the deep layers of the soil.

From the anionic group, the absorption of bicarbonate and bicarbonate ions is higher than that of chloride.

Although a number of scientists noted that sulphates are mainly absorbed by the deep layers of the soil, in our experiments, a high absorption of sulphate by the upper arable layer of soil is noted. With a water supply rate of 500 m^3/ha, the absorbing 63%, with a water supply rate of 1000 m^3/ha - 55%, and at a rate of 1500 m^3/ha - 50%.

Thus, with an increase in the thickness of the soil layer, the degree of purification increases, and with an increase in the load norm, there is a slight increase in the content of the main components in the lysimetric waters.

When applying the norm of 1500 mm, the degree of purification in the 0-90 cm layer was low and amounted to 16-51%. There is observed the leaching of such an important element as calcium outside the corneal zone of the soil.

The decrease in soil absorption of various ingredients can be explained:

– weakening by the end of the growing season their consumption of plants;

– a decrease in the microbiological activity of gray soils;

– relative “saturation” of the filtering layer with added substances;

– changes in the cation composition of the soil absorbing complex;

– deterioration of the water-physical properties of the upper horizon of the paid soil horizon during irrigation and treatments;

– meteorological conditions and other factors, alone or in combination with causing a change in the sorption properties of the soil. [7,8]

Methods. Factors that are dependent on the treatment of wastewater from soil conditions and water supply rates, as well as the concentration of the ingredient, the temperature of the wastewater and the duration of the intervals between irrigation can be recorded:

$$A = \frac{A_{H}}{log\frac{A_0}{A_H}}, \quad (1)$$

where A – degree of purification, %; A_O – pollution BOD5 (biological oxygen demand), used irrigation water, mg/l; A_H– pollution BOD5 irrigation water after filtration through the soil to a depth of H, mg/l.

For the conditions of gray soils is:

at a rate of 600 m^3/haA_H = 19,6

at a rate of 1000 m^3/haA_H = 28,2

at a rate of 1500 m^3/haA_H = 30,6

Our experimental data showed a high degree of BOD5 purification of a 90 cm soil layer at a load rate of up to 1000 m^3/ha. This is of great agricultural importance, since as a result, the accumulation of organic matter significantly increases the fertility of the soil. A further increase in the water supply rate leads to a decrease to 28-52%.

Many researchers believe that the regulation of inter-irrigation periods, which largely determine the use of plants by the introduction of nutrients and their fixation in the soil, can increase the stability of sorption processes in the soil.

In order to prevent the leaching of wastewater ingredients outside the root zone (this not only causes free loss of nutrients, but also the danger of contamination of groundwater), it is necessary to avoid supplying large amounts.

In terms of irrigation with wastewater for environmental safety, an equilibrium should be maintained between the intake of various nutrients from wastewater and their use by plants, which are mainly regulated by inter-irrigation periods.

It is clear from here that the longer the irrigation period is, the higher is the absorption capacity of the soil, and the degree of purification is also meant.

The cleaning properties of gray soils, noted above, takes place only during the period of soil saturation with water. From the moment of their full saturation with water, natural wastewater treatment does not occur and chemical means flowing into the filtrate are subject to the composition of the wastewater.

Based on the data obtained from the lysimetric experience, we were able to identify that the amount of runoff from that other soil profile (H) depends on the applied irrigation norms and it can be expressed:

$$W = \frac{m \cdot \omega}{10000} \cdot \left(H - h\right), \qquad (2)$$

where W – average runoff, m^3; m – irrigation rate per 1 m depth; ω – lysimeter surface area; H – estimated depth of moisture, m; h – the depth of the soil layer through which the filtrate goes.

These data allow carrying out balance calculations of ingredients entering the soil with wastewater (table 2).

Table 2 – Balance calculation of elements of mineral nutrition and water-soluble salts in soil, kg/ha

Indicators	**Ingredients,kg**			
	N	**P_2O_5**	**K_2O**	**Summa of salts, mg/ha**
Irrigationrate, 600 m^3/ha				
Receivedwithwastewater	18	9,5	11,4	816
Filtrate volume, through 30 cm layer, 450 m^3				
Filtrationcontent	13,5	450	8,55	512
Absorbed in a layer of 0-30 cm	4,5	4,95	2,85	204
Filtrate volume, through 60 cm layer, 240 m^3				
Filtrationcontent	5,2	2,54	4,56	326
Absorbed in a layer of 0-60 cm	12,8	3,0	6,64	490
Filtrate volume, through 90 cm layer, 60 m^3				
Filtrationcontent	1,8	0,00	1,14	61,5
Absorbed in a layer of 0-90 cm	16,2	5,94	10,26	734,4

Results. The overall qualitative and quantitative expression of the processes of absorption and migration of wastewater ingredients introduced into the soil with irrigation water has its own characteristics. The content of ingredients in the filtered and irrigation waters is not identical and is a variable value depending on a number of factors. In quantitative terms, their migration lags behind the rate of moisture filtration: with an increase in the filtration layer. This lag is more pronounced. With increasing irrigation rates, the absorption capacity of the soil is manifested to a lesser extent.

When irrigation of lysimeters with treated wastewater, the predominant part of the nutrients in them absorbs the arable soil horizon and they will be used by plants, the other part accumulates in the lower layers of the soil profile, turning off for a long time from the active circulation of substances in the soil-plant-soil system.

The degree of absorption of the ingredients of sewage gray soils can be adjusted by changing the irrigation regime. According to the results of lysimetric experiments, disposable feed rates of 600–1000 m^3/ha turned out to be the most acceptable from the ecological point of view. With this approach, highly efficient wastewater treatment and more complete utilization of nutrients introduced into the soil is achieved.

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СУАРУ АЛҚАПТАРЫНЫҢ ТӨГІНДІ СУЛАРМЕН СУҒАРУДЫҢ ЭКОЛОГИЯЛЫҚ ЖҮКТЕМЕ НОРМАСЫ

Аннотация. Мақалада төгінді суларды топырақты тазартудың дәрежесін зерттеу бойынша далалық лизиметриялық зерттеулердің материалдары келтіріледі. Суғармалы төгінді сулардың топырақпен өзара байланысын зерттеу мақсатында Алматы облысы жағдайында Е.И.Шиловтың күрек тәрізді формадағы лизиметрлерін қолдану арқылы табиғи тәжірибе жүргізілді.

Түйін сөздер: төгінді сулар, лизиметрлер, тазалау, боз топырақ, ингредиенттер, сүзінді.

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НОРМА ЭКОЛОГИЧЕСКОЙ НАГРУЗКИ ОРОСИТЕЛЬНЫХ ПОЛЕЙ СТОЧНЫМИ ВОДАМИ

Аннотация. В статье приводятся материалы полевых лизиметрических исследований по изучению степени почвенной доочистки сточных вод. В целях изучения взаимодействия оросительных сточных вод с почвой нами в условиях Алматинской области проведены натурные опыты с использованием лизиметров совкообразной формы Е.И.Шиловой.

Ключевые слова: сточные воды, лизиметры, очистка, сероземные почвы, ингредиенты, фильтрат.

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