J. Agr. Sci. Tech. (2000) Vol. 2: 9-20

Reclamation of a Sandy Desert Through Floodwater Spreading: L Sediment-Induced Changes in Selected Soil Chemical and Physical Properties

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ABSTRACT

Floodwater spreading (FWS) for the artificial recharge of groundwater (ARG), is an easy and economical method of desertification control. An integrated approach to desertification control based on FWS for the ARG was adopted in the Gareh Bygone Plain in southern Iran. Deposition of the suspended load (SL), carried by floodwater into the sedimentation hasins and infiltration ponds, stabilizes the drifting sand and reclaims the eroded rangeland on which the ARG projects are executed. Results of some of the physical and chemical analyses performed on the one to four-year-old sediment samples obtained from the first three sedimentation basins at the Gareh Bygone Plain ARG scheme show that of the 19 factors analyzed, only two changed significantly due to the settlement of the SL in the basins: sand content decreased by 7.9 and 3.8% at the 0-10 and 0-30 cm depth respectively; and the ESP increased by 17.2% at the 0-30 cm depth. Regression equations were developed correlating soil content of organic matter, total N,P, saturation percentage and CEC with silt + clay content. These relationships indicate the geological origin of N and perhaps P and the importance of SL in the fertility status of the drifting sand.

Keywords: Artificial recharge of groundwater, Sandy soils , Water spreading.

[DOR: 20.1001.1.16807073.2000.2.1.8.4]

INTRODUCTION

Human-induced accelerated erosion is, according to Dregne, "the principal desertification threat" [7]. Soil erosion puts about three million ha (mha) of land out of production each year [28]. This, along with other degradative causes such as toxification and conversion to non-agricultural use, reduces about 1% of the world's 1500 mha cropland to a state of near or complete uselessness**[28). The severity of this situation was further emphasized by** Hendry [11] and Kassas [14] who estimated the extern of the land removed annually from agricultural production by desertification at about 27 and 21 mha, respectively. This, in a world, which is faced with feeding 90-100 million additional mouths each year, is ominous indeed.

Drought has rightly been implicated as the other cause of desertification. The fact that soil is the rooting zone of plants and the

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main source of water for them in the desert environment, has been consequential in characterizing soil erosion as "pseudodr-**ought" [28].** Therefore, any activity, which checks erosion and builds up soil in arid and semi-arid areas, may be termed desertification control (DC). It is fortunate that water, which is "the destroyer of land" [7|, may be convened into the renovator of the desert through its proper management [16|, particularly when one takes into account the tact that the desert streams are, by nature, sediment-laden.

It is well-known that water-laid sediment along streams or in their deltas have been developed into some of the most productive soils all over the world. However, in many instances, man has emulated nature and diverted sill-laden streams away from their courses to build terraces by sediment accumulation behind stone walls or earth embankments built across gentle hillslopcs or broad valleys. This is a very effective method of dcseri reclamation. Stabilization of the drifting sand, and their transformation into productive soils, through induced sedimentation of the suspended load **onto** them, has been practised for millennia on the northeastern fringe of the great Iranian desert in the province of Khorasan.

An important feature of the deposition of water-borne silt, clay and organic matter on sandy soils is the improvement in their physico-chemical properties. The volume of water retained by sandy soils **is** usually enhanced by the addition of organic matter [1()|, clay 117), or both **[26].** Moreover, Peterson ***et at*** |21] found particles with 5-20/im in diameter are the most important soil constituent in the available soil water (ASW) range. Brown and Duble [5| established that the addition Of 5% "soil" to sand doubled its ASW for a 35 cm layer and recently, Whilmyer and Blake (27] noted the importance of the silt: clay ratio in the water relation of sand. Increasing soil water storage in the desert environment usually favors soil-related biological activities. Improvement in the fertility status of soils by siltation is as old as the story of the Nile [9,2].

An integrated approach to DC, based on floodwater spreading (FWS), was adopted in the Gareh Bygone Plain (GBP) in southern Iran in 1983. Some of the pertinent information on the study area may be found elsewhere **[15].** The main purpose of this investigation was to quantify the changes that occurred during the 1983-86 period in some of the physico-chemical properties of the soil of three consecutive sedimentation basins (SBs) in the GBP-ARG facilities.

Characteristics of the Study Area

The research site is on a debris cone deposited by the Bisheh Zard River (BZR) on the SE corner of the Gareh Bygone Plain (28°38' N, 53°55' E), 200 km to the SE of Shira/., Iran, at an elevation of 1140 m. The GBP is a NW-SE syncline formed by the tectonic movements of the Zagros mountain ranges during the Mio-Plioccne epoch [13], and filled up with calcareous alluvium transported by the tributaries of the Shur River of Jahrom during the Plio-Pleistocene epoch and the Quaternary period.

The alluvium of the debris cone has been entirely provided by the Agha Jari (Mio-**Pliocene)** and Bakhtyari (Plio-Pleistocene) Formations; the former consists of the rhythmically intcrbedded calcareous sandstones, red marls and grey to green siltstones; the latter, a hard conglomerate, is composed of pebbles and cobbles of Cretaceous, Eocene, and Oligocene limestones and dark brown ferruginous cherts [13].

The debris cone is covered with a layer of the drifting fine sand ranging in thickness from a few millimeters to a few centimeters. A massive coarse loamy sand, with the average sand, silt and clay percentages of 70, 18 and 12, respectively, forms the A horizon, 10-20 cm thick. The stony C horizon lies directly under the A horizon. More details will be given later.

The climate is mediterranean with cold winters and hot summers. The mean annual precipitation **is** 150 mm of which about 90%, that is of cyclonic origin, occurs during the late fall to early spring; convective storms contribute the rest in the summer [8]. The Class A pan evaporation averages 2860 mm per year **[1].**

The soils of the GBP are characterized by an aridic moisture regime and a (hyper) thermic temperature regime [24]. The area is considered to be somewhat colder in the winter and hotter in the summer than Fasa, 50 km to the NW of the research site at an elevation of 1340 m, where the absolute maximum and minimum temperatures of 43°C and -7°C, respectively, have been recorded. Hot, dry south-westerly winds cause almost daily sandstorms from May to September, inclusively. These winds, which sometimes reach gale force, break and overthrow eucalyptus trees and render the country roads impassable by burying them under 20-30 cm of the drifting sand. Some of these winds raise the temperature to 50°C in the shade during July and August.

The BZR is an ephemeral stream which flows, on the average, three times a year contributing about one million m^3 of runoff to the Bisheh Zardj (BZj) ARG system on which the study was conducted (Fig. **1).**

Amygdalus scoparia Spach and *Pistacia atlantica* Desf., the original vegetation of the area, have been almost completely eradicated by man. Very few stems of *Populus euphratica* Oliv., *Tamarix aphylla* (L.) Karsten, *Lycium depressum* Stocks, *ZiTyphus nummularia* (Burm. f.) Wight and Walk, and *Pteropyrum aucheri* Jaub. and Spach are found by the stream banks and in the rivulets and depressions. *Artermisia sieberi* Besscr, *Atriplex leucoclada* Boiss., *Carex stenophylla* Wahl., *Helianthemum salicifolium* (L.), Miller, *Stipagrostis plumosa* (L.) Munro ex T. Anders., *Cynodon dactylon* L. Pers., *Alhagi camelorum* Fisch., *Peganum harmata* L., and *Medicago* ssp. are some of the more abundant plant species in the GBP.

METHODS

Floodwater Spreading Layout

The FWS system on which this study was conducted was the first in a series of eight systems constructed on both sides of the BZR in the GBP since 1983. The silt-laden floodwater of the BZR, which is automatically diverted to the head of the first SB via an inundation canal and a conveyor-spreader channel (CSC), is spread in a shallow sheet along its entire length. When the flow leaves this basin and enters the second one through six chutes it has lost most of its coarse load; moreover, some seepage has taken place as well.

This process is repeated five times, until a rather clear water flows into the infiltration pond. The SBs are essentially the disposal areas in the Australian design [22,23] with the following modifications to suit the purpose:

(i) Immediately after the junction with the inundation canal the grade of the CSC [diversion spreader bank of Quilty 22,23] was set at 0.0003 for 85% of its 1337 m length to ensure a more uniform spreading along this reach. The slope of the final 15% was gradually reduced to zero to maximize the probability of delivering adequate water for 3 ha of native forage and eucalyptus trees in low flows.

(ii) The vertical interval was increased to 1.10 m to decrease the number of level-silled channels.

(iii) Masonry structures were installed in the gaps to prevent erosion and to improve

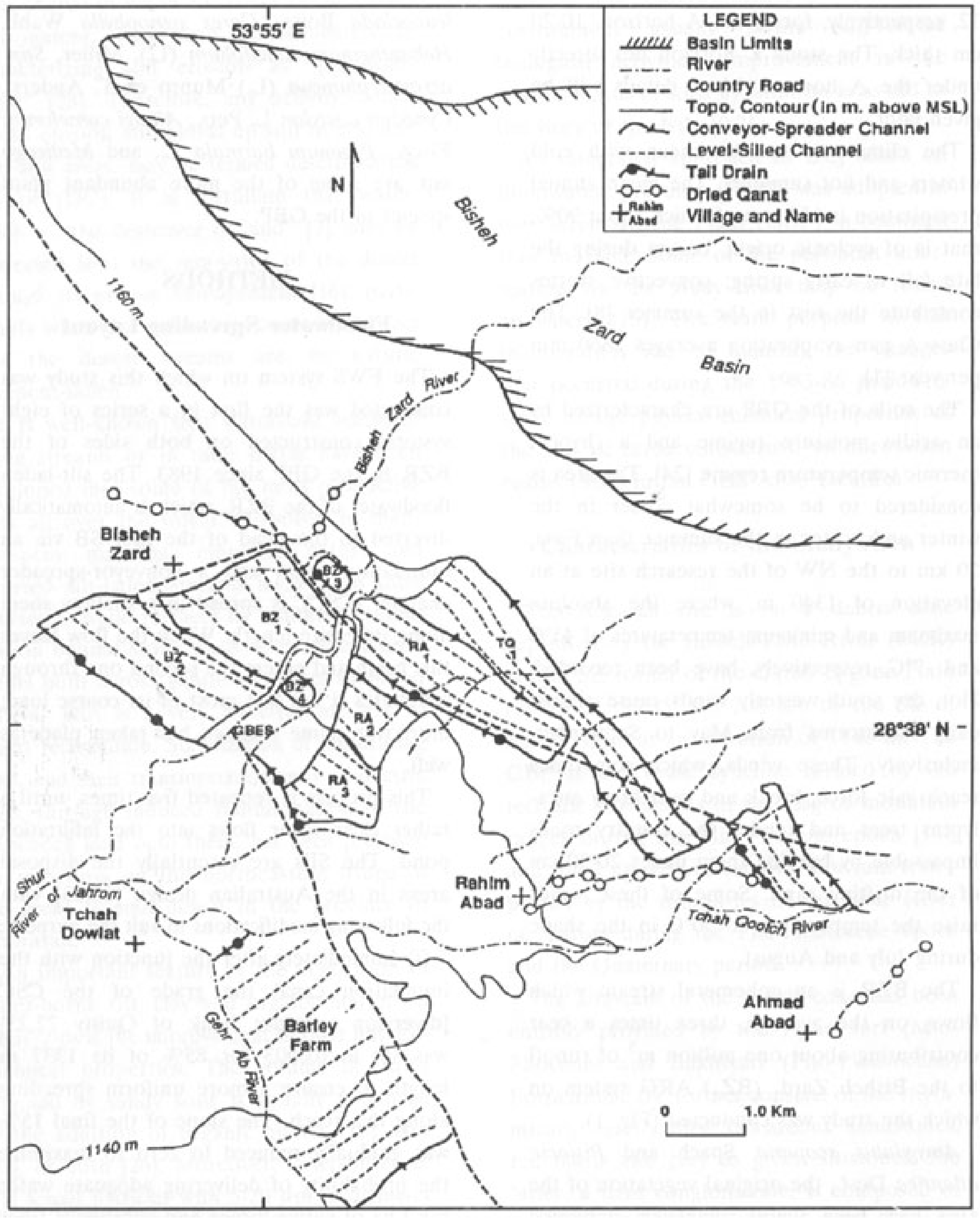

Figure 1. Sketch map of the Gareh Bygone Plain floodwater spreading systems.

[DOR: 20.1001.1.16807073.2000.2.1.8.4]

infiltration and sedimentation.

(iv) End walls were constructed to better define the spreading area. A more detailed description of the work may be found in Kowsar [15].

Field Methods and Sampling

The study was conducted in February 1987, four years after the start of the GBP-ARG project on the first three consecutive SBs of the Bisheh Zardj (BZj) system (Fig. 2).

Each of the three SBs was divided lengthwise into 12 **somewhat** equal plots. One plot of each SB, which due to its higher position had remained oui of flootlwater, was laken as the control, and the other 11 were taken as the treated plots. Twelve soil sampling stations were established randomly along the two diagonal transects of each plot. A reconnaissance survey indicated that sedimentation effects were apparently limited to the surface 30 cm; therefore, only three 10 cm increments were extracted using a bucket auger. The samples from similar increments of each plot were thoroughly mixed and a 2 kg subsample was collected from each composite and used for laboratory analyses by standard methods **[3].**

Statistical Analyses

Analysis of variance of the physico-chemical characteristics of the soil samples assumed a split-plot experimental arrangement with Hooded (treated) and not flooded (control)

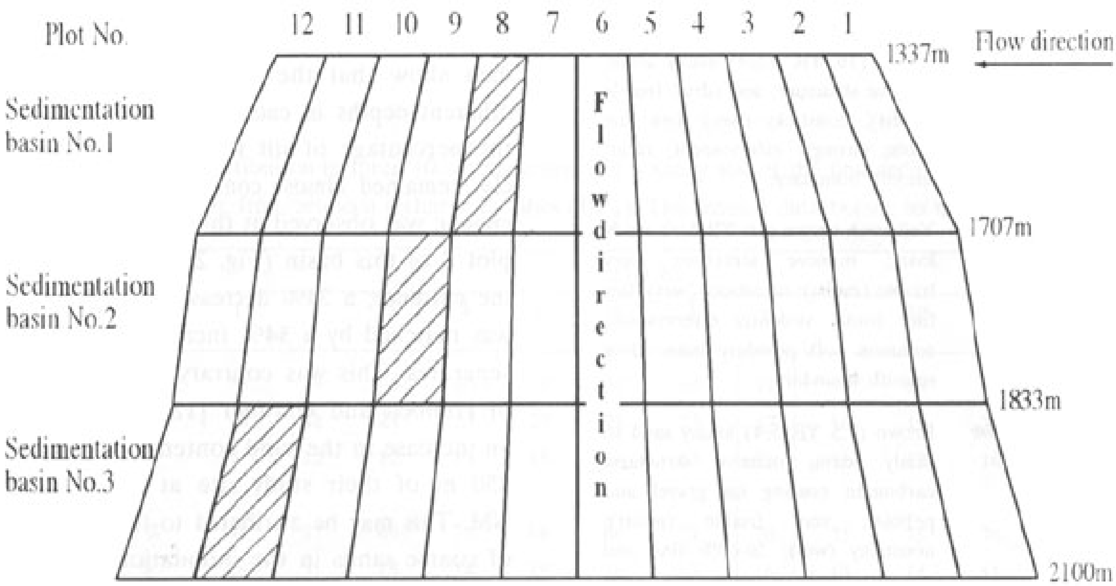

Figure 2. Schematic presentation of the first three sedimentation basins of the Bisheh Zardj artificial recharge facilities in the Gareh Bygone Plain, Iran. Control plots are hatched. The length of each channel in meters is shown on its right side.

[DOR: 20.1001.1.16807073.2000.2.1.8.4]

as main plots, the three depth increments as subplots, and the three SBs as replications. Simple and multiple linear regressions were used to determine relations among some of the soil properties. Dependent variables considered were organic carbon, total N,P, saturation percentage and CEC; independent variables considered were percentage of clay, clay + silt, and organic carbon.

RESULTS AND DISCUSSION

A description of profile No. 1 and the results of soil analyses are presented in Tables 1 and 2, respectively. Judging from the available data, the soil of the site is classified as a coarse loamy over loamy skeletal, carbonatic, (hyper) thermic, Typic Caleiorthids. The dominant clay species detected in the sedimentation basins are chlorite, mica and smectite [18]. Apparently, siltstones and marls, with the mean sand, silt and clay percentages of 18, 60 and 22; and 6, 52 and 42, respectively, provide most of the suspended load (SL), which is expected to drastically change the physico-chemical properties of this sandy soil.

Table 1. Soil description of the Gareh Bygone Plain artificial recharge of groundwater site

Horizon	Depth	Description (Moist color)
AP	0-15 cm	Yellowish brown to dark yellowish-brown (10 YR 4.5/4) sandy loam; massive structure; soft (dry), friable (moist), nonsticky (wet); few fine roots; strongly effervescent; clear, Smooth boundary.
Cjca	15-50	Yellowish brown (10 YR 5/4) sandy loam; massive structure; very friable (moist); nonsticky (wet); few fine roots; violently effervescent; common soft powdery lime; clear smooth boundary.
HC_2ca	50-100	Brown (7.5 YR 5/4) loamy sand to sandy loam; massive structure: carbonate coating on gravel and pebbles; very friable (moist); nonsticky (wet); 50-60% fine and coarse gravel by volume; strongly effervescent; gradual smooth boundary.
IIC_3ca	100-150	Brown (7.5 YR 5/4) loamy sand; massive structure; loose (moist): non-sticky (wet); 60-70% fine and coarse gravel by volume; thin, discontinuous, carbonate coating on gravel and pebbles; strongly effervescent.

Deposition of the SL into the SBs has changed the texture of the soil at the 0-30 cm depth to varying degrees; rather substantially close to the entrance of the flow to the site, and to a smaller extent towards the far end of the SBs. Moreover, although the thickness of sediments exceeds 30 cm in many places, the texture of the top 10 cm layer is finer than that of the two lower increments.

Particle size distribution for the first SB, which was affected most by the suspended load deposition, is presented in Table 3. The data show that the percentage of sand at different depths in each plot decreased, while the percentage of silt increased and that of clay remained almost constant. The maximum change was observed at the 0-10 cm depth of plot 2 of this basin (Fig. 2), 110-20 m from the entrance; a 34% decrease in sand content was matched by a 34% increase in silt-sized separates. This was contrary to the findings of Hubbell and Gardner [12] who reported an increase in the sand content over the first 450 m of their study site at Deer Spring, NM. This may be attributed to the settlement of coarse sands in the inundation canal and the CSC, which in one event, amounted to 90% of the suspended load (unpublished data). Hydraulics of sediment transport in this CSC is the subject of a future manuscript. Furthermore, the caly-sized particles usually remain in suspension for a long lime and migrate to the infiltration pond, and also possibly, to depths far below the 30 cm sampling limit.

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Table 2. Selected physico-chemical properties of the soil of the Garth Bygone Plain artificial recharge site.

Soil property	1 lorizon			
	Ap	CC_1ca	$IICC_2ca$	$IICC_3ca$
Depth, cm	0-15	15-50	50-100	100-150
Sand, %	70.0	72.0	77.0	84.0
Silt, %	18.0	16.0	13.0	8.0
Clay, %	12.0	12.0	10.0	8.0
Total N, %	I).042	0.032	0.029	0.032
Organic C, %	0.27	0.15	0.15	0.10
$CaCO_3$, %	36.0	44.0	41.0	40.0
Saturation percentage	28.0	27.0	23.0	22.0
pH 1:1 (soil / water)	8.0	8.1	8.0	8.0
Electrical conductivity, ils/m	0.54	0.74	0.78	0.84
Available K. rag/kg	180.0	100.0	100.0	80.0
Available P. mg/kg	3.7	1.4	1.0	0.6
Sodium adsorption ratio	0.63	1.41	1.34	1.01
Exchangeable sodium percentage	1.89	4.52	7.07	4.32
Exchangeable sodium cmol/kg	0.14	0.19	0.29	0.16
Cation exchange capacity cmol/kg	7.4	4.2	4.1	3.7
Water soluble Cx^{2+} + Mg^{2+}	3.60	4.00	6.00	6.0
W;iter soluble Na . mmol/1	0.85	2.00	2.31	1.75
W;iter soluble K , mmol/1	0.19	0.19	0.21	0.22

Table 3. Particle size distribution in three 10 cm increments of a sandy soil of the first sedimentation basin in the Gareh Bygone Plain, Iran, artificial recharge facilities (BZj). The framed data belong to the control plot.

Depth	Solid Property	Plot NO.											
cm		1	2	3	4	5	6	7	8	9	10	11	12
0-10	Sand, %	56	40	64	60	58	65	64	71	73	69	67	64
	Sill, %	36	48	24	27	27	21	23	17	16	19	17	19
	Clay, %	8	12	12	13	15	14	13	12	11	12	16	17
10-20	Sand, %	61	57	69	71	68	68	71	70	75	75	76	75
	Silt, %	28	31	18	14	18	18	17	16	13	14	11	13
	Clay, %	11	12	13	14	14	14	12	14	12	11	13	12
20-30	Sand, %	68	66	69	73	69	70	72	72	76	73	74	71
	Silt, %	21	22	17	14	17	17	9	15	12	15	13	17
	Clay, %	11	12	14	13	14	13	19	13	12	12	13	12

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One reason for a rather high sand content in the 10-30 cm layer of the analyzed samples may be the gradual deposition of the drifting sand onto the surface of the SBs, particularly during the early period of the ARG project before the shelterbelts became functional. The establishment of very efficient windbreaks of *Eucalyptus camaldulensis* Dehnh. and *Atrip/ex ientifortnis* (Torr.) Wats., and an effective vegetative ground cover, have increased the deposition of sand in the upwind basins; thus, these three SBs which are downwind of seven basins with a total fetch of about 2 km, have received very little sand grains since 1985. Moreover, the larger silt content in the top 10 em of the surface Of the firsi SB, relative to the second and third ones (data not shown), lends support to this hypothesis, since contrary to expectations, the sand percentage is lower in the upper reaches of the FWS system than in its downstream extremities.

Selected physical and chemical properties of the suface 30 cm of the soils of the flooded and control sites are presented in Table 4. Of the 19 properties examined, sedimentation significantly (P=0.05) decreased the percentage of sand and increased that of ESP. Other changes, although considerable in the case of silt and exchangeable sodium, were not significant at the 5% level. Table 5 shows the detailed data for the three, 10 cm increments. Mean silt content increased by 21.4% in the surface 30 cm, but by 33.1% in the 0-10 cm increment. Clay content showed a minor decrease. Saturation percentage increased by 6.6 and 8.0% in the surface 30 cm and in the 0-10 cm depth, respectively. Soluble R and Na increased by 13.5 and 74.0% respectively, in the surface 30 cm; the highest increase for K (27.0%) was observed in the 10-20 increment; for Na, it was 98.0% in the 0-10 cm layer.

Table 4. Effects of the suspended load deposition on selected physico-chemical properties of the 0-30 cm depth of a sandy soil in the Gareh Bygone Plain, Iran.

Soil Property	Flooded	Control	LSD 1%	LSD 5%
Sand, %	70.4"	73.2	3.5	1.5
Silt, %	17.7	14.5	10.7	4.7
Clay, %	11.9	12.2	10.0	4.3
Saturation, %	25.0	23.4	6.6	2.8
Soluble K, nimol/l	0.28	0.25	0.19	**0.09**
Soluble Na, mmol/1	1.64	0.94	4.34	*XM*
Soluble Ca + Mg, mmol/l	3.95	3.95	3.23	**1.40**
Total soluble cations, mmol/1	5.86	5.14	7.17	3.11
Organic C, %	0.17	0.20	0.32	0.14
Total N, %	0.034	0.034	0.008	0.003
EC, ds/m	0.58	0.47	0.50	0.22
Available K, mg/kg	148	156	91	39
Available P, mg/kg	4	4	8	3
$CaCO_3$, %	38.11	38.28	2.81	1.22
pH (saturated paste)	7.98	7.96	0.32	0.14
CEC, cmol/kg	6.3	6.3	2.0	0.9
SAR	1.16	0.67	2.70	1.17
Exchangeable Na, cmol/kg	0.20	0.17	0.08	0.04
ESP	3.3[fl]	2.8	0.9	0.4

Significant at the 5% level.

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Table 5. Effects of the suspended load deposition on selected physico-chemical properties of the three 10 cm increments of a sandy soil in the Gareh Bygone Plain, Iran.

Soil Property	0-10 (in		10-20 cm		20-3 cm	
	Flooded	Control	Hooded	Control	Flooded	Control
Sand, %	66.9a[fl]	72.7 b	71.9 b	73.3 b	72.5 b	73.7 b
Silt, %	21.3 a	16.0 b	16.4 b	13.7 b	15.3 b	14.0 b
Clay, %	H.7 ii	11.3 a	11.8 a	13.0 a	12.1 a	12.3 a
Saturation, %	24.2 a	22.3 a	24.1 a	23.0 a	26.7 b	26.00 ab
Soluble K. mmol/1	0.32 a	0.30 ab	0.27 ab	0.21 b	0.28 ab	0.26 ab
Soluble Na. mmol/1	1.45 a	0.73 a	1.68 a	0.93 a	1.78 a	1.56 a
Soluble Ca + Mg, mmol/1	4.74 a	4.27 a	3.44 a	3.07 a	3.67 a	4.53 a
Total soluble cations, mmol/1	6.50 a	5.30 a	5.38 a	4.21 a	5.71 a	5.93 a
Organic C, %	0.25 a	0.27 a	0.15 be	0.21 ab	0.10 c	0.13 be
Total N, %	0.043 a	0.042 *a*	0.032 b	0.033 b	0.026 c	0.027 c
EC, dS/m	0.62 a	0.51 a	0.55 a	0.41 a_	0.59 a	0.48 a
Available K, mg/kg	168 ab	181 a	148 ab	153 ab	128 b	134 b
Available I', mg/kg	7 a	6a	4a	5 a	3a	3a
$CaCO_3$, %	35.57 a	34.50 a	38.40 b	38.33 b	40.37 c	42.00 d
pH (saturated paste)	7.95 a	7.97 a	8.00 a	7.97 a	8.00 a	7.97 a
CEC, cmol/kg	7.1 a	6.7 a	6.3 ab	6.6 a	5.5 b	5.6 *b*
SAR	0.93 a	0.49 a	1.27 a	0.76 a	1.30 a	0.76 a
Exchangeable Na, cmol/kg	0.20 a	0.17 a	0.21 a	0.17 a	0.20 a	0.18 a
ESP	2.77 ab	2.55 a	3.41 c	2.62 a	3.69 c	3.22 be

Numbers in a row followed by the same letter are not significantly different (P = 0.05).

The increase in Ca+Mg of 11.0% was seen in the 0-10 cm increment. There was no change in N whatsoever. The increase in EC for the surface 30 cm was 25.7%, with the highest (33.4%) belonging to the 10-20 cm layer. Available K and P decreased by 5.2 and 3.1%, respectively, in the surface 30 cm of soil. However, while K decreased by 7.0% in the 0-10 cm increment, P increased by 11.5% in the same layer. Although $CaCO_3$ content remained unchanged in the surface 30 cm and in the upper two 10 cm increments, it decreased by 4.0% in the 20-30 cm layer. Whereas pH remained unchanged, sodium adsorption ratio (SAR) increased by 73% because of an increase in the Na concentration of soil solution while ESP increased by 17.2%, perhaps due to low cation exchange capacity of soil in the top 30 cm depth.

The similar level of total N in the freshly-laid sediment and in the soil of the site points to the geological origin of N as has been reported by Boyce *et al.* [4] for south-western and central Nebraska, and by Strat-house *et al* [25] for the San Joaquin Valley, California. The average total N content of a limited number of samples of siltstones and marls of the Bisheh Zard Basin, whose runoff was utilized in the ARG system, was 4760 and 8400 mg/kg, respectively.

Of the 99 regression equations developed, correlating some of the important soil properties to a few of the soil constituents, only seven are presented here; the complete set will be reported later.

1. For 0-10 cm, 1st SB:
   Organic C(%) = 0.128+0.011 (clay+silt,%)
   F=23.98 P=0.0006 R^2=70.57%

2. For 0-10 cm, 1st SB:
   Toial N(%) = 0.023+0.00058 (clay+silt,%)
   F=9.55   P=0.011 R^2=48.86%

3. For 10-20 cm, 1st SB:
   Total N{%)=0.022+0.0339 {organic C, %)
   F= 14.66   P=0.003 R^2=59.45%

4. For 10-20 cm, 1st SB:
   p (mg/kg)=0.0364+11.151 (organic C, %)
   F= 10.31   P=0.009 R^2=50.78%

5. For 10-20 cm, 1st SB:
   CEC(cmol/kg)=4.562+7.641 (organic C,%)
   F=7.29   P=0.003 R^2=42.17%

6. For 10-20 cm, 2nd SB:
   CEC (cmol/kg) - 4.460+0.144 (clay, %)
   F=6.81   P=0.02 R^2=43.08%

7. For 0-10 cm, 1st SB:
   Saturation *{%)* -21.198+0.064 (clay+silt, %)
   F=2.93   P=0.117 R^2=22.68%

The highly significant relationship that exists between the total N content and the sum of clay + silt of each sample indicates the potential of Agha Jari Formation as a source of N for the flood irrigated fields. Further study is in progress to characterize the species of N in the rock samples in order to optimize Hood diversion into various planted fields. Although inclusion of organic matter as a source of N in the regression equation seems logical, the very significant relationship, which exists between organic C and the total clay+silt content, would eliminate its inclusion as an independent variable. The close relationship of organic matter with clay and clay+silt contents has been previously reported by Burke *et at* [6] and Nichols [19].

CONCLUSIONS

A 2.8% decrease in sand content of the 0-30 cm soil of the SBs was the only significant (P=0.05) change due to the deposition of the suspended load (Table 4). Although not statistically significant at the *5%* level, a 3.13% increase in silt content may add 11.5% to the ASW of this coarse loamy sand (Peterson, *et al.* (20], Table 3). Considering that a small difference in water content of sandy soils substantially changes their water potential, and therefore, their unsaturaled hydraulic conductivity, it seems that this minute addition of silt, along with other statistically insignificant changes, has greatly improved the microenvironment for plant growth as evidenced by a 10-fold increase in dry matter yield of the site (50 vs 500 kg ha'^{1} yr"^{1}). This points to a need for further research, and/or the application of another statistical design to detect the cause(s) of such obvious and biologically meaningful differences.

In addition to recharging the dangerously depleted aquifers and rejuvenating upwards of 20,000 qanats, the rc-building of which would require an astronomical capital outlay and hundreds of years of strenuous work, FWS can be used as a suitable method of reclaiming badly eroded soils and making them productive once again. Although man has not acquired the power to change many climatological phenomena in his favor, he can accommodate himself to the vagaries of the weather by storing food and water for the lean years. Although floodwatcr spreading is the least efficient irrigation method, it should be practised for years to come considering its overall benefits. For a world faced with environmental problems, hunger and unemployment, FWS, particularly by manual labor, offers a panacea.

ACKNOWLEDGEMENTS

The authors are indebted to Drs. A. Abtahi

[DOR: 20.1001.1.16807073.2000.2.1.8.4]

and N.A. Karimian of Shiraz University for thciT guidance throughout this study. Gratitude is expressed to the late M. Pashali and M. Azizi of the Research Institute of Forests and Rangeland; Y. Bordbar, M.A. Ehyaee, K. Ramcshni, B. Rowshan and M. Tavallaee of the Soil and Water Research Institute; and A.R. Ghaffari of the Seed and Tree Improvement and Production Institute for their cooperation in the different phases of this project. Special thanks are due to Drs. I. Kalantari and M.J. Malakouti for encouraging this project. Thanks are also due to Mrs. P. Kowsarnia for typing this manuscript.

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کاربرد گسترش سیلاب در آبادکردن بیابانهای شنی:
۱- تأثیر ته‌نشست‌ها در برخی ویژگی‌های فیزیکی و شیمیایی خاک

چکیده

گسترش سیلاب به منظور تغذیهٔ مصنوعی آبخوانها، در مناطقی که انجامش میسّر است، روشی ساده و ارزان برای بیابان‌زدایی می‌باشد. ته‌نشینی بار معلّق سیلابها در رسوبگیرها و استخرهای تغذیه، شنهای روان را تثبیت و مراتع فرسایش یافته‌ای راکه طرحهای مربوطه در آنها اجرا می‌گردند، آباد می‌کند. کوششی هماهنگ برای بیابان‌زادیی، که پایهٔ آن بر گسترش سیلاب و تغذیهٔ مصنوعی آبخوانها گذاشته شده است، در دشت گربایگان، جنوب ایران، تحقّق یافت. نتایج تجزیه‌های فیزیکی و شیمیایی نمونه‌های ۴-۱ ساله ته‌نشست‌های سه رسوبگیر نخستین طرح فوق مؤیّد آن است که تنها دو عامل از ۱۹ عامل مورد بررسی به گونه‌ای معنی‌دار تغییر کرده‌اند: مقدار شن، در اعماق ۱۰-۰ و ۳۰-۰ سانتی‌متری، به ترتیب ۷/۹ و ۳/۸ درصد کاهش یافته و ESP در ژرفای ۳۰-۰ سانتی‌متری ۱۷/۲ درصد فزونی گرفته است. معادلات وایازی همبستگی‌هایی معنی‌دار را بین مواد آلی ازت کل، فسفر، درصد اشباع آب و CEC و مجموع رس و لای نشان می‌دهند. از این روابط می‌توان منشأ زمین‌شناسی N و احتمالاً P و همچنین اهمیّت بار معلّق را در باروری شنهای روان استنباط کرد.