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Feasibility of Recovering Soil Nutrients through Flood Water Spreading

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ABSTRACT Flood water contains high amount of sediment affecting the fertility of the coarse grain alluvial fans and flood plains through increasing nutrients. In this study, the effects of the flood water spreading on the soil nutrients recovery were investigated during 10 years (2004-2014) at the Poldasht Flood Spreading Station of West Azarbaijan in Iran. Flooded three upper strips were selected at the flood spreading system. Three composite samples resulted from mixing four samples, in each strip were taken from 0-30 cm depth. Soil organic carbon (SOC) and total nitrogen (TN), exchangeable phosphorus (P) and potassium (K) were determined at the laboratory. To statistically analyze the data, t-test, in case of normal distribution, and otherwise non-parametric test of Kruskal Wallis were used. Results showed that the amount of SOC and TN increased from 0.23 to 0.33% and 0.027 to 0.039%, respectively. Noticeably, SOC, TN and P contents in the upper strips were significantly more than in the lower bands ($p \leq 0.05$). In addition, exchangeable P and K were significantly increased ($p \leq 0.05$) from 2.69 to 5.32 and 145.93 to 206.52 ppm, respectively, but there was no significant change in ($p \leq 0.05$) K content. These results also showed that flood water spreading increased the soil nutrients which may reduce the fertilizer requirement.

Key words: *Exchangeable ions, Flood water, Sediment, Soil properties*

1 INTRODUCTION

Extreme flood events may flush large amounts of sediment stored in the lower parts of the system (Keesstra *et al.*, 2009). Sediment trapping can be an alternative measure to prevent the negative off-site effects of soil erosion (Mekonnen *et al.*, 2015). When floodwaters recede, affected areas are often blanketed in silt and mud. This sediment can be full of nutrients, benefiting farmers and agribusinesses in the area. The flood water spreading is one of the suitable ways for the control and efficient use of flood water in arid and semiarid regions. By this way, the flood sediments were reused and soil fertility increased (Oweis *et al.,* 2001).The deposition of fine suspended material with different origins in flooded area may include a wide range of changes in the surface and the depth of the soil. The impact of this on some of the characteristics of the soil like pH, EC, gypsum and lime, SOC, P, N, S, Ca, Mg, Na and K content, depends on the quality and quantity of floods and it depends on the intensity of precipitation, floods volume and geological conditions of the watershed.

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The flood water spreading is an suitable way to exploit deposits of nutrient-rich water that have some important uses include more fertile soil with nutrients supply (Unger *et al.,* 2009). Sandy textured sediments are usually poor with OC and N (Lamond, 1993).Although increasing of the nitrogen content in form of ammonium occurs in the flooded soil but if the flood continues, the nitrogen content will be reduced by de-nitrification process (Clifford and Milburn, 2006). Fakhri *et al.* (2003) at the Bushehr Province, Tangestan Research Station concluded that 8 years of flood water spreading increased clay and silt content which led to a reduction in Sand percent of soil texture. Moreover, the saturated soil moisture percent increased (at α=5% level of significance), whereas organic materials, total nitrogen, and pH didn't show significant changes. So soil fertility was not statistically different among treatments and control points.

The results of Sokouti Oskoee *et al.* (2004) research in the field of the flood water spreading in Poldasht during four years showed that the SOC content in the second, third and fourth year was 1.8, 2 and 2.3 times more than the first year, respectively. The soil total nitrogen (TN) content also, in the fourth year was 1.3 times more than the first year.

Results of Soleimani (2006) in Musian plain in south of Ilam Province in Iran, showed that during 5 years the SOC content, increased 10 to 35% compared to control in 0- 25 cm of the soil depth. The TN content also reached from 0.025% in the first year to 0.035% in the last year of the study. The results of Sarreshtehdari and Skidmore (2005) study showed that the soil P and SOC contents increased significantly in floodwater spreading plan. In addition, there were the significant changes in the intervals between each of these factors in the embankment.

According to Shariati *et al.* (2005) results, the flood water spreading increase significantly the SOM, TN, P ($p \leq 0.01$) and K ($p \leq 0.05$). The results of Sarreshtehdari (2005) showed that P and OM changed significantly and improved after the FSP (Flood Spreading). The improvement of fertility and physicochemical conditions certainly point positively on the impact of the Ab-Barik-Bam FSP station.

Lotfollah Zadeh *et al.* (2006) showned that the soil K content increased significantly through FSP. Tavassoli *et al.* (2000) also indicated that the increase of K content in Kaboodar-Ahang FSP station is common phenomena. This is particularly very important in the area with intense erosion which reaches to 10,000 t km^{-2} y^{-1}. In addition, it has been shown that the distribution of soil nutrients by flood water spreading is different. In this process, the transfer of most of the elements occurs by fine particles (Toor *et al.,* 2004).Turner and Haygarth (2000) have concluded that the flood water spreading can have beneficial effects on distribution of different forms (specially the available form) of the soil phosphorus.

The results of mentioned researches showed that the flood water spreading changed the soil fertility. When the suspended solids have nutrient-rich material, the flood water spreading will increase the soil's nutrients. Therefore it is necessary to study the possibility of the soil nutrients recovery through flood water. In this study, the effects of the flood spreading on the main soil nutrients recovery were investigated during 10 years at the flood spreading station in West Azerbaijan, Iran.

2 MATERIALS AND METHODS

2.1 Study Area

Poldasht flood spreading station (FS) is located in 21 km southeast from Poldasht City in West Azarbaijan Province of Iran. This station covers approximately 300 ha and extends from the 39° 0'- 39° 15' North latitudes to the eastern 44° 45'- 45° 10' longitudes (Figure 1). Regional climate is semi-arid, with an average annual rainfall of 223 mm, and the average annual temperature of about 13°C. The FSP station lies on Quaternary sediments with the dominant soil texture of Coarse Sandy Loam. The soil classified as Orthents with land use of range.

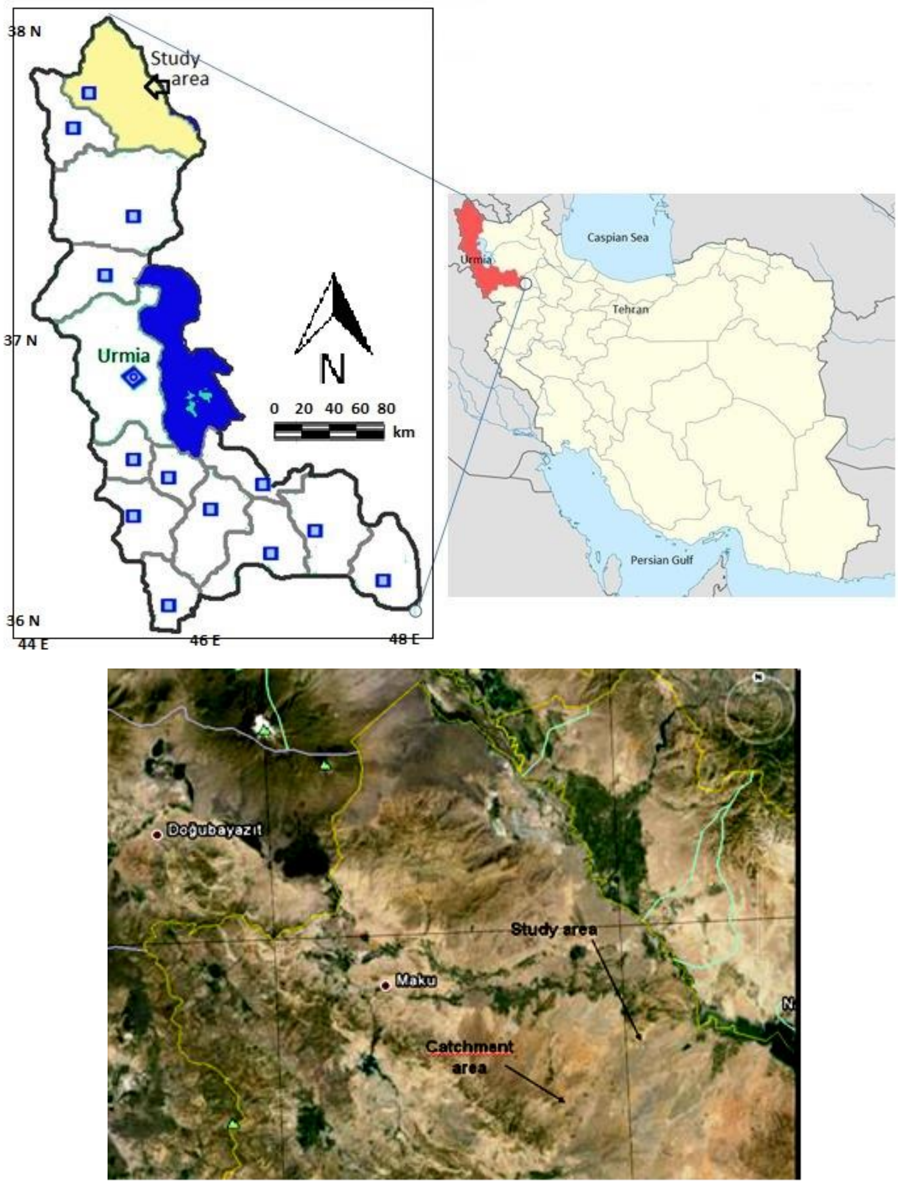

Figure 1 Location of the study area in Iran

2.2 Research Methodology

Soil samples were taken from 0-30cmdepth of three upper strips as showed in Figure 2. There were three replicates in every strip and in each replication four samples were taken. Then the four soil samples were mixed together to prepare a composite soil sample. The SOC, TN, exchangeable P and K contents on 90 soil samples, collected during the 10 years of study, that is totally 360 tests, were determined using the standard methods (Ehiaee and Behbahani-zade, 1998). The obtained data were analyzed in a completely randomized design. For statistical analysis, if the data showed a normal distribution, t-test and otherwise Kruskal Wallis test was used. Kolmogorov-Smirnov method was used to check the data on ‘normal distribution’. So, the trend of soil nutrients variation was identified in the flood water spreading stripes, and also during experiment years.

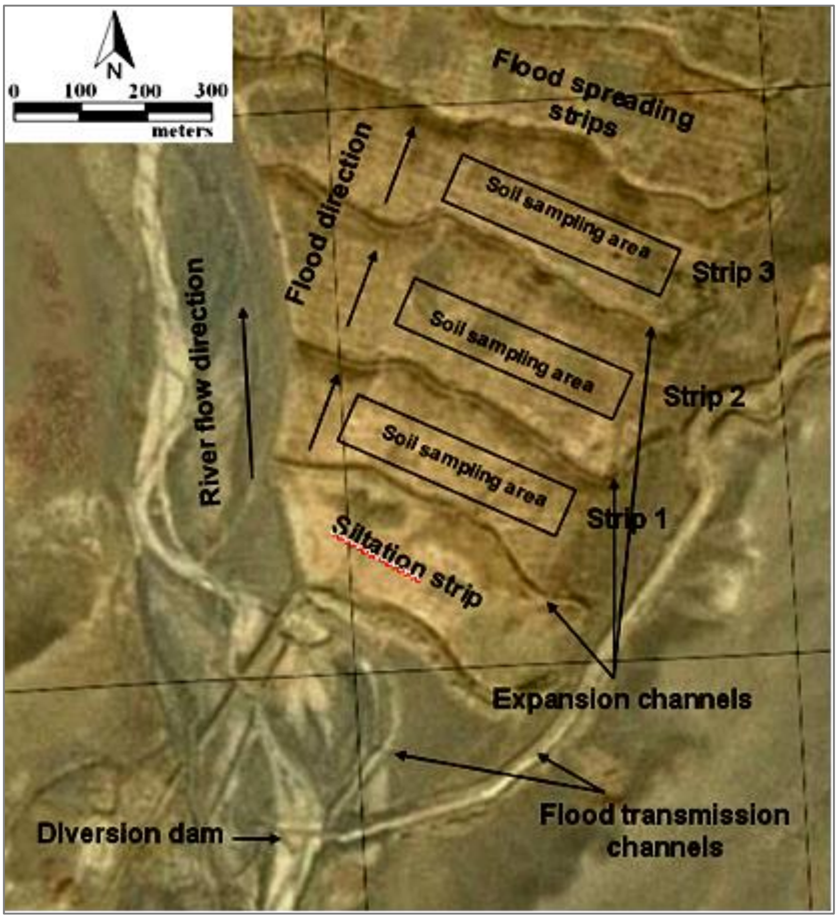

Figure 2 Soil sampling points in the flood water spreading strips in the study area

3 RESULTS

The statistical analysis of soil data showed that the mean of SOC, TN, Available P and K content were 0.28 %, 0.03 %, 3.77 ppm and 180.13 ppm, respectively (Table 1).

The mean SOC in the first, second and third flood water spreading strips were 0.4, 0.2 and 0.2 %, respectively. The TN in the first till third flood water spreading strips was 0.05, 0.03 and 0.03 %, respectively. The mean exchangeable P was 4.3, 4.2, and 2.8 ppm, and the mean exchangeable K was 167.4, 181.7 and 191.3 ppm for first, second and third FSP strips respectively. The normality test showed that only K had the normal distribution with coefficient of more than 0.05 (Table 2), there fore, the SOC, TN and P were analyzed by Kruskal Wallis test.

Based on the results the changes of the soil nutrients contents which had not the normal distribution were significant at ($P \leq 0.05$). There were significant differences between the first, fifth and tenth year in the TN, SOC and available P content ($P \leq 0.05$). The available P showed significant changes in fifth and tenth years (Tables 3, 4 and 5). Changes probably caused by transport and deposition of sediments and nutrients on the soil surface during implementation years.

Table 1 The statistical analysis of soil nutrients data during 10 years

Soil Nutrients	The Number of Soil Samples	Mean Value	Standard Deviation	Minimum	Maximum
SOC (%)	90	0.28	0.15	0.02	0.86
TN (%)	90	0.03	0.02	0.00	0.10
P (Exchangeable)(ppm)	90	3.77	3.20	0.10	23.00
K (Exchangeable)(ppm)	90	180.13	92.46	40.00	242.00

Table 2 The results of the normal test of the soil nutrients data by Kolmogorov-Smirnov test

Description		SOC (%)	TN (%)	P (ppm)	K (ppm)
Normal Parameters	**Mean**	0.285	0.03	3.77	180.13
	Standard Deviation	0.148	0.02	3.20	92.46
Kolmogorov-Smirnov Z		1.521	1.52	1.84	1.19
Asymp. Sig. (2-tailed)		0.020	0.020	0.002	0.113

Table 3 Analysis of changes between the first and fifth years data by Kruskal Wallis test

	SOC(%)	TN(%)	P(ppm)
Chi-Square	9.728	9.728	16.536
df	1	1	1
Asymp. Sig.	0.002	0.002	0.000

Table 4 Analysis of changes between the first and tenth years data by Kruskal Wallis test

	SOC(%)	TN(%)	P(ppm)
Chi-Square	11.755	11.765	53.293
df	2	2	2
Asymp. Sig.	0.003	0.003	0.000

Table 5 Analysis of changes between the fifth and tenth years data by Kruskal Wallis test

	SOC	TN	P(ppm)
Chi-Square	0.021	0.021	22.637
df	1	1	1
Asymp. Sig.	0.885	0.885	0.000

The difference between the exchangeable K in the first year (145.93 ppm) with the fifth and tenth years (187.96 and 206.52 ppm, respectively) were significant ($p \leq 0.05$). But the content of this nutrient was not significantly changed in the fifth and tenth years (Table 6). These changes can be attributed to the quality of sediments.

The results showed that the SOC and TN significantly increased from 0.23 to 0.33% and 0.027 to 0.039 % during the study years. Also during the study years the exchangeable P and exchangeable K increased significantly from 2.69 to 5.32 ppm and 145.93 to 206.52 ppm. Although, the increase in obtained values was low or close to each other during experiment years, but the changes were statistically significant ($p \leq 0.05$).

Study of changes within strips showed the SOC and TN in the first strip (0.4 and 0.48 %, respectively) have significant difference with such nutrient in second and third strips 0.22 and 0.23 % for SOC and 0.26 and 0.27 % for TN, respectively. The exchangeable P content in the first and second strips (4.3 and 4.2 ppm, respectively) changed significantly compared with third strip (2.8 ppm).Analysis of variance for exchangeable K content (with normal distribution) was indicative of no significant changes of this nutrient content on the strips (Table 7).

Table 6 Mean comparison of the available K by t-test in the study years

Dependent variable	Year (I)	Year (J)	Sig.
	1	5	0.016
		10	0.001
K	5	1	0.016
		10	0.283
	10	1	0.001
		5	0.283

Table 7 Analysis of variance of the exchangeable K in the samples

		Sum of squares	df	Mean squares	F	Sig.
K	**Between the groups**	15683.94	2	7841.97	0.92	0.40
	Within the groups	1360923.07	159	8559.26		
	Total	1376607.01	161			

3 DISCUSSIONAND CONCLUSION

The soils of FSP station classified as Orthents and the soil nutrients are naturally poor. The results showed that the SOC and TN significantly increased during the study years at P≤0.05. These results were in agreement with the ones determined by Sarreshtehdari and Skidmore (2005), Sokouti Oskoee *et al.* (2004), and Soleimani (2004). On the other hand, Lamond (1993) reported a reduction in the organic matter content of the soil in these conditions. He stated that by spreading the flood water on the soil, large amounts of sediment transported and deposited on the soil surface. In these conditions a lot of native plants could not grow. Thus, the loss of plants also reduced the amount of organic carbon. But gradually the plants, such as *Salsola kali, Atriplex leucoclada Agropyron elongatum* that are resistant to sedimentation, water logging and salinity have grown in the region and the organic matter increased.

Sarreshtehdari and Skidmore (2005) reported that flood water spreading on topsoil increased significantly the soil P content. These results were in agreement with the results of the present study. The sediments of the floods could be the main reason of increasing of the soil P content. Also, the activity of soil microorganisms can be increased by increasing of soil organic matter and this can influence the increasing of P content in the soil.

The results of Tavassoli *et al.* (2000) showed an increase in the soil K content by flood water spreading on the topsoil. Lotfollah Zadeh *et al.* (2006) also showed that the soil K content distribution in the soil increased significantly (P≤ 0.05) by flood water spreading. The mobility of the K and amounts of the plant consumption for this element can be the reasons for the soil K content changes in flood spreading systems.

Therefore, changes in soil nutrient by flood water spreading on the topsoil can be dependent on the type of land use of the upstream fields that has changed over the experiment years. Since the agricultural fields in the upstream of the study area covers considerable area, so the application of chemical fertilizers and its leaching by erosion and deposition in the study area can increase the nutrients of the soil. Although soil nutrients increase is slight and gradual, but this means the nutrient recovery can have an important role in reducing the use of fertilizers in these areas. Review the results of the studies showed that the issue of nutrient recovery from flood spreading neglected and only changes of these elements has been expressed.

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امکان‌سنجی بازیافت عناصر غذایی خاک از طریق پخش سیلاب

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چکیده سیلاب‌ها حاوی مواد رسوبی بوده که پس از نهشته‌گذاری در حاصل‌خیزی مخروط افکنه‌ها و دشت‌های سیلابی متشکل از رسوبات دانه‌درشت از طریق افزایش عناصر غذایی، مؤثر هستند. در این پژوهش، اثر پخش سیلاب بر بازیافت عناصر غذایی اصلی خاک در عرصه پخش سیلاب بر آبخوان پلدشت واقع در استان آذربایجان‌غربی طی ۱۰ سال (۱۳۹۳-۱۳۸۳) مورد ارزیابی قرار گرفت. در این رابطه، در حد فاصل نهرهای گسترش سیلاب و سه نوار اول سیل‌گیری شده پخش سیلاب، سه نمونه مرکب حاصل از اختلاط چهار نقطه در هر نوار و از عمق صفر تا ۲۰ سانتی‌متری خاک به‌همراه لایه رسوب، نمونه‌برداری و عوامل درصد ازت کل و کربن آلی، فسفر و پتاسیم قابل جذب خاک اندازه‌گیری شد. برای مقایسه میانگین‌ها، چنان‌چه داده‌ها دارای توزیع نرمال بود، از آزمون t و در غیر این صورت از آزمون ناپارامتری Kruskal Wallis استفاده شد. بر اساس نتایج به‌دست آمده، مقدار کربن آلی و ازت کل خاک در طول سال‌های اجرای طرح به‌طور محسوسی به‌ترتیب از ۰/۲۳ به ۰/۳۳ و از ۰/۰۲۷ به ۰/۰۳۹ درصد افزایش یافته است. مقدار فسفر تبادلی هم در طول سال‌های اجرای طرح از ۲/۶۹ به ۵/۳۲ و پتاسیم قابل تبادل از ۱۴۵/۹۳ به ۲۰۶/۵۲ قسمت در میلیون به‌طور معنی‌داری ($p \leq ۰/۰۵$) افزایش یافته است. از سوی دیگر، اختلاف مقادیر برخی از عناصر مانند فسفر، کربن آلی و ازت خاک در طول نوارهای پخش بالادست به‌طرز معنی‌داری ($p \leq ۰/۰۵$) تا دو برابر بیش‌تر از نوارهای پایینی بوده ولی میزان پتاسیم تغییر معنی‌داری ($p \leq ۰/۰۵$) نداشته است. این نتایج نشان داد که پخش سیلاب موجب افزایش عناصر غذایی اصلی خاک شده که به‌تبع آن امکان کاهش کاربرد کود به‌وجود آمده است.

کلمات کلیدی: جریان‌های سیلابی، رسوب، ویژگی‌های خاک، یون‌های قابل تبادل