

Research Article

# The Efficiency of Salt Washing in Fields Levelled with Laser Levelers

Odilbek Eshchanov<sup>\*</sup> , Umrbek Sharipov , Rashid Xo'janiyazov 

Land Reclamation and Collector-Drainage Network Laboratory, Scientific Research Center of Water Problems Under the Cabinet Ministries of the Republic of Uzbekistan-SRCWP, Urgench, Uzbekistan

## Abstract

This article highlights contemporary difficulties including new salt leaching technologies for reducing salinity in cotton fields. Also, the impact of dividing fields into floors with a check mark (check mark) on salt leaching requirements in laser leveled areas. Field studies were carried out in five different research fields from February to March 2024 in compliance with specific methodological requirements. The experiments were carried out on farms in the Urgench area of the Khorezm region, where laser leveling work was finished in early 2024 while considering soil salinity and mechanical properties. The soil samples were collected from the research sites before and after the salt leaching period to establish the success of the process, the level of salinity, and the mechanical composition of the soil. Samples were analyzed in a laboratory to determine the level of soil salinity and the amount of salts (anions and cations -  $\text{Cl}^-$ ,  $\text{HCO}_3^-$ ,  $\text{Ca}^{+2}$ , and  $\text{Mg}^{+2}$ ), and the mechanical composition of the soil was assessed using the Kachinsky method based on the water-physical properties. The results showed that high-quality field leveling ( $\pm 2$  cm) with laser levelers improves salt leaching quality, maintains uniform water depth, and prepares the region for seed planting, as demonstrated in a 16-hectare experimental field. However, other factors also affect this, such as the depth of plowing the field, the intensity of water entering the field, the amount of water consumed, and the availability of water during irrigation (day and night).

## Keywords

Irrigated Land, Leaching, Laser Leveling, Salinity, Saline Soils, Salt-Washing

## 1. Introduction

Water use has been increasing globally by roughly 1% per year over the last 40 years and is expected to grow at a similar rate through to 2050, driven by a combination of population growth, socio-economic development and changing consumption patterns [1]. It is becoming the scarcest resource for future worldwide agricultural development [2]. A significant portion of the population will be impacted by acute water scarcity, particularly in arid regions [3]. Irrigated agriculture

is a significant economic activity in many arid and semiarid areas. It is a vital source of employment and revenue in rural areas and contributes significantly to regional domestic goods. As water shortage worsens, it will have a detrimental impact on both agricultural output and overall economic development [4]. According to the Khorezm regional reclamation expedition, 265.5 thousand hectares of irrigated areas under observation in the region consist mainly of sandy loam and clay

<sup>\*</sup>Corresponding author: odilbek.icwc@mail.ru (Odilbek Eshchanov)

**Received:** 24 January 2025; **Accepted:** 7 February 2025 **Published:** 24 February 2025



Copyright: © The Author(s), 2025. Published by Science Publishing Group. This is an **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

soils, of which 0.5% are non-saline, 60.6% are slightly saline, 28.5% are moderately saline, and 10.4% are strongly saline. Since irrigated land areas have varying degrees of salinity, salt leaching activities are carried out in the autumn-winter and winter-spring periods [5]. In order to obtain high yields from agricultural crops, it is advisable to implement other complex measures to prevent salinization by washing out harmful salts in the soil and to improve the reclamation condition of the soil. In recent years, the region has successfully leveled irrigated lands with laser levelers before salt washing. At the same time, in practice, the size of the plots prepared by farms for salt washing with laser levelers ranges from 2.0 hectares to 10.0 hectares. Therefore, since the size of the plots in the previous recommendations was up to 0.5 hectares, it is important to study the scientific basis for the impact of the size of the large plot (chel) on the salt washing standards [6-8].

The authors also note that when saline leaching through large swales, under hydrostatic pressure, the drainage side slopes are damaged, the swales are washed away, water from the fields is pumped into the drains, and as a result, silt settles in the drains. Saline leaching for large swales also leads to a significant reduction in the water use coefficient compared to leaching for small swales [7, 9]. According to the authors, the basic rule of salt leaching should be applied differently to medium- and highly-saline soils (twice), separated by three to six days, and to low-saline soils (once). Fields should get water supplies so the check can be filled out and the water table can be formed as quickly as feasible [10, 11]. Furthermore, research showed that when preparing saline areas for salt leaching on leveled lands with a slope of up to 0.002, the checks' width should be 50 m, their length should be 50 m, and each check's width should be 0.25 hectares. The checks' maximum area should not be more than 0.5 hectares. The amount of water provided for salt leaching depends on the degree of salinity of the land: the water rate for low-saline lands is 1500 m<sup>3</sup>/ha, once; the water rate for medium-saline lands is 2500 m<sup>3</sup>/ha, twice; and the water rate for highly saline lands is 4000 m<sup>3</sup>/ha, divided into three doses [12, 13].

Irrigated land leveling with laser levelers is a method of leveling the field surface using specially equipped laser levelers such that the gap between the lowest and highest places on the field surface is less than 3.0 cm. Leveling an irrigated crop field with laser levelers allows you to evenly moisten all sections of the crop field, increase land reclamation, evenly germinate seeds, evenly give nutrients to the crop, and evenly develop it, all while saving irrigation water. Therefore, there is a high demand for land leveling technology using laser equipment. Beginning in 2023, agricultural producers who purchase automated land leveling units with laser equipment imported from abroad and manufactured in our republic will be reimbursed by the Republic of Uzbekistan's State Budget for 30% of the cost of land leveling units [14]. The Ministry of Agriculture of the Republic of Uzbekistan's Inspection for Supervision of the Agro-Industrial Complex ("Uzagroinspektion") reports that the country's inventory of laser land level-

ing equipment is growing. Due to the incentives offered for laser leveler purchases the Uzagroinspektion registered 591 new, contemporary laser levelers in 2024. Currently, over 1.5 thousand contemporary, resource-efficient laser levelers are registered in the country. In contrast, Uzbekistan had just 127 units of this number in 2017. Particularly, in the Khorezm region, the number of laser levelers reached 450 units during 2018-2024, and the leveled area of irrigated land reached 149.8 thousand hectares (56% of the total irrigated area) [15].

A specific set of techniques has been developed in this field based on the aforementioned findings of years of research; however, the recommended check size for salt leaching is 0.25 to 0.5 hectares. As a result, laser levelers are currently being used in practice, and farmers are figuring out the check size based on their own experience, indicating that no scientific recommendations satisfy the requirements. Therefore, after the introduction of new innovative laser levelers for leveling irrigated lands in the region, there is a need to conduct scientific research on the check size for effective salt leaching activities. This article presents the findings of field research that examined the effects of land-leveling technology using laser equipment and the salt leaching standards corresponding to the checks' size.

## 2. Materials and Methods

This section presents the materials and methods used in the paper. It covers the description of the experimental area, experimental design, soils and water, sample collection and laboratory analysis.

### 2.1. Description of the Experimental Area

The Khorezm region is located in the north-west of the Republic of Uzbekistan and covers a total land area of 608.2 thousand hectares, accounting for 1.35% of Uzbekistan's territory, with 267.7 thousand hectares (or 44%) irrigated. The region's climate is severely continental, with hot and dry summers and short, cold winters. It is also noteworthy for its rapid fluctuations in daily air temperature and high evaporation. Evaporation is particularly high during the growing season [16]. The studies were conducted at two places in the Urgench district of Khorezm. The first experimental field Khorezm Scientific and Experimental Station belongs to the "Scientific Research Institute of Cotton Selection, Seed Production and Cultivation Agrotechnologies" (SRICSSPCA), and the second one is the "Ibroxim-Farida" farm field.

### 2.2. Experimental Design and Measurement of Water

A similar design was established in both experimental fields as a common method of irrigation, with four different sizes of checks in each field. Water from the head channel is supplied to the field channel directly and one after another.

Table 1 shows information regarding the experimental fields, such as the size of the check basin, irrigation time for salt washing, and total and average irrigation amount. Internal farm canals were used to supply water to the field. The amount of water applied to each plot and check was measured using a water meter (Chipoletti drain, VC-50). Determination of water flow by a trapezoidal weir (TW) were computed using the following equations:

$$Q = 1.9 * b * H \sqrt{H}, \text{ m}^3/\text{s}$$

where:  $b$  is the width of the weir threshold, (m);  $H$  is the water pressure above the weir threshold, (m);

### 2.3. Soils and Water

According to soil analysis data, the “Ibrahim-Farida” farm field has a “silty clay loam” texture that is “slightly” and “medium” saline, indicating a chloride-sulfate salinity type. The Khorezm Scientific and Experimental Station (SRICS-SPCA) field has a similar “silty clay loam” soil texture with “slightly” and “medium” salinity, which correspond to the chloride-sulfate salinity type. The mineralization of irrigation water used during the salt washing period was 0.88 g/l at the “Ibrahim-Farida” farm and 1.01 g/l at the Khorezm Scientific and Experimental Station field.

### 2.4. Sample Collection and Laboratory Analysis

Soil samples were obtained prior to irrigation (salt washing) and after irrigation in advance of plowing. At the end of the salt leaching period, soil samples were taken from the study sites to assess the effectiveness of the salt leaching process, determine the level of salinity. Samples were analyzed in the laboratory to assess soil salinity (dry residue, anions and cations -  $\text{Cl}^-$ ,  $\text{HCO}_3^-$ ,  $\text{Ca}^{+2}$ , and  $\text{Mg}^{+2}$ ), pH and mechanical composition. All experiments and soil sample collection were conducted according to the guidelines provided in Dospekhov's “Field Experiment Methodology” and “Methods of Field Experiments” by the SRICSSPCA's [17, 18].

## 3. Results

In 2024, the average water input intensity during the salt washing period on a 16.0 ha plot leveled with a laser leveling device on the “Ibroxim-Farida” (F-1) farm field was 352 l/sec, allowing the salting washing time to be completed in 33 hours (average water depth of 9 cm), and the actual salt washing rate for one time was 2632  $\text{m}^3/\text{ha}$  (see Table 1).

**Table 1.** Amount of water used for salt leaching in the study fields (2024).

Field number	Check size (ha)	Number of brine washes	Irrigation date (salt washing)	Total water consumption ( $\text{m}^3/\text{ha}$ )	Average water consumption ( $\text{m}^3/\text{ha}$ )
F-1	16,0	2	23.02-18.03	3986	1993
	3,1	2	24.02-18.03	4511	2255
	3,75	2	25.02-19.03	4748	2374
	2,8	2	26.02-19.03	4774	2387
	7,7	3	14.02-22.03	7551	2517
F-2	3,26	3	12.03-29.03	2982	994
	3,44	3	12.03-29.03	3281	1094
	4,57	1	25.03-3.04	5356	5356

Note: The study fields were leveled in February 2024.

At the same time, the fact that the field was plowed to a depth of 70 cm before salt washing made a difference. The second salt washing had an average water input intensity of 116 l/sec for 52 hours longer than the first (average water depth of 8 cm), resulting in an actual salt washing rate of 1354  $\text{m}^3/\text{ha}$ . The total salt washing rate for two times was 3986  $\text{m}^3/\text{ha}$ , despite the fact that low-saline fields require a rate of 2500  $\text{m}^3/\text{ha}$ . As a result, the soil salinity changed from slightly

saline to non-saline (see Table 2).

In an experimental field F-1 (total size 9.65 ha and divided into three checks), the salt leaching rate in checks in 2024 was 2338  $\text{m}^3/\text{ha}$ , with one check remaining slightly-saline and two checks moving from medium-saline to slightly-saline (Table 2). In 2022, the Khorezm Scientific and Experimental Station's area (F-2) was leveled using laser levelers (Figure 1). Prior to salt washing, it was plowed to a depth of 35-40 cm in

the fall of 2023 and leveled with a short-base laser leveler.



**Figure 1.** Laser land leveling in the "Ibrahim-Farida" experimental field.

In this experimental field F-2, some of the field was divided into 10 checks with ditches to investigate the salt-washing process in small checks and compare the effect of check size. Based on this investigation, the sizes ranged from 0.6 to 1.0 ha, with a ditch height of 50 cm, an upper portion width of 30 cm, and a lower part width of 140 cm.



**Figure 2.** Water leakage to another part due to the rupture of the shell during the salting process.

In certain situations, the ditches were not compacted to the required level, and water entering one ditch leaked into another, making it impossible to quantify water consumption for individual ditches in the field, therefore water consumption was computed for an area (see Figure 2). After three salt washings, the actual washing rate was 7,500 m<sup>3</sup>/ha. The soil changed from medium-saline to slightly saline conditions.

**Table 2.** Soil salinity levels in the study area before and after salt washing.

Field number	Number of brine washes	Number of sampling point	Types of salinity	Before salt washing		After salt washing	
				Dry residue	Salinity level	Dry residue	Salinity level
F-1	2	3,1	Chloride sulfate	0,401	Medium saline	0,310	Slightly-saline
		3,75		0,411	Medium saline	0,291	Slightly-saline
		2,8		0,303	Slightly-saline	0,285	Slightly-saline
		7,7		0,408	Medium-saline	0,262	Slightly-saline
F-2	3	3,26	Chloride sulfate	0,381	Slightly-saline	0,296	Slightly-saline
		3,44		0,333	Slightly-saline	0,284	Slightly-saline
	1	4,57		0,414	Medium-saline	0,271	Slightly-saline

Note: Based on the check size, sampling points ranged from 3 to 5.

The experimental field F-2 was plowed in autumn 2023 to a depth of 35-40 cm and laser leveled on March 10, 2024. The area was divided into two checks, the first measuring 3.26 ha and the second 3.44 ha. The salt washing was done three times, and the total washing rate was 3132 m<sup>3</sup>/ha, with an average washing rate of 1044 m<sup>3</sup>/ha for each washing. The findings indicate that twice as much water was saved than if the area had been leveled normally. The soil was classified as slightly-saline and has stayed in that category. Also, in field F-2, there was a single plot of 4.57 ha that was di-

vided into three checks, and during the salt-washing process, water was observed moving from one check to another as a result of the water washing away some checks (Figure 1). As a result, it was impossible to maintain separate water accounts for each plot. Furthermore, because the pumping unit operated from 8:00 a.m. to 19:00 p.m., the salting rate was high, and a significant amount of time was spent salt washing since the water was pumped into the field from a different location every day, as well as interruptions. At the same time, the salinity level in the low-saline group did not fall but



remained unchanged.

## 4. Discussion

Field experiments reveal that high-quality field leveling with laser levelers significantly impacts salt leaching rates, allowing the water level to be maintained at the same depth even when the field area exceeds 10 hectares. Since the irrigated lands in the Khorezm region have relatively small slopes, laser levelers are extremely effective for leveling the soil. Land leveling with laser technology is primarily performed in agricultural crop-free areas from autumn until the ground freezes, and then in the winter-spring months following the ground freeze [6]. According to Ramazanov and Yakubov's [19] research, strict adherence to prescribed sizes in production conditions is challenging. As a result, they recommend a maximum check size of 0.5 ha. In areas larger than 0.4-0.5 ha, it is nearly hard to maintain a consistent water layer throughout the entire area during salt leaching, and as a result, uniform soil desalination does not occur. Furthermore, due to the presence of micro-lows and micro-elevations, the soil in the field after salt leaching does not reach the same level, delaying the timing of operations before spring sowing. The findings by Shirokova et al. [20] somewhat concur with our results, which indicated that in the Republic of Karakalpakstan, leaching efficiency in field-based land leaching operations decreased by 20-37% as plot sizes increased from 0.3 to 1 hectare and by 32-43% as plot sizes increased from 0.3 to 3 hectares (i.e., leaching efficiency decreased by 1.4 times). Another study on salt leaching in the Fergana and Mirzachul valleys revealed that water must enter the check from temporary irrigation canals at a minimum flow rate of 30 to 40 liters per second to achieve the intended results. The ideal time for salt washing is December (2/3 salt washing rate) and February-April (1/3 salt washing rate) and suggested plot sizes be up to 0.25 hectares, depending on the slope conditions of region [12].

The results of our study showed that, for all options considered, the amount of water needed for salt washing was less than the norm recommended by the regional reclamation expedition. The regional reclamation expedition has set salt leaching standards of 2,500 m<sup>3</sup>/ha in slightly saline soils once, 4,000 m<sup>3</sup>/ha in medium saline soils twice, and 6,000 m<sup>3</sup>/ha in highly saline soils three times.

## 5. Conclusions

The results of field research show that high-quality leveling of the field using laser levelers definitely affects the salt leaching standards, making it possible to maintain the water level at the same depth, even when the size of the field (field) is 16 hectares in the example of field-1. Depending on the soil type, the average amount of water used for salt washing in experimental areas leveled with laser levels ranged from

4000 m<sup>3</sup>/ha to 7500 m<sup>3</sup>/ha. However, other factors also affect this, including the depth of plowing of the land, the intensity of water entering the field, the high or low water consumption, and the factors of uninterrupted water supply to the field day and night. Additionally, the soil salinity was comparatively decreased at one level after the salt leaching.

In a situation where water is scarce in our region, in addition, the Khorezm region, located in the lower reaches of the Amudarya River in the Aral Sea region, is the most difficult area for water supply, in this regard, the demand for the technology of land leveling with laser levelers, which is considered an innovative method for rational use of existing water resources, will continue to grow in the future. In this regard, not only for farms and Agroclusters, but also for small landholders and owners of homestead land, laser levelers are an important innovative method for saving water for irrigation and as a source of income.

At the end of this research work (after the second year of the experiment), a scientifically based manual will be prepared on the impact of the size of the fields divided into floors by leveling (fields) on salt leaching standards in areas leveled with laser levelers. This manual will play an important role in improving the land reclamation condition for farms and agroclusters in increasing the efficiency of water use during the salt leaching period compared to the current situation.

## Abbreviations

Cl <sup>-</sup>	Chloride
HCO <sup>3-</sup>	Bicarbonate Ion
Ca <sup>+2</sup>	Calcium
Mg <sup>+2</sup>	Magnesium
pH	Potential of Hydrogen
TW	Trapezoidal weir
	Scientific Research Institute of Cotton
SRICSSPCA	Selection, Seed Production and Cultivation Agrotechnologies

## Acknowledgments

We express our gratitude to the Ministry of Water Resources of the Republic of Uzbekistan for providing the opportunity to carry out a research project to address the current issue and extend our sincere thanks to Agrobank ATB for its financial support and assistance.

## Author Contributions

**Odilbek Eshchanov:** Conceptualization, Supervision, Project administration, Resources, Investigation, Writing-original draft, Data curation

**Umrbek Sharipov:** Conceptualization, Writing-original draft, Investigation, Methodology, Writing-review & editing

**Rashid Xo'janiyazov:** Data curation, Formal Analysis, Investigation, Methodology

## Funding

This work is supported by Agrobank ATB Uzbekistan (Agreement No. 03/17-ITK1-1).

## Conflicts of Interest

The authors declare no conflicts of interest.

## References

- [1] AQUASTAT. n.d. Aquastat: FAO's Global Information System on Water and Agriculture. Rome, Food and Agriculture Organization of the United Nations (FAO). [www.fao.org/aquastat/en/](http://www.fao.org/aquastat/en/) (Accessed in November 2022).
- [2] UN-Water, 2023. The United Nations World Water Development Report 4: Managing Water Under Uncertainty and Risk. United Nations World Water Assessment Programme, UNESCO, Paris, France.
- [3] Mancosu, N., Snyder, R. L., Kyriakakis, G., Spano, D., 2015. Water scarcity and future challenges for food production. *Water (Switzerland)* 7, 975-992. <https://doi.org/10.3390/w7030975>
- [4] UN-Water, 2016. The United Nations World Water Development Report 2016: Water and Jobs. United Nations World Water Assessment Programme, UNESCO, Paris, France.
- [5] Reports of the reclamation expedition of "Chapqirgoq Amudarya" ITHB, 2024. (in Uzbek).
- [6] Ergamberdiev, O., Tischbein, B., Franz, J., Lamers, J. 2008. Science brief from the ZEF-UNESCO project on Sustainable Management of Land and Water Resources in Khorezm, Uzbekistan, (ZEF) University of Bonn.
- [7] Begmatov, I. A., Matyakubov, B. Sh., Akhmatov, D. E., Pulatova, M. V. 2020. "Analysis of saline land and determination of the level of salinity of irrigated lands with use of the geographic information system technologies" // *InterCarto. Inter-GIS GI Support of sustainable development of territories Proceedings of the International conference. Volume 26-3 p. 309-316.* <https://doi.org/10.35595/2414-9179-2020-3-26-309-316>
- [8] Matyakubov, B., Koshekov, R., Avlakulov, M., Shakirov, B. "Improving water resources management in the irrigated zone of the Aral Sea region" // *E3S Web of Conferences*, 264, 03006 (2021), 02 June 2021, p. 8: <https://doi.org/10.1051/e3sconf/202126403006>
- [9] Recommendations for washing saline soil. 2010. Central Asian Irrigation Scientific Research Institute SANIIRI. (in Uzbek).
- [10] Hoffman, G. J., 1986. Guidelines for reclamation of salt affected soils. *Applied Agricultural Research* 1: 65-72.
- [11] Rhoades, J. D., Loveday, J. 1990. Salinity in irrigated agriculture. In *Irrigation of agricultural Crops*. Stewart BA, Nielsen DR (eds).
- [12] Khamidov, M. Kh., Begmatov, I. A., Isaev, S. X. 2014. "Water-saving irrigation technologies", A textbook for higher education institutions. Tashkent. TIMI, p. 178.
- [13] Khamidov, M. Kh., Khamraev, K. Sh., Isabaev, K. T. 2020. Innovative soil leaching technology: A case study from Bukhara region of Uzbekistan. *IOP Conf. Series: Earth and Environmental Science* 422 (2020). <https://doi.org/10.1088/1755-1315/422/1/012118>
- [14] Resolution of the President of the Republic of Uzbekistan No. PQ-23 dated January 26, 2023 "On additional measures to further support the activities of cotton raw material growers". (in Uzbek).
- [15] Reports of the "Uzagroinspection" in 2024. (in Uzbek). <https://agroinspeksiya.uz/uz/news/mamlakatimizda-lazerli-yer-tekislash-texnikalari-soni-ortib-bormoqda>
- [16] National report on the state of land resources of the Republic of Uzbekistan, Davyergeodezkadastrqo'mitasi, Tashkent, 2023: 8 p.
- [17] Dospexov, B. A. 1985. Field experiment methodology, 5th ed. add. and rework. Moscow. Agropromizdat, pp. 248-256. (in Russian).
- [18] SRICSSPCA, 2007. "Methods of Field Experiments", UzPITI. Tashkent 2007. p: 147. (in Uzbek).
- [19] Ramazanov, A. Yakubov, X. 1988. Flushing and moisture-charging irrigation, Tashkent, Mehnat, 192 p. (in Russia).
- [20] Shirokova, Yu. I., Poluashova, G., Rajabov, K., Koshekov, R. 2005. Efficiency of flush irrigation. International scientific and practical conference "Scientific support as a factor in sustainable development of water management", Taraz-October 20-21. p. 165 (in Russia).