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Study of water Quality in Different Stations of Karkheh River based on Langelier and Ryzner Indices for Determining Potential Clogging of Droppers

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Abstract: The aim of this study was carried out to determinate the Possibility of utilization of Karkheh River water for drip irrigation. Regarding climatic conditions of Iran, it is necessary to apply high efficiency irrigation methods particularly for crops with high water requirement. Clogging of droppers is the most important and serious issue that threatens a trickle irrigation system. In the present article, in order to study the potential of Karkheh River as a water source, the water quality of the river was examined in 5 stations along the river in a 30-year period. To prognosticate the potentiality of carbonate calcium sedimentation and the corrosion in the irrigation equipments, Langelier Saturation Index (LSI) and Ryzner Stability Index (RSL) were used, respectively. The results showed that, based on Wilcox diagram, the water of this river enjoys appropriate quality for agricultural purposes in most cases (with the exception of droughts). The results also showed that the LSI was positive in all stations and it is possible that droppers clog due to carbonate calcium deposition. While, RSL was in most cases below 6.8 and there is little possibility of metal parts corrosion in trickle irrigation system. It can be recommended that, regarding limited water sources, downstream lands of this river can be irrigated through trickle irrigation systems with droppers that are less sensitive to clogging in order to prevent from chemically clogging of droppers. Finally, acid washing by collecting watering pipes and droppers in one place and injection of acid after is recommendable.

Key words: Karkheh River, langelier index, ryzner stability index, trickle irrigation

INTRODUCTION

The main challenge of human being in the next decades will be the necessity to increase production of agricultural products to increased population. This problem gets even sever in countries such as Iran facing limited water sources and soil. For this reason expansion of pressured irrigation systems is unavoidable. In this regard dropper irrigation method is highly important due to increasing efficiency coefficient and economization of water consumption. The most substantial problem with dropper irrigation systems is clogging of droppers. Droppers' clogging is the most important issue that confronts trickle irrigation systems. Droppers' clogging reduces water distribution constancy and consequently reduction of water consumption efficiency and increase of the water required in irrigation (Capra and Scicolone, 1998). Nakayama and Bucks (1991) reviewed the work made on clogging and the strategies to reduce it and stressed that these processes have a close relationship with quality of irrigation water. In general, the clogging in croppers is due to physical, chemical or biological contamination. Chemically clogging resulting from sedimentation of calcium carbonate, magnesium carbonate and calcium sulphate, is among the first parameters that should be studied before designing trickle irrigation system. Chemical clogging due to deposition of calcium carbonate, magnesium carbonate and calcium sulphate, is among the first parameters that should be studied before designing trickle irrigation system. One of the factors that clog the droppers in such kinds of water (water that contains high amount of calcium), is injection of phosphated fertilizers into trickle irrigation systems. In such conditions, the phosphor in phosphated fertilizers deposits in two forms of calcium phosphate II in irrigation pipes and droppers (Nakayama *et al*., 1978).

The clogging of droppers leads to disproportionate distribution of water along the ancillary pipe and so influences evenness of water application and production of product (Clark, 1992; Hills *et al*., 1989). Hills *et al*. (1989) studied the consequences of chemically clogging of droppers on even distribution showed that as calcium, magnesium and bicarbonate ions and PH of irrigation water increase, the clogging of droppers will increase as a result of deposit of carbonate calcium and magnesium carbonate, leading to reduced flow rate in droppers. Since solubility of carbonate calcium reduces with increased water temperature, water temperature is

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Table 1: Langelier Index of Payab Sad Sattarkhan studied projects (Husseinzadeh and Rafie, 2009).

Project	Langelier index
A	- 1.20
B	0.21
C	- 0.52
D	0.40
E	1.40

Table 2: Characteristics of Payab Sad Sattarkhan studied projects and the number of clogged droppers (Husseinzadeh and Rafie, 2009)

Project	Area (acres) of droppers	Total no. droppers	Clogged
A	4	8000	552
B	26	4080	1020
C	18	3360	440
D	14	220	627
E	1.1	2684	645

one of the factors that influences clogging of droppers (Hills *et al*., 1989; Zur and Tal, 1981).

Because the reason of clogging of droppers differs from one region to another, even under similar water quality conditions it is not feasible to use evaluation of potential clogging in one region for other regions as clogging of droppers depends on environmental conditions such as temperature and characteristics of droppers. The general recommendation to prevent from chemical clogging is lowering pH of irrigation water through acid injection into trickle systems. Chemical reaction equation that causes sedimentation of calcium carbonate is as follows:

$$CaCO_3(S) + H^+ \leftrightarrow Ca^{2+} + HCO_3^- \quad (1)$$

High concentrations of calcium and bicarbonate and high level of PH or high water temperature drivers the balance to left and hence carbonate calcium deposits.

Foreseeing calcium carbonate sedimentation is the most common reason of chemically clogging of droppers is usually made through LSI (Christiansen *et al*., 1977; Hills *et al*., 1989). Bucks *et al*. (1979) classified water quality regarding potential clogging of droppers, which is still a valid classification with few changes.

In a study of the reasons of droppers' clogging in pressure irrigation projects of Payab Sad Sattarkhan and providing strategies to eliminate them, Langelier and index and the number of clogged droppers were studied (Table 1 and 2).

Positive Langelier index indicates potential sedimentation of calcium carbonate and clogging of droppers, and conversely, negative index shows lower potential of calcium carbonate sedimentation in droppers. In project E, 35% of droppers do not work properly, with highest rate of clogging (Langelier index 1.4) and lowest clogging rate is related to project A with almost 7% clogging (Langelier index 1.2).

Since Karkheh catchment stands in the 3rd rank for consuming surface water in the country, and 4th rank for consuming underground water. As evidenced through study of water consumption, the water consumption is now related to agricultural applications while its industrial and mineral consumptions include only 0.32% of total water consumption (Basim and Hajishah, 2009). Therefore expansion of trickle irrigation systems in Karkheh river downstream lands in addition to expansion of the agricultural products farming lands, will not pose problems for agriculture sector if industrial and urban sectors develop in these regions and their share of water consumption increases. The aim of present study is to seek for possibility of using water of Karkheh River in catchment basin in Khoozestan Plain.

MATERIALS AND METHODS

In this study, data and information on quality of water of Karkheh River for 5 stations Hamidieh, Abdolkhan, Nissan- Soosangerd, Hofel-Soosangerd, Hoveyzeh in Khoozestan province (Fig. 1), the reports of Khoozestan Water and Electricity Utility within 30 years (from 1978 to 2007) were used.

In order to determine quality of irrigation water, we used Wilcox Diagram. The most important water classification system is Wilcox method in terms of agriculture. In this method, the risk of EC salinity is diagnosed in four classes- low salinity with EC<250 (C1), mean salinity with EC between 250 and 750 (C2), high salinity with EC between 750 and 2250 (C3) and very high with EC>2250 (C4) microμ/cm and the risk of sodiumization is specified through SAR in four classes- low intoxication with SAR<10 (S1), mean with SAR between 10 and 18 (S2), high with SAR between 18 and 26 (S3) and very high (S4) (Alizadeh, 2001).

To foresee sedimentation of carbonate calcium, which is the most prevalent chemical sedimentation in irrigation water, Langelier Saturation Index (LSI) was used and to foresee corrosion potential, Ryzner Stability Index (RSI) was used as follows (Paykari and Mehrabani, 2004):

$$LSI = pH_m - pH_s \quad (2)$$

$$RSI = 2pH_s - pH_m \quad (3)$$

where, pH_m and pH_s are respectively the measured acidity and carbonate calcium saturation acidity, gained from the following equation:

$$pH_s = -Log\left[\frac{K_2 \times \gamma_{Ca^{+2}}\left[Ca^{+2}\right] \times \gamma_{HCo_3^-}\left[HC_{O3}-\right]}{K_{sp}}\right] \quad (4)$$

Fig 1: Status of water quality measurement stations in Karkheh River

Table 3: Classification of water quality status as regards carbonate calcium sedimentation and corrosion (Houshmand *et al.*, 2009)

Langelier Index	Ryzner index	Water quality status
2.0	<5.5	High sedimentation
0.5	5.5-6.2	Almost sedimentation and a little corrosive
0.0	6.2-6.8	Non-sedimentation and non-corrosive
- 0.2	6.8-8.5	Almost corrosive
- 0.5	>8.5	Highly corrosive

where,

$[pCa^{2+}]$: Calcium concentration (mol/L)

$[HCO_3]$: Bicarbonate concentration (mol/L)

K_2 and Ksp are carbonated equation coefficient (mol/L), which are gained according to the environmental temperature from the relevant table (Alizadeh, 2001).

γca^{2+} and γ_{HCo3} are the coefficients of equation gained from the following formula:

$$Log\gamma = -\frac{0.5(Z_i)^2 \mu^{0.5}}{1+\mu^{5/0}} \quad (5)$$

$$\mu = 2.5\times 10^{-5}\times EC \quad (6)$$

where, Z_i is ionic capacity of Ca^{2+} and HCO^{3-} and EC is electric conductivity (dS/m).

Positive numerical amount for LSI indicates possible deposition of carbonate calcium ($CaCO_3$) in irrigation water; while negative amounts show possibility of low sedimentation of $CaCO_3$. Langelier saturation index shows water tendency to sedimentation or lack of sedimentation. Therefore, according to the report of sedimentation reports and corrosion in urban water networks, Ryzner corrected Langelier index and presented Ryzner index. This index is applied in systems with water movement speed above 0.6 m/s. Classification of water quality status is shown (Table 3) according to LSI and RSI indices.

RESULTS AND DISCUSSION

Quality of Karkheh River water in various stations and years is presented (Table 4). Results show that based on Wilcox water quality classification, C_2S_1 water quality class in the best condition (wet years and winter in some years) and in the water with good quality, water quality class in most cases is one of those falling in C_3S_1, C_3S_2 and C_3S_3 categories, and under category of water with appropriate quality and under worst condition, water quality class is C_4S_2 and C_4S_3 from the group of water with inappropriate quality. Quality of river water was not the same in all stations and it deteriorates within river length so that the worst water quality in all years was measured in Hoveyzeh station. Quality of water in four

Table 4: Quality of river water in various stations and years

Station	Hofel		Nissan		Hamidieh		Abdolkhan		Hoveyzeh	
Year	best condition	worst condition	best condition	worst condition	best condition	worst condition	best condition	worst condition	best condition	worst condition
1978	-	-	-	-	C_2S_1	C_3S_2	C_2S_1	C_3S_1	-	-
1979	-	-	-	-	C_3S_1	C_3S_2	-	-	-	-
1980	-	-	-	-	C_2S_1	C_3S_2	-	-	-	-
1981	-	-	-	-	C_2S_1	C_3S_2	C_2S_1	C_3S_1	-	-
1982	-	-	-	-	C_2S_1	C_3S_2	C_2S_1	C_3S_1	-	-
1983	-	-	-	-	C_3S_1	C_4S_2	C_2S_1	C_3S_2	-	-
1984	-	-	-	-	C_3S_1	C_3S_2	C_2S_1	C_3S_2		
1985	-	-	-	-	C_2S_1	C_4S_2	C_2S_1	C_3S_2	C_3S_1	C_4S_2
1986	-	-	-	-	C_2S_1	C_3S_2	C_3S_1	C_3S_2	C_3S_1	C_4S_2
1987	C_2S_1	C_3S_1	C_2S_1	C_3S_1	C_2S_1	C_3S_2	C_2S_1	C_3S_2	C_3S_1	C_4S_2
1988	C_2S_1	C_3S_1	C_2S_1	C_3S_1	C_2S_1	C_4S_2	-	-	C_3S_2	C_4S_2
1989	C_3S_1	C_4S_2	C_3S_1	C_4S_2	C_2S_1	C_4S_2	-	-	C_3S_2	C_4S_2
1990	C_3S_1	C_4S_2	C_3S_1	C_4S_2	C_2S_1	C_4S_2	-	-	C_3S_2	C_4S_2
1991	C_3S_1	C_4S_2	C_3S_1	C_4S_2	C_3S_1	C_3S_2	-	-	C_3S_2	C_4S_2
1992	C_3S_1	C_3S_2	C_3S_1	C_3S_2	C_2S_1	C_3S_2	C_2S_1	C_3S_2	C_3S_2	C_4S_2
1993	C_2S_1	C_4S_2	C_2S_1	C_4S_2	C_3S_1	C_3S_2	C_3S_1	C_3S_1	C_3S_2	C_4S_2
1994	C_3S_1	C_4S_2	C_3S_1	C_4S_2	C_2S_1	C_3S_2	C_3S_1	C_3S_2	C_3S_1	C_4S_2
1995	C_3S_1	C_4S_2	C_3S_1	C_4S_2	C_2S_1	C_4S_2	C_3S_1	C_3S_1	C_3S_2	C_4S_2
1996	C_3S_1	C_4S_2	C_3S_1	C_4S_2	C_3S_1	C_4S_2	C_3S_1	C_3S_1	C_3S_2	C_4S_2
1997	C_2S_1	C_4S_2	C_2S_1	C_4S_2	C_2S_1	C_4S_2	C_3S_1	C_3S_2	C_3S_2	C_4S_2
1998	C_3S_1	C_4S_3	C_3S_1	C_4S_3	C_2S_1	C_4S_2	C_3S_1	C_3S_2	C_3S_2	C_4S_2
1999	C_2S_1	C_4S_2	C_2S_1	C_4S_2	C_2S_1	C_4S_1	C_3S_1	C_3S_2	C_3S_2	C_4S_3
2000	C_2S_1	C_4S_2	C_2S_1	C_4S_2	C_2S_1	C_3S_2	C_3S_1	C_3S_2	C_3S_2	C_4S_2
2001	C_2S_1	C_4S_2	C_2S_1	C_4S_1	C_2S_1	C_4S_1	C_3S_1	C_3S_2	C_3S_2	C_4S_2
2002	C_2S_1	C_4S_1	C_2S_1	C_4S_1	C_2S_1	C_3S_1	C_3S_1	C_3S_2	C_3S_1	C_4S_1
2003	C_2S_1	C_4S_1	C_2S_1	C_3S_1	C_2S_1	C_3S_1	C_3S_1	C_3S_2	C_3S_1	C_4S_1
2004	C_2S_1	C_4S_2	C_2S_1	C_3S_1	C_2S_1	C_3S_1	C_3S_1	C_3S_2	C_3S_2	C_4S_2
2005	C_2S_1	C_4S_2	C_2S_1	C_4S_1	C_2S_1	C_4S_1	C_3S_1	C_3S_2	C_3S_2	C_4S_3
2006	C_2S_1	C_4S_1	C_2S_1	C_4S_1	C_2S_1	C_4S_1	C_3S_1	C_3S_2	C_3S_1	C_4S_2
2007	C_2S_1	C_4S_2	C_2S_1	C_4S_2	C_2S_1	C_4S_2	C_3S_1	C_3S_2	C_3S_2	C_4S_3

stations of Abdolkhan, Hamidieh, Hofel and Nissan was similar in most cases with appropriate water quality under quality classes C_3S_1 and C_3S_2 (with the exception of summer and some severe droughts (like that in years 1998-99)). But water quality in Hoveyzeh station was often inappropriate under quality classes C_4S_2 and C_4S_3. Anyway regarding that due to daily irrigation in trickle irrigation system, soil solution is always kept dilute in root area and moreover salts go far from root in humidity front, and regarding that quality of water of Karkheh river is in most cases good, it is authorized to irrigate the farms irrigated through this river by trickle system. The point that is worthy of mention here is that in trickle irrigation, salts accumulate in surface layer due to deep washing of soil and this may lead to salinity of surface layer. To solve this problem it is recommended to consider appropriate leaching during farming season and even heavy washing of salts through surface irrigation in non-cultivation season and in winter.

pH of river water fluctuates between 7.7 and 8.3 and hence the potential sedimentation of Karkheh river water is estimated at mean level.

To make a more precise study on the sedimentation potential and water corrosion, LSI and RSI indices were used respectively. Amount of Langelier Saturation Index (LSI) and Ryzner Stability Index (RSI) are provided for various years and stations (Table 5).

These results show that Langelier saturation index in Abdolkhan station is between 0.37 and 0.97 and Ryzner stability index is between 6.4 to 7. Based on the classification made in Table 1, water of Karkheh River in this station deposits sediment in most cases and is non-corrosive. According to Ryzner index it is observed that water of Karkheh River exceeds 6.8 in a few years and becomes corrosive and water status is appropriate in other years. This means that there is little possibility of corrosion of metal parts of system, such as central control system, joints and faucets, and pump pipes. Quality of Karkheh water in Hamidieh station is like that in Abdolkhan station regarding potential of sedimentation and corrosion of metals.

Langelier saturation index and Ryzner stability index in Hofel and Nissan stations in Soosangerd is the same in most cases and is relatively between 0.7 to 1.1 and 6 to 6.5. Based on the classification provided in Table 1, water of Karkheh river in these stations deposits sediment and is non-corrosive. In these two stations, the quality of water is more appropriate as regards metals corrosion but is worse than the said two stations regarding producing sediment.

The results also show that the water of Karkheh River in Hoveyzeh station has the worst quality as regards sedimentation and the potential clogging of droppers (Langelier index is 1 in most cases) and it has no problem regarding metals corrosion (smaller index is less than 6.2 in most cases).

Table 5: Langelier Index (LSI) and Ryzner Index (RSI) in various stations and years

	Hofel		Nissan		Hamidieh		Abdolkhan		Hoveyzeh	
Station	LSI	RSI	LSI	RSI	LSI	RSI	LSI	RSI	LSI	RSI
Year	Index	Index	Index	Index	Index	Index	Index	Index	Index	Index
1978	-	-	-	-	0.74	6.45	0.60	6.71	-	-
1979	-	-	-	-	0.69	6.56	-	-	-	-
1980	-	-	-	-	0.33	7.00	-	-	-	-
1981	-	-	-	-	0.63	6.65	0.61	6.68	-	-
1982	-	-	-	-	0.70	6.58	0.67	6.65	-	-
1983	-	-	-	-	0.92	6.23	0.62	6.69	-	-
1984	-	-	-	-	0.80	6.52	0.79	6.42	-	-
1985	-	-	-	-	0.74	6.48	0.61	6.71	0.95	6.21
1986	-	-	-	-	0.84	6.44	0.67	6.82	0.96	6.22
1987	0.78	6.44	0.65	6.68	0.74	6.48	0.96	6.28	0.97	6.16
1988	0.58	6.72	0.45	6.89	0.75	6.55	-	-	0.78	6.41
1989	0.89	6.49	1.01	6.23	0.66	6.66	-	-	1.01	6.10
1990	0.85	6.37	0.77	6.45	0.82	6.46	-	-	1.01	6.11
1991	0.77	6.45	0.67	6.71	0.69	6.64	-	-	0.88	6.31
1992	0.76	6.51	0.79	6.48	0.77	6.54	-	-	0.91	6.25
1993	0.67	6.64	0.70	6.65	0.79	6.46	0.60	6.74	0.92	6.31
1994	0.82	6.37	0.75	6.52	0.84	6.37	0.95	6.34	1.00	6.09
1995	0.84	6.38	1.08	5.97	0.93	6.25	0.83	6.40	1.06	9.03
1996	0.96	6.28	0.97	6.33	1.03	6.23	0.94	6.40	1.12	6.01
1997	0.98	6.39	0.99	6.29	0.95	6.42	0.88	6.51	1.17	5.99
1998	1.07	6.14	0.89	6.42	0.99	6.32	0.89	6.46	1.13	5.97
1999	0.97	6.25	1.00	6.15	0.93	6.28	0.90	6.45	0.87	6.26
2000	0.93	6.33	0.88	6.36	0.89	6.38	0.78	6.56	1.15	5.89
2001	0.70	6.51	0.68	6.53	0.68	6.58	0.65	6.62	0.71	6.41
2002	0.87	6.34	0.85	6.38	0.82	6.04	0.75	6.55	0.90	6.24
2003	0.71	6.53	0.65	6.62	0.66	6.60	0.31	7.00	0.85	6.27
2004	0.79	6.47	0.72	6.56	0.73	6.58	0.87	6.53	0.97	6.17
2005	0.90	6.27	0.89	6.32	0.96	6.21	0.62	6.63	0.96	6.20
2006	0.81	6.43	0.80	6.44	0.67	6.64	0.47	6.73	0.90	6.23
2007	0.75	6.51	0.80	6.45	0.74	6.53	0.50	6.74	0.91	6.20

CONCLUSION

Results showed that LSI was positive in all stations and there is likelihood of clogging of droppers due to sedimentation of carbonate calcium but LRI was most often less than 6.8 and the likelihood of corrosion of metals parts in trickle irrigation system is low. Therefore regarding limitation of water sources of downstream lands of this river, we may use trickle irrigation and to prevent from chemical clogging of droppers it is recommended to use droppers with less sensitiveness to clogging, and collect watering pipes and droppers in one place after irrigation and wash with acid injection.

REFERENCES

Alizadeh, A., 2001. Principles and Practices of Trickle Irrigation. 2nd Edn., Astan Quds Razavi, Mashad (in Persian).

Basim, I. and M. Hajishah, 2009. Methodology of Study of Environmental Works of Management Projects and Reusing Agriculture Drainage Water- Case Study of Drainage Water Management Project of Karkheh River South Part. Proceeding of The 2nd national conference of irrigation and drainage networks management. University of Shahid Chamran, Jan, 27-29, pp: 284-290.

Bucks, D.A., F.S. Nakayama and R.G. Gilbert, 1979. Trickle irrigation water quality and preventive maintenance. Agric. Water Manage., 2: 149-162.

Capra, A. and B. Scicolone, 1998. Water quality and distribution uniformity in drip/trickle irrigation systems. J. Agric. Eng. Res., 70: 355-365.

Christiansen, J.E., E.C. Olsen and L.S. Willardson, 1977. Irrigation water quality evaluation. J. Irr. Drain. Div. ASCE, 103(IR2): 155-168.

Clark, G.A., 1992. Drip irrigation management and scheduling for vegetable production. HortTechnology, 2(1): 32 37.

Hills, D.J., F.K. Nawar and P.M. Waller, 1989. Effects of chemical clogging on drip tape irrigation uniformity. Trans. ASAE, 32(4): 1202-1206.

Houshmand, A.R., F. Moradzadeh and A.A. Zareh, 2009. Possibility of utilizing of Karun River in zone of Amirkabir Agro-Industrial-Co for drip irrigation. Proceeding of the 1st national conference of water management. University of Shahid Bahonar, March, 14-15, pp: 125-131.

Husseinzadeh, R. and Z. Rafiee, 2009. Study of clogging of droppers in Sattarkhan dam downstream. Third Iranian Conference on Constriction Experiences of Hydraulic strictures and Irrigation and Drainage Networks. University of Tehran, Iran, October, 21-22, pp: 355-360.

Nakayama, F.S., R.G. Gibert and D.A. Bucks, 1978. Water treatments in trickle irrigation systems. J. Irr. Drain. Div. ASCE, 104(1): 23-34.

Nakayama, F.S. and D.A. Bucks, 1991. Water quality in drip/trickle irrigation: a review. Irrigation Sci., 12(4): 187-192.

Paykari, M. and M. Arjmand, 2004. Fundamentals of Water Refining. 1st Edn., Arkan Publications, Tehran (in Persian).

Zur, B. and S. Tal, 1981. Emitter discharge sensitivity to pressure and temperature. J. Irr. Drain. Div. ASCE, 107: 1-9.