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Ecological Quality Assessment of Drainage Water of Irrigated Lands at SYR Daria Middle Course

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ABSTRACT

The goal of this work is to carry out an ecological assessment of drainage water qualitative composition at Syr Daria middle course and to set factors that worsen a reclamative condition of irrigated lands during the irrigation of cultivated crops. It was found out that the salinity level of drainage water at irrigated lands of Makhtaaral area in South Kazakhstan region varies significantly 1.009-7.275 g/l. There is a lesser change range in Shardara irrigation area – 0.976-2.412 g/l and in the area of Arys-Turkestan channel – 1.031-3.449 g/l. According to the analysis of ion composition SO_4^{2-} is a predominant anion of Syr Daria middle course, its concentration in Makhtaaral area is high in comparison with Shardaria area and the area of Arys-Turkestan channel; it varies within 1.521-2.054 g/l or 31.68-42.80 mg-eq/l. According to the analysis of cation composition of drainage water the predominant cations of the majority of collectors are Na^+ and Mg^{2+}. If the salinity level of drainage water increases then difference in concentration of cations Na^+ and Mg^{2+} rises sharply. It was found out that the percent of toxic salts is about 63.2-80.3% from the total salt content. Besides, for crops the most harmful toxic salt is regular sodium carbonate – Na_2CO_3, it is 10 times more toxic than chlorine.

Key words: Qualitative composition, drainage water, deterioration, soil, irrigation, ecology

INTRODUCTION

According to Kazakhstan experience in operation of irrigation facilities, the modern systems of water resources control and of water and land resources protection from deterioration and pollution used in irrigation schemes lead to a disorder of the natural balance of irrigated ecosystems. The result is the acceleration of the pollution processes of surface water and groundwater, the increase of irrigated lands degradation level and the instability of irrigated agriculture (Vyshpolsky, & Mukhamedjanov, 2005; Aydarov, 1985). Irrigated lands of South Kazakhstan are located in trans-border river basins that is why available water supply of the operating irrigation schemes is in the range 75-95% and during low water years it goes down to 50-60%. At the same time large volumes of waste waters and discharge waters gathered in river basins (up to 30-50% of water delivery) are being dumped, polluting water sources and environment of the surrounding areas. (Rau, 1988). For example, volume of drainage waters that were discharged outside irrigation schemes of Kazakhstan south regions was 1293.76 mln. m^3 in the year 2012 (table 1). Usage of drainage water at irrigated lands is limited by its low quality, though its salinity level does not exceed 3 g/l in the majority of irrigation facilities today. However qualitative composition of drainage water used for irrigation could result in the alkalization of soils (Borovsky, 1982; Vyshpolsky, *et al.*, 2008; Karimov, *et al.*, 2009).

Table 1: Volume of drainage waste water of South Kazakhstan, mln. m^3

South Kazakhstan	Region			
in general	Kyzylorda	South Kazakhstan	Jambyl	Almaty
1293.76	266.5	829.4	12.36	185.5

When drainage water falls into rivers it pollutes not only water resources but also underlying irrigated ecosystems. Due to this reason the salinity level of Syr Daria river low course reached 2.5-2.6 g/l in late 80th of the last century. The same situation was in Asa-Talas, Shu and Ili river basins: an increase of the salinity level and a decrease of water resources quality. This led to the deterioration of soil and ecological state of irrigated ecosystems and afterwards worsened soil fertility and their agricultural expulsion (Rozov, 1956; Rau, 1988; Saparov, 2013). That is why today only 1.3 mln. ha of irrigated lands from former 2.36 mln. ha are constantly irrigated. The analysis of soil and ecological state of irrigating facilities proves that 40-50% of irrigated lands were salinized and 30% were alkalinized and lost a nutrient reserve. Thus, in order to use drainage water for irrigation of cultivated crops it is necessary to assess their quality and to determine factors influencing ecological and reclamation state of irrigated lands (Dukhovny, *et al.*, 2007; Yakubov, *et al.*, 1988; Shirokova, 2002;).

Irrigated lands of Makhtaaral, Shardara, Otyrar, Arys and Turkestan areas of South Kazakhstan region are located in Syr Daria middle course. Area of the irrigated lands is 317.8 thousand hectares (Anzelm, 2012). 49.5% of irrigated lands are salinized (table 2). High salinity level of irrigated lands of Syr Daria middle course is explained by the low quality of irrigation water and proximity of salted ground water.

Table 2: Area of irrigated lands of Syr Daria middle course and their salinity level

Area	Gross area,	Including:			
name	thous. ha	non-saline	low-saline	mid-saline	high-saline
Arys	18.3	11.2	2.8	1.9	2.4
Makhtaaral	138.8	62.1	24.6	39.2	12.9
Otyrar	36.5	12.1	8.9	10.8	4.7
Turkestan	56.2	49.3	3.5	1.1	2.3
Shardara	68.0	25.7	18.7	9.1	14.5
Total:	317.8	160.4	58.5	62.1	36.8
		50.5	18.4	19.6	11.5

Growing deterioration (pollution, exhaustion of water resources) at irrigated lands of Syr Daria middle course is inevitable due to the following reason: irrigation facilities were constructed and operated with the only purpose to get maximum crop production. For this purpose high volumes of chemical fertilizers were added and negative salinity balance was created by dumping big volumes of drainage water (20-40% of water withdrawal) outside irrigation schemes (Vyshpolsky, & Mukhamedjanov, 2005). As a rule this water returns to irrigation sources (river channels), that is why its quality deteriorates in downstream of rivers (Magay, & Kruglov, 1987). At the present stage of irrigation development many countries began to use methods of integrated control over water resources (surface and ground). Provided that agricultural producer has limited water resources, the stated complex problem could be solved by setting indexes for reasonable rise of efficiency coefficient of irrigation system and of watering method, of volume of underground water used for subirrigation and of drainage water used for irrigation (Ikramov, 2002). In any case effectiveness of financial investments in the reconstruction of irrigation facilities should be evaluated by the level of crop production and by the prosperity level of rural population; it should depend on how efficiently surface and ground water is used for growing crops; it is also influenced by intensification of biological cycle and decrease of geological cycle of irrigated lands, by increase of their ecological stability due to the reduction of negative influence of irrigation facilities to the environment (Parfenova, & Reshetkina, 1992; Vyshpolsky, & Mukhamedjanov, 2005).

Methodology

In order to define whether the drainage water is suitable for irrigation of cultivated crops and for salinity control of soil the following criteria were used: soil salination hazard; soil alkalization hazard; toxicity level of some ions (Ganjara, *et al.*, 1985). Thus, drainage water quality was defined according to: total salt content; quantitative indexes of anions and cations; various ion ratios; sodium carbonate presence; toxic and non-toxic salts (Rakhimbaev, & Ibragimov, 1978).

Water samples were took for chemical analysis every month from April to September during vegetation period in order to determine the dynamics of mineralization and of ions and salt composition of drainage water. Ecological assessment and pattern of changes of ion and salt composition of irrigation water, underground and drainage water are defined according to: CO_3^{2-}, HCO_3^-, Cl^-, SO_4^{2+}, Ca^{2+}, Mg^{2+}, Na^+, NO_2, NO_3, P_2O_5, K_2O, humus, pH (Ganjara, *et al.*, 1985; Yakubov, *et al.*, 1988). These ions bound to each other to form tentative salts. This helped to determine quantitative indexes of toxic and non-toxic salts. Chemical analysis of drainage water sample was conducted in the laboratory of Kazakhstan Scientific Research Institute of Water Economy.

Results of chemical analysis of drainage water samples gave opportunity to evaluate its ecological state and to determine factors that have negative influence on reclamative state of water and land resources. Techniques worked out by I.N. Antipov-Karataev and G.M. Kader and sodium adsorptive ratio (SAR) were used to achieve the purpose (Yakubov, *et al.*, 1988; Shitikov, *et al.*, 2003; Shirokova, 2002). Magnesium influence was determined by percent of magnesium in its rate to the sum-total of calcium and magnesium cations. Magnesium has a negative influence on soil if the percent is more than 50%.

High content of sodium and magnesium cations in salinized drainage water used for irrigation and salinity control causes soil alkalization and has negative influence on the development of cultivated crops. Influence of water quality on soil alkalization is determined according to the relation worked out by I.N. Antipov-Karataev and G.M. Kader (Ganjara, *et al.*, 1985; Yakubov, *et al.*, 1988; Shitikov, *et al.*, 2003):

$$K = \frac{Ca^{2+} + Mg^{2+}}{Na^{+} + 0{,}23 \cdot \tilde{N}} \qquad \text{...(1)}$$

where: Ñ – water salinity, g/l; Ca^{2+}, Mg^{2+}, Na^+ – cations content in water, mg-eq. If K>1 soil alkalization does not occur, K<1 then water is considered not suitable for irrigation.

Sodium adsorptive ratio (SAR) is used for the evaluation of water quality for soil alkalization hazard in foreign practice:

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}} \quad ...(2)$$

If SAR < 10 – soil alkalization hazard is low; SAR = 10-18 – it is medium; SAR = 18-26 – it is high; SAR > 26 – it is extremely high.

Sodium hydro carbonate contained in water also influences soil alkalization processes. It precipitate calcium cations and in a less degree magnesium cations, thus disturbing cation balance and increasing sodium salinization hazard. Evaluation is performed according to the value of RSC (residual sodium carbonate), determined by difference between alkalinity and sum of calcium and magnesium ions (Ganjara, *et al.*, 1985; Yakubov, *et al.*, 1988; Shitikov, *et al.*, 2003):

$$RSC = (CO_3^{2-} + HCO_3^{-}) - (Ca^{2+} + Mg^{2+}); \quad ...(3)$$

If RSC > 2,5 mg-eq/l – then water is not suitable for irrigation; RSC = 1.25-2.5 mg-eq/l – partially suitable; RSC < 1.25 mg-eq/l – suitable.

Soil sodium salinization hazard is evaluated by the content of regular sodium in water – Na_2CO_3. If Na_2CO_3 < 0.3 mg-eq/l – then water is safe for irrigation; Na_2CO_3 = 0.3-0.6 mg-eq/l – is suitable for irrigation; Na_2CO_3 > 0.6 mg-eq/l – is not suitable for irrigation without ameliorants.

Water alkalinity is determined by pH value. If pH = 6.5-7.9 – water is neutral; pH = 8.0-8.5 – weakly alkaline; pH = 8.6-9.0 – strongly alkaline; pH>9 – extremely alkaline.

High concentration of magnesium cations in irrigation water has unfavorable effect on chemical properties of soil. Magnesium influence is determined by percent of magnesium in its rate to the sum-total of calcium and magnesium cations (Ganjara, *et al.*, 1985; Yakubov, *et al.*, 1988; Shitikov, *et al.*, 2003):

$$Mg^{*} = \frac{Mg^{2+}}{Ca^{2+} + Mg^{2+}} \cdot 100 \quad ...(4)$$

Magnesium (Mg^{*}) determined by this equation has a negative influence on soil if its percent is more than 50%.

RESULTS

Volumes of drainage water and change range of its salinity

According to the analysis of drainage water formation in Syr Daria middle course volumes of drainage waters depend on technical condition of irrigation facilities, on drainage working capacity, on irrigation norms and farming standards (table 3). During the investigation period sizes of drainage water run-off in Syr Daria middle course changed from 338.17 to 712.46 mln. m^3, and in some areas the sizes varied: from 158.6 to 235.4 mln. m^3 in Makhtaaralsk; from 112.6 to 457.56 mln. m^3 in Shardara areas (Anzelm, 2012). Their minimum values are recorded during low water years, when irrigation norms are reduced and drainage water intake for irrigation is increased.

Table 3: Volume of drainage water in areas of South Kazakhstan region

Area name	Drainage water run-off, mln. m^3					
	2008	2009	2010	2011	2012	2013
Arys	5.7	5.64	4.76	-	-	-
Makhtaaral	158.6	235.4	169.51	208.1	219.3	228.04
Otyrar	2.0	2.2	5.93	1.5	7.0	6.5
Turkestan	36.54	38.69	45.37	34.94	28.6	28.8
Shardara	217.65	266.79	112.60	269.81	457.56	331.62
TOTAL:	420.49	548.72	338.17	514.35	712.46	594.96

Salinity level of drainage water of irrigation facilities at Syr Daria middle course shows that its maximum level was at irrigated lands of Makhtaaral area of South Kazakhstan region – 1.009-7.275 g/l (table 4). Salinity change range of drainage water reduced to 0.976-2.412 g/l in Shardara irrigation area and to 1.031-3.449 g/l in the area of Arys-Turkestan channel.

Table 4: Salinity level of drainage water of irrigation facilities at Syr Daria middle course

No.	Area	Salinity level, g/l			Number of samples, pcs	Coefficient of variation (V), %
		minimum	middle	maximum		
1	Makhtaaral	1.009	2.268	7.275	72	85.4
2	Shardara	0.976	1.562	2.412	30	47.3
3	Turkestan	1.031	1.755	3.449	25	36.1

High variability of drainage water in Makhtaaral area is explained by the fact that salinity level of underground water varies in a wide range 0.75-25.3 g/l. Besides area of irrigated lands with the salinity level of underground water more than 10 g/l in Makhtaaral area is 5325 Ha (table 5). In other areas of Syr Daria middle course the salinity level of underground water is not more than 10 g/l. The bsalinity level of drainage water of irrigated lands in Shardara and Turkestan areas changes mainly within the limits 1-4 g/l.

Table 5: Allocation of irrigated lands according to the salinity level of ground water

No.	Administrative district	Gross area, Ha%	Salinity level of ground water, g/l				
			0-1	1-3	3-5	5-10	>10
1	Arys	18256	10960	6085	1211	-	-
		100	60	33	7.0		
2	Makhtaaral	138800	150	36725	69197	27403	5325
		100	0.1	26.0	49.9	20	4.0
3	Otyrar	36539	1248	27447	4969	2875	-
		100	3.4	75	14.0	8.0	
4	Turkestan	56244	34288	20237	821	898	-
		100	61.0	36.0	1.5	1.5	
5	Shardara	68003	1510	63366	2957	170	-
		100	2.2	93.2	4.4	0.2	
Total	317842	48156	153860	79155	31346	5325	
	100	15.1	48.4	24.9	9.9	1.7	

Note: in numerator – ha; in denominator – % from gross area

Ion composition of drainage water

Ion composition of drainage water shows that predominant anion of Syr Daria middle course is SO_4^{2-}. Concentration of this anion in Makhtaaral area is high in comparison with Shardara and Turkestan areas; it varies within 1.521-2.054 g/l or 31.68-42.80 mg-eq/l (table 6). Concentration of chlorine ions is 2-3 times less in comparison with SO_4^{2-}. SO_4^{2-} is also a predominant anion in Turkestan area. Tough concentration of Cl^- is less than concentration of HCO_3^-. The same regularity of anion changes in drainage water takes place in other collectors. This means that soil alkalization processes take place at irrigated lands of Arys-Turkestan channel, because chemism of water salinization is hydro carbonate sulfated.

According to the analysis of cation composition of drainage water the predominant cations of the majority of collectors are Na^+ and Mg^{2+}. If the salinity level of drainage water increases then difference in concentration of cations Na^+ and Mg^{2+} rises sharply. For example, in Arnasay collector salinity level of Na^+ is 0.818 g/l and of Mg^{2+} is 0.255 g/l or 35.56 and 16.6 mg-eq correspondingly. Cations $C\alpha^{2+}$ have minimal values and vary within 0.196-0.296 g/l in all collectors.

Qualitative composition of drainage water salts

Qualitative composition of drainage water salts of irrigated lands in Syr Daria middle course shows that toxic salts dominate (table 7). Though their percent in sum of salts varies within 63.2-

Table 6: Ion composition of drainage water

Irrigation facility	Collector name	Anions				Cations			Sum of salts, g/l
		CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	Na^+	
Makhtaaral	Sardoba	0.034	0.249	0.366	1.521	0.212	0.246	0.377	3.005
		1.12	4.08	10.32	31.68	10.60	20.20	16.40	
	D-3	0.028	0.239	0.457	1.686	0.260	0.224	0.494	3.388
		0.96	3.92	12.88	35.12	13.00	18.40	21.48	
	Jetysay	0.038	0.234	0.349	1.544	0.216	0.202	0.453	3.036
		1.28	3.84	9.84	32.16	10.80	16.60	19.72	
	Arnasay	0.034	0.259	0.824	2.054	0.296	0.255	0.818	4.540
		1.12	4.24	23.20	42.80	14.80	21.00	35.56	
	Kyzylkum	0.034	0.229	0.378	1.601	0.204	0.190	0.531	3.167
		1.12	3.76	10.64	33.36	10.20	15.60	23.08	
	Northen	0.024	0.185	0.466	1.578	0.196	0.229	0.488	3.166
		0.80	3.04	13.12	32.88	9.80	18.80	21.24	
	Eastern	0.028	0.229	0.469	1.670	0.260	0.241	0.458	3.355
		0.96	3.76	13.20	34.80	13.00	19.80	19.92	
Shardara	Shardara	0.019	0.190	0.236	0.641	0.152	0.107	0.169	1.514
		0.64	3.12	6.64	13.36	7.60	8.80	7.36	
	Kosseyt-1	0.019	0.322	0.236	0.833	0.160	0.090	0.334	1.994
		0.64	5.28	6.64	17.36	8.00	7.40	14.52	
	Kosseyt -2	0.043	0.224	0.199	0.739	0.048	0.165	0.233	1.651
		1.44	3.68	5.60	15.40	2.40	13.60	10.12	
	Koksu	0.024	0.195	0.227	0.797	0.084	0.136	0.267	1.730
		0.80	3.20	6.40	16.60	4.20	11.20	11.60	
	Uzyn Ata	0.034	0.210	0.133	0.587	0.068	0.124	0.160	1.316
		1.12	3.44	3.76	12.24	3.40	10.20	6.96	
Turkestan	K-1	0.028	0.293	0.111	0.580	0.080	0.073	0.252	1.417
		0.96	4.80	3.12	12.08	4.00	6.00	10.96	
	K-2	0.048	0.293	0.224	0.983	0.100	0.115	0.430	2.193
		1.60	4.80	6.32	20.48	5.00	9.50	18.70	
	K-3	0.034	0.351	0.398	1.555	0.170	0.017	0.643	3.321
		1.12	5.76	11.20	32.40	8.50	14.00	27.98	
	K-4	0.024	0.312	0.125	0.580	0.080	0.079	0.253	1.453
		0.80	5.12	3.52	12.08	4.00	6.50	11.02	
	K-5	Trace	0.239	0.037	1.025	0.70	0.091	0.122	1.784
			3.92	1.04	21.36	13.50	7.50	5.32	

Note: in numerator – mg-eq/l; in denominator – g/l

Table 7: Qualitative composition of drainage water salts of irrigated lands in Syr Daria middle course

Area	Collector	Non-toxic salts			Toxic salts						Sum
	name	$Ca(HCO)_2$	$CaSO_4$	sum	Na_2CO_3	$NaHCO_3$	$MgSO_4$	Na_2SO_4	NaCl	sum	of salts
Makhtaaral	Sardoba	0.332	0.443	0.775	0.059		1.215	0.353	0.603	2.230	3.005
		11.0	14.7	25.7	2.0		40.4	11.7	20.1	74.3	100
	Northern	0.246	0.460	0.706	0.042		1.128	0.525	0.765	2.460	3.166
		7.8	14.5	22.3	1.3		35.6	16.6	24.2	77.7	100
	Arnasay	0.343	0.718	1.061	0.059		1.265	0.798	1.357	3.479	4.540
		7.6	15.8	23.4	1.3		27.9	17.6	29.9	76.6	100
Shardara	Shardara	0.253	0.305	0.558	0.034		0.529	0.006	0.388	0.956	1.514
		16.7	20.1	36.8	2.2		34.9	0.4	25.6	63.2	100
	Kosseyt	0.428	0.185	0.613	0.034		0.444	0.515	0.388	1.381	1.994
		21.5	9.3	30.8	1.7		22.3	25.8	19.4	69.2	100
	Uzyn ata	0.275		0.275	0.059	0.003	0.615	0.145	0.219	1.041	1,316
		20.9		20.9	4.5	0.2	46.7	11.0	16.7	79.1	100
Turkestan	K-1	0.324		0.324	0.051	0.067	0.36	0.432	0.182	1.093	1.417
		22.9		22.9	3.6	4.7	25.4	30.6	12.8	77.1	100
	K-2	0.389	0.014	0.403	0.086		0.570	0.766	0.368	1.790	2.193
		17.7	6.4	18.4	3.9		26.0	34.9	16.8	71.6	100
	K-3	0.467	0.186	0.653	0.059		0.844	1.112	0.653	2.668	3.321
		14.1	5.6	19.7	1.8		25.4	33.5	19.7	80.3	100

Note: in numerator – g/l; in denominator – % from sum of salts

80.3%. For crops the most harmful toxic salt is regular sodium carbonate – Na_2CO_3 (Aydarov, 1985). Soda is 10 times more toxic than chlorine. Presence of soda in drainage water reduces the opportunity to use it for irrigation.

Content of regular soda in drainage water of Makhtaaral area varies within 0.042-0.059 g/l and forms 1.3-2% of the salt sum. Percent of regular soda in the sum of salts increases in drainage water of Shardara area and forms 4.5%, in the area of Arys-Turkestan channel it is 3.9%. In drainage water of irrigated lands of Shardara area and of Arys-Turkestan channel sodium hydrogen carbonate $NaHCO_3$ was found. In the area of Arys-Turkestan channel percent of sodium hydrogen carbonate is 4.7% of the salt sum.

Toxic sulfates $MgSO_4$ and Na_2SO_4 predominate in drainage water of irrigated lands in Syr Daria middle course; they compose more than a half of all salts in water. For example, sum of toxic sulfates is 52.1% of the salt sum in water of Sardoba collector. Toxic sulfates are also predominant salts in Shardara area and in the area of Arys-Turkestan channel.

Percent of toxic NaCl varies within 12.8-29.9% from the sum of salts. Minimal values of sodium chloride were taken in drainage water of irrigated lands in the area of Arys-Turkestan channel. Maximum content of sodium chloride is in drainage water of irrigated lands of Makhtaaral irrigation area. In this area concentration of NaCl varied within 0.603-1.357 g/l, and their percent is 20.1-29.9% of the salt sum. Non-toxic salts of drainage water are calcium hydro carbonates and sulfates. Percent of these salts varies within 18.4-30.8% of the salt sum.

Quality assessment of drainage water

Results of chemical analysis of drainage water in irrigated lands of Syr Daria middle course helped to assess its quality by other factors. PH factor shows that water is mostly weakly or medium alkaline. Possibility for intersystem use of drainage and waste water in order to increase water supply of irrigated lands is supported by the data received from chemical analysis (table 8). Monitoring of chemical composition of drainage and waste water conducted by South Kazakhstan hydrogeological ameliorative expedition shows that in most cases it could be used without irrigation water.

Table 8: Evaluation of drainage water quality in different irrigation facilities

Basin	Irrigation facility	Collector	Factor				
			pH	RSC	Mg^*,%	K	SAR
Syr Daria middle course	Makhtaaral	D-3	8.65	-7.1	60.8	2.6	2.2
		Sardoba	8.70	-8.8	70.7	2.4	2.9
		Western	8.65	-7.3	76.9	2.8	2.4
		Northern	8.60	-7.4	79.6	2.3	2.9
		Jetysay	8.45	-9.9	81.5	2.2	3.4
		Togain	8.60	-6.8	73.5	2.4	2.6
		Arnasay	8.45	-7.4	85.7	2.0	3.7
	Shardara	Shardara	8.6	-10.72	44.9	1.62	2.6
		Kosseyt-1	8.6	-9.48	48	1.03	5.23
		Kosseyt -2	8.6	-7.6	43.3	1.80	6.1
		Koksu	8.6	-14.24	50.0	1.16	5.3
		Uzyn Ata	8.55	-17.08	50.4	0.93	7.1
	Turkestan	K-1	8.35	-6.2	79.6	1.7	4.4
		K-2	8.05	-7.5	85.7	1.1	7.2
		K-3	8.00	-10.1	92.8	1.0	8.2
		K-4	8.05	-11.0	77.1	1.3	5.8
		K-5	8.25	-23.5	23.2	7.9	1.0
Acceptance limits		<8.0	<1.25	<50	>1	<10	

Comparative analysis of these data shows that high concentration of magnesium cations and high pH alkalinity, values of which exceed maximum permissible values, limit the use of drainage water for irrigation of lands in Syr Daria middle course. That is why use of drainage water of irrigated lands in Syr Daria middle course for irrigation of cultivated crops results in soil dusting and alkalization.

DISCUSSION

Results of ecological quality assessment of drainage water in irrigated lands of Syr Daria middle course prove that its salinity level consistently reduces (Ligay, 1984). This process occurs due to the diverting of ground water outside irrigation facility by means of collector drainage system for more than 50 years. This results in increase of their operation period for irrigation of cultivated crops. Results of ecological assessment of the salinity level underline the fact that drainage water can be used for irrigation of lands in Syr Daria middle course. Applicability of drainage and waste water for irrigation and subirrigation are supported by the fact of Turkestan irrigation facility reclamation. During first years of it's collector and drainage system operation maximum salinization level (6-9 g/l) of drainage water was forming provided soil depth horizon of unsaturated zone contained about 1-2% of salts and salinity level of ground water varied within 5-10 g/l (table 9). While unsaturated zone demineralized the salinization level of infiltration water decreased thus underlying the fact of desalinization of surface layers first and then of underground layers of mantle watery depth. Significant decrease of drainage water salinization shows that reclamative period terminates because salinity level of ground water (the key object of reclamation which blend in collector and drainage system) has decreased to 2-3 g/l. At this level of ground water desalinization the pace of seasonal accumulation of salt reduces to maximum limits and could be easily closed up by supplemental irrigation (Vyshpolsky, *et al.*, 2010).

Besides, operational experience of irrigation facilities indicates that if collector and drainage system has low operating capacity then salinity level of surface layers of ground water increases. This is also the reason for intensification of processes of salt accumulation in soil and for decrease in quality of irrigated lands. It is reasonable to solve this problem by founding the drainage system maintenance department which will not only increase the operating capacity of the drain but will also improve the salt conditions of soils and ground water. This method of rationalization collector and drainage system work is conditioned by the tendency for increase of salt concentration in ground water. In particular the area of irrigated lands where salinity level of ground water is 3-5 g/l has increased for 8.2%. This led to the intensification of salt accumulation in soils, to decrease of irrigated lands efficiency and to the loss of competitiveness by farms and agricultural unions.

Table 9: Chemical composition of drainage water, g/l

Site of sampling	Years				
	1964-1966	1972-1974	1993-1995	2000-2005	2008-2014
K-1-1	6.0-8.0	5.0-6.0	2.3-2.8	1.4-1.9	1.3-1.8
K-1-2	6.5-8.5	5.0-6.5	2.5-3.0	1.5-2.0	1.4-1.9
K-1-3	7.0-9.0	6.0-7.5	2.5-3.0	1.5-2.0	1.4-1.9
K-5-1	-	1.5-2.0	1.3-1.8	1.0-1.4	1.0-1.4

According to experimental investigations irrigation schemes with percolative irrigation practice where level of ground water usually did not rise higher than 2.0 m spent for filtration 20…25% of the water that has sunk into the soil. 30-40% of these losses were compensated by capillary rise of ground water to root layer during the irrigation interval. Taking into account process losses of temporary irrigation scheme (5%), infiltration (15-20%) and discharge from irrigated fields (10-15%), irrigation norms had a gross rise for 30-35% in comparison with norms set according to bioclimatic method. That is why even with high efficiency coefficient (0.65-0.70) of irrigation scheme the calculated water supply of irrigated lands was achieved due to increase of the forecasted water intake for 20-25%, this means that head water intake exceeded 10 thous. m^3/ha. Provided such water intakes to irrigation schemes located in slightly drained areas, sizes of drainage put-off usually increased to 25-40% from water intake. As a rule this water returned to riverbeds and decreased hydrochemical composition of a river run-off.

Thus if collector drainage water with high salinity level is used then drainage water is diluted with irrigation water that has low salinity level. Dilution of irrigation and drainage water is performed directly in irrigators or in special diversion chambers. Irrigation and drainage waters are pumped to diversion chamber separately. Volume of irrigation water used to decrease the salinity level of drainage water could be defined by means of calculation according to the results of chemical analyses of water samples.

Usage of return water at saline soils that have big stocks of gypsum and carbonates in soil solids ensures not only desalination of soils but also their dealkalinization. This can be explained by the fact that solvability of salts in solid soils rises if concentration of mobile chlorides is high. In the result of this process the rate of exchange reactions between soil solution and soil absorption complex grows making desalination of soils more intensive.

CONCLUSION

Generalization of experimental materials proves that if cultivated crops are irrigated by drainage water then assessment of soil and ecological conditions of irrigated lands and therefore the determination of control parameters for water and salt regime of soil should be based on the detection of rates and orientation of soil and ecological processes in root zone of soils. First of all it should be accomplished by comparative analysis of soil solution (C_{ss}) with the salinity level of irrigation water (C_{iw}). Thus, in the context of intensifying shortage of water resources in irrigated lands, one of the ways to intensify their water supply is the usage of drainage water for irrigation and washing. Drainage water can be used for irrigation only if it's salinity level is always less then concentration of soil solution. Therefore while using saline water for irrigation and washing of salinized soils it is necessary to control the salinity level of soil solution (C_{ss}) and to compare it to the salinity level of return water (C_{iw}) used for irrigation and washing. If $C_{ss} < C_{iw}$, then processes of soil salinization take place in a root zone. Thus, adherence to the equation $C_{ss} < C_{iw}$ is one of the major requirements for usage of ground and drainage water for irrigation and washing. This equation ensures washing out of salts by infiltration water and reduction of their stocks in a soil root zone.

Another factor influencing soil and ecological condition of irrigated soils is ion composition of drainage water. Even if the salinity level of water is low, processes of alkalization and dusting can occur in soils of a root zone depending on ion composition. This requires an integrated ecological assessment of drainage water.

Usage of saline water for irrigation aggravates soil and ecological condition of irrigated lands it has negative influence on the growth, development and productivity of cultivated crops. If the salinity level of irrigated water rises then water consumption of cultivated crops increases. This fact predetermines the necessity to increase the number of waterings and therefore sizes of irrigation norms. Increase of irrigation water and of infiltration losses of watering the cultivated crops by salinized water will result in rise of drainage condition of irrigated ecosystems.

Generalization of research results illustrates that in order to use drainage water for irrigation of cultivated crops it is necessary to define rate and orientation of soil and ecological processes that take place in a soil root zone. Results of these researches give opportunity to determine optimal parameters for drainage water employment technique for irrigation of cultivated crops.

The usage of drainage waters for irrigation of cultivated crops is one of the ways to increase the water supply of Kazakhstan irrigation facilities in the conditions of constantly decreasing water resources. Moreover, the area of irrigated land suitable for drainage water irrigation is about 600-650 thous. ha. It composes 50% of Kazakhstan irrigated lands that are used nowadays.

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