Scientific Papers. Series E. Land Reclamation, Earth Observation & Surveying, Environmental Engineering. Vol. V, 2016
Print ISSN 2285-6064, CD-ROM ISSN 2285-6072, Online ISSN 2393-5138, ISSN-L 2285-6064

EVALUATION OF TAIL AND DRAINAGE WATERS ACCEPTABILITY FOR REUSE IN AGRICULTURE IN DRY REGIONS

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Abstract

Evaluations have been done on the basis of data the author obtained during his stage in Turkmenistan as an expert of Islamic Development Bank on Water Resources Development and Effective Water Use in the country. Drainage and tail water discharge data evaluated in the paper are collected from different drainage system structures constructed in different Willayets (Provinces) of Turkmenistan. As a result of the investigations the total volume of the drainage water was estimated as 5.6 – 6.0 km^3 per year. About 1.2 km^3 volume of the drainage water, as in the case of some collectors in Ahalskii and Dashoguzkii Region is with low salinity level and suitable for the purposes of irrigation. Relatively low salinity levels in the ranges of 2-2.6 g/l or 3.13- 4.06 dS/m were determined in waters of Gaurskii Main Collector, Ashgabatskii Collector, Geok-Tepinskii Drainage in Ahalskii Region of Turkmenistan. It was concluded that application of drainage waters with relatively law salinity level and ground waters for irrigation could increase the yearly irrigation water volume of the country from 26 km^3 to approximately 30-32 km^3. In addition, as a consequence these measures will promote enlargement of the irrigated lands in the country and will permit more agricultural food production.

Key words*: evaluation, drainage water, irrigation, Turkmenistan.*

INTRODUCTION

Turkmenistan is located in Central Asia between 35^0 08' and 52^0 48' N and 52^0 27' and 66^0 41' E, between the Caspian Sea in West and Amu Darya river in East. Climate of the country is sharply continental or subtropical desert with the exception of the inshore zone of the Caspian Sea.

The highest average amounts of the precipitations on the territory of the country is measured as 398 mm in the mountains, while the smallest amounts of 95-105 mm are observed in the regions above Kara-Bogaz Bay and Northeaster part of Turkmenistan (Çakir, 2005).

The land fund of the country is 488 100 km^2 and major part covered with pastures. On the other side, the soils are reported as poor on humus and rich in carbonates that is typical for dry regions. The desert occupies up to 80% of the whole territory of Turkmenistan. Karakum appears to be one of the largest deserts in the world and occupies the whole central part of the country stretching up to Kazakhistan (FAO, 1997; FAO, 2013).

The territory of Turkmenistan belongs to the zone of deficient watering. Annual average rainfall is 76-380 mm, while annual evaporation from the water surface reaches up to 1000-2300 mm levels. Therefore evaporation is many times as much as rainfall, which makes irrigation application a limitation factor for agriculture. At the same time, land area suitable for irrigation and agricultural cultivation in Turkmenistan constitutes 17 million hectares. Since prevailing climatic conditions are typical for the arid regions, only little more than 10% of them (about 2 million ha) are under agriculture, due to irrigation water shortage (Çakir, 2005). Although the perception of Central Asia, including Turkmenistan, as being a uniform area was (indirectly) promoted during the Soviet Union era, ecologically this region is very heterogeneous (Kienzler et. al., 2012).

According to O'Hara (2000) agriculture in the newly independent republics of Central Asia, is almost entirely dependent on irrigation. That's why access to water is essential and it plays an important role in the social and economic well-being of the country. Due to inadequate rates of season precipitations in all crop production in Turkmenistan is irrigated (Bucknall et al., 2003). Though, water resources which could be delivered for irrigation are strongly limited.

Pender and Mirzabaev (2008) reported that most of the irrigated crop land of the country is in the vicinity of the Syr Darya and Amu Darya rivers, and is irrigated by surface irrigation.

On the other side, the matter of water logging and salinisation of Turkmenistan's soils is widely accepted as one of the most serious environmental problems along with the sharp water scarcity (Çakir, 2005). O'Hara (1997) reported that evaluations from the mid-1980s onwards indicates that there has been a significant increase in the area of land where the water table is less than 2 m below the surface and more and more land is becoming saline.

Declining soils and water quality has significant implication for future agricultural development in the country.

In Turkmenistan, investment in improved drainage has been among the highest priorities of the government, which is constructing the vast Turkmen Lake (also called the Golden Age Lake) in the Karakum Desert to collect saline irrigation drainage water (Stone, 2008).

The prevailing desert climatic conditions with extremely low rainfall quantities on the one hand, and very limited fresh water resources on the other, makes the evaluation of drainage waters of relatively low salinity as a possible water source for agricultural irrigation an unavoidable requirement.

MATERIALS AND METHODS

Drainage and tail water discharge data evaluated in the paper are collected from different drainage system structures constructed in different Wilayets (Provinces) of Turkmenistan shown on Figure 1.

While the location of the hydraulic structures observed from specialist of the governmental institution as Ministry of Water Economy and Ministry of Agriculture (MWE, 1998); and specialists from the "Turkmensuvylymtaslama" Institute are schematically presented on Figure 2.

Figure 1. Map of Turkmenistan

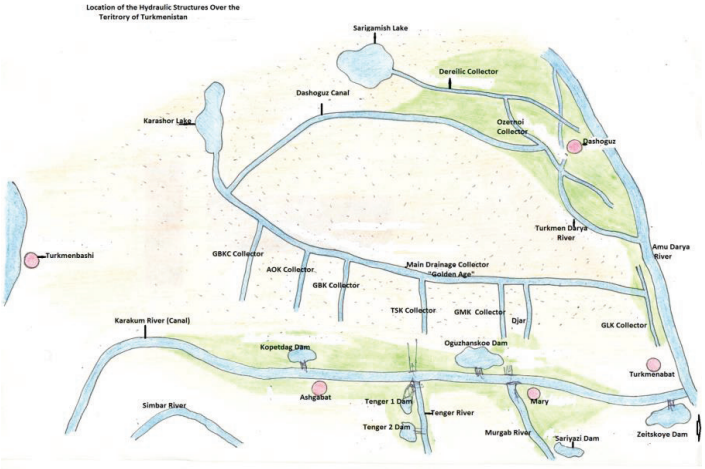

Figure 2. Schematically presentation of drainage structures over irrigated lands of Turkmenistan

In order to determine salinity levels and chemical compositions of salt into drainage-tail water mixture, water samples were taken periodically from different parts of drainage system laid on the figure.
Water salinity analysis was carried out in the laboratories of the Ministry and the Institute "Turkmensuvylymtaslama" in Ashgabat using methods given by Arinuskina (1952). While evaluations of the laboratory data and classification of investigated waters were performed on the basis of world-wide criteria published in Richards (1954).

RESULTS AND DISCUSSIONS

a) Short overview on Fresh Water Resources and Water Storing Facilities in Turkmenistan

Main water resources of Turkmenistan are the Amu-Darya river (22.0 km^3), Murgab (1.6 km^3), Tedjen (0.9 km^3), Atrek (0.4 km^3) and small rivers of Kopetdag (Table 1).

Table 1. Mean annual runoff and ground water withdraw in Turkmenistan

Nature of the Source	Source name	Water Amount mln m^3/year
1. Surface Water (Rivers)	1.1 Amu-Darya including Karakum Artificial River	22.000
	1.2 Murgab River	1.631
	1.3 Tedjen River	169
	1.4 Atrek River	354
	1.5 Small Rivers	150
	Total surface water	24.304
2. Underground water		1.269
Total 1 + 2		25.573
Dam capacity		6.220

Water resources of Turkmenistan differ by extremely irregular placement on the territory of the country: 95% of all the water resources of the country are provided by Amu-Darya river, while a share of 5% belong to all other rivers, small rivers, springs and underground aquifers withdraw.
Agriculture in Turkmenistan is totally dependent on irrigation. Even sheep grazing in the desert need watered pastures to survive (Stanchin and Lerman, 2007).
The largest and most important waterway in Turkmenistan is the Kara Kum canal, constructed in the 1950s and is at 1.400 km the longest canal in the world (Balakayev, 1979; FAO, 2013). The river (Canal) crosses the country and actually supplies almost all the water required for agricultural, industrial and other purposes of the country. Actually it appears to be the largest hydraulic structure in the world, with recent flow up to 600 m^3/s which is projected reach 800m^3/s after the reconstruction and caring 11 km^3 water per a year (Çakir, 2005). The importance of the Karakum river for Turkmenistan agriculture is much more visible from the figures pointing out that about 80% of land suitable for agriculture is located in the south and south-east of the country, while Amu-darya supplying more than 95 % of water resources flows in the east of Turkmenistan (FAO, 2013). The canal brings water to the capital Ashgabat and to the oases in the south. Each year the canal takes 10-12 km^3 from the Amu Darya river (Orlovsky and Orlovsky, 2002).
According to evaluations in FAO (2013), in 2004, wastewater production was estimated as 1,275 km^3 and treated wastewater 0.336 km^3 all of which was directly reused. Nevertheless it could be concluded that wastewater do not play a significant role in Turkmenistan. Agricultural drainage water, however, is a substantial additional source for pasture irrigation, growing salt-resistant trees and forage crops and for fisheries.

b) Drainage Water Availability and Degree of Water Salinity

The prevailing dry climatic conditions with extremely low precipitations amounts on one side, and domestic and agricultural water requirements of the country on the other, requires evaluation of drainage waters of relatively low salinity as a possible water source to alleviate the problem of water scarcity in Turkmenistan. It could be said that drainage water is another source that could also attribute to water resources from the point of agricultural water use.
As a result of the investigations the total volume of the drainage water was estimated as 5.6-6.0 km^3 per year. Some part of the drainage water, as in the case of some collectors in Ahalskii (Table 2) and Dashoguzkii Region (Table 4), is with low salinity level and suitable for the purposes of irrigation.

Table 2. Average discharge, volume and average salinization value of drainage waters in Ahalskii Region (Welayet) of Turkmenistan

Drainage system	Average Discharge (m^3/s)	Drainage volume (mln.m^3/year)	Average Salinity Level (g/l)	Average Salinity Level (dS/m)
Prikopetskaya Zone				
Kahiskii Main Collector	0.18	5.65	14.10	22.08
Gaurskii Main Collector (GMK)	1.84	58	2.14	3.34
Ashkabatskii Collector (AK)	3.00	95	2.00	3.13
Geok-Tepinski Drainage System (GTDS)	4.31	136	2.60	4.06
Tedjenskaya Zone				
Tedjenskii Main Collector (TMK)	6.34	200	20.00	31.25
Tedjenskii South-western Collector (TSWK)	1.40	44	15.00	23.44
Total:	17.10	538.65	9.30	14.55

Relatively low salinity levels in the ranges of 2-2.6 g/l or 3.13-4.06 dS/m were determined in waters of Gaurskii Main Collector (GMK), Ashgabatskii Collector (AK) Geok-Tepinskii Drainage (GTDS) from Prikopeteskaya Zone in Ahalskii Region of Turkmenistan.

On the other side, while waters from most of the collectors in Dashoguski Wilayet, neighboring Uzbekistan were determined to have relatively low salinity levels fluctuating in the ranges of 2.31-3.26 g/l or 3.61- 5.10 dS/m (Table 4), drainage waters from all collectors in Mariiski regions (Table 3) appeared to have high salinity level in the ranges of 6.15-15.0 g/l or 9.60-23.43 dS/m and unusable for the purposes of irrigation.

Chemical characteristics and amounts of drainage water sources acceptable for irrigation purposes in the region are summarized in Table 5.

As could be concluded from data in the mentioned table, the yearly average total volume of water suitable for irrigation is about 1,255 mln.m^3/year which seems to be a valuable figure for the countries as Turkmenistan with serious water shortage.

Major part (852 mln.m^3/year) of drainage water of acceptable quality are those from the Main Leftside Collector (MLK) of Lebapskii Region, with salinity and alkalinity (SAR) levels of 2.45 dS/m and 3.19; and classified in S4A1 salinity-alkalinity class.

While less total water amounts of 135 and 268 mln.m^3/year, are provided respectively by Geok - Tepinskii Eastern Collector (GTEK) and Gaurskii Main Collactor (GMK) in Ahalskii Region.

Table 3. Average discharge, volume and average salinization value of drainage waters in Mariiskii Region (Welayet) of Turkmenistan

No	Drainage system	Average Discharge (m^3/s)	Drainage volume (mln.m^3/ year)	Average Salinity Level (g/l)	Average Salinity Level (dS/m)
1	Djar	14.00	441	8.72	13.63
2	Kese-yab	8.18	258	6.15	9.60
3	Djar-say	1.77	56	9.95	15.55
4	Oguzhan	9.64	304	15.00	23.43
	Total:	33.59	1059	9.95	15.55

Moreover the chemical composition of waters from the former collector appeared to be worse with salinity and alkalinity levels up to 4.38 dS/m and 7.38 (SAR) respectively.

Table 4. Average discharge, volume and average salinization value of drainage waters in Dashoguzkii Region (Welayet) of Turkmenistan

No	Drainage system	Average Discharge (m^3/s)	Drainage volume (mln.m^3/year)	Average Salinity Level (g/l)	Average Salinity Level (dS/m)
1.	Ozernii (at border with Uzbekistan)	62.40	1.968	2.87	4.48
2.	Daryalyik (at border with Uzbekistan)	41.76	1.317	2.31	3.61
3.	*All at the border*	*104.16*	*3.285*	*2.71*	*4.23*
4.	Final Part of Ozernii System o	88.60	2.794	3.26	5.10
5.	Ozernin (at the territory of Dashoghuz Region)	26.20	825.6	4.22	6.59
6.	Final part of Daryalyik Drainage System	81.42	2.570	2.83	4.42
7.	Daryalyik Drainage System (in territory of Dashoghuz Region)	39.66	1,250.6	3.22	5.03
8.	*Total of Ozernii and Daryalyik at territory of Dashoghuz Region*	*65.86*	*2.077*	*3.16*	*4.94*
9.	*Total of Ozernii and Daryalyik*	*170.02*	*5.362*	*3.04*	*4.75*

Water quality parameters of drainage waters from Gaurski Main Collector could be accepted as highest of all waters included in Table 5, since salinity and alkalinity levels and salinity-alkalinity class of mentioned water source were determined as 2.05 dS/m, 4.41 and S3A1.

Table 5. Summary of data for waters appropriate for irrigation

No	Region	Drainage System	Total water volume (mln.m^3/year)	Salinity level (dS/m)	Alkalinity (SAR) level	Salinity-Alkalinity Class
1	Lebapskii Region	Main Leftside Collector (MLK)	852	2.45	3.19	S4A1
2	Ahalskii Region	Geok-Tepinskii Eastern Collector (GTEK)	135	4.38	7.81	S4A1
3		Gaurskii Main Collector (GMK)	268	2.05	4.41	S3A1
	Total:		1255			

Very limited quantities of water with relatively low salinity in the ranges of 3.61-5.10 dS/m were recorded in some of the collectors in Dashoguzkii Region (Table 4).

Turkmen lake, being constructed nowadays in the Karakum desert, is an important drainage water collecting structure in Turkmenistan. Design capacity of the artificial lake is 132 km^3 with annual average flow of 11 km^3. Turkmen lake is projected to collect flows by means of two main drainage canals, i.e. Dashoguz branch and Golden Age Main drainage canal from all regions of the country (Çakir, 2005).

Dashoguz (210 m^3/s discharge) branch stretching for 383.8 km will divert drainage water from the left bank of the Amu-Darya and from Dashoguz region.

While main drainage canal stretching for 720 km across the Karakum desert will collect waste water from all regions.

Schematically presentation of hydraulic structures as water storing reservoirs and drainage collector system is given on Figure 2.

In general, renewable water sources especially in non-arid regions are important part of the total water volume which could be allocated for agricultural crops irrigation.

However, the total volume of groundwater in Turkmenistan is estimated to be as low as 3.36 km^3/year, 3km^3/year of which is estimated to be formed by the infiltration from the rivers and surface runoff generated in upstream countries.

Due to lack of enough equipment for the extraction of water, only about 1.27km^3/year is being extracted and used for irrigation (Table 1).

Currently all available fresh water resources of Turkmenistan are totally used however acute water shortage is available in all regions of the country. Growing need of irrigation water and shortage of water resources require integrated measures aiming development of measures on improvement of water resources management in Turkmenistan.

Taking into account that crops prevailing in the agricultural structure of country are cotton (42.0%), wheat (49.0%) and forage crops (5.0%) (data not included), all ft which relatively resistant to low and moderate water salinity levels (Ayers and Westcot 1976); Ayars et al. 1993; Maas and Grattan 1999; Tanji and Kielen 2002), drainage voter volumes included in Table 5 reaching up to 1,250-1,300 mln.m^3/year could be accepted as a valuable reserve to decrease deficit of irrigation water source of the country.

CONCLUSIONS

Turkmenistan owns very limited water resources which appear a restricting factor for agricultural activities over larger areas, under the conditions of dry desert climate.

Total fresh water resources about25 mln.m^3/year is not adequate for the needs of the country. The requirement for alternative supplemental water sources is obvious.

Significant part of the drainage water available in Ahalskii, Lebapskii and Dashoguzkii Regions containing low salt quantities are suitable for irrigation.

A programme related to reuse of drainage waters of low salinity level should be developed.

Though, special measures need to be taken in order to prevent any additional salinization of the soil due to low quality water application. Use of the ground water potential of the country also could alleviate water shortage problem of the country. Presently less than

25 % of the potential is being extracted and used for irrigation.

Application of drainage water volume with relatively law salinity level and underground waters for irrigation could increase the yearly irrigation water volume of the country from 26 km^3 to approximately 30-32 km^3. As a consequence these measures will promote enlargement of the irrigated lands in the country and will permit more food production.

ACKNOWLEDGMENTS

The author is acknowledged to the authorities from Islamic Development Bank, especially to Mr. Mohammad Awward and Raja Anayat from the Technical Cooperation Office for their technical and financial support prior, during and after his stay in Turkmenistan. He also appreciated the contributions of Mr. Altiyev Tekabay Altiyevic, First Deputy Minister of Water Resources Ministry and Mr Cumageldi İzmailov, Head of the Department for International

Relationships in the Ministry of Agriculture of Turkmenistan. Special thanks to Mr. Hanmmamedov Mohammad Agayevic, Director of the Institute "Turkmensuvy-lymtaslama", his Deputy Mr. Chichayev Durdi Chichayevich and to the members of the research team in the Institute, Dr. Bashim Balakayev, Dr. Ovez Nazarmammedov, Mr. Dovran Basarov and Dr. Kurbanmurat Obezmuradov for their cooperation and valuable help in the process of evaluations executed by the expert during his stay in Turkmenistan. The technical contributions of Dr. Davlet Babayevic, Director of National Cotton Research Institute in Ashkabat are also appreciated.

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