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Flood water influence on soil fertility in some districts of lower Sindh, Pakistan

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Abstract

In order to visualize the damage caused by 2011 rains and flood in some districts of lower Sindh, Pakistan i.e. Mirpurkhas, Umerkot, Sanghar and Badin, a study was initiated to review the facts regarding the macronutrient status along with necessary physico-chemical soil properties. The seven randomly selected soils were sampled, three samples from each spot were taken at three depths (0-15, 15-30 and 30-45cm). Hence from every location three spots were randomly chosen, as one for relatively non-flooded soils (as a reference index) adjacent to heavily flooded soils for long durations. The analytical data after passing through laboratorial procedures depicted a variety of soil textures (from light to medium and heavy at some locations). Whereas, the pH of these soils was moderate to highly alkaline and electrical conductivity was recorded from 0.11 to 22 dS m^{-1}. The macronutrients as nitrogen was deficient, phosphorous was also in lower levels (0.1-3.7 mg kg^{-1}) but potassium mostly remained in higher fractions (69-259 mg kg^{-1}). The results also indicated that soils were found highly saline on many locations that might be due to the salt deposition by stagnant water. While, loss of organic matter were also reported may be because of rapidly flowing flooded water over them.

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Introduction

Sindh province of Pakistan has a unique topography. Being almost flat and at the base of Indus basin, the surplus water in the form of floods and monsoon rains has to cross through it which is usually beyond the normal intake capacity of drains. The designated discharge capacity of drain LBOD (Left bank outfall drain) was 4000 cusecs while the drain water flowed with the rate of 18000 cusecs (Sindh - NDMA., 2012), this additionally drained water pressurized the drains to overtop and breach. Thus in this context the year 2011 had proved to be more devastating especially for the districts of lower Sindh including Sanghar, Mirpurkhas, Umerkot and Badin.

During August 2011, two heavy and fatal spells of monsoon rains had seriously hit these districts by inundating them through directly affecting 8.9 million populations causing about hundreds of human causalities and thousands of animal deaths. The major source of livelihood and the economic back bone of the people of these districts are agriculture, livestock and fisheries. All of these sectors were extremely damaged due to these torrential rains which gave a financial loss of 160, 107 PKR millions (Sindh - NDMA., 2012). According to NDMA (National disaster management authority), the standing crops on 4.5 million acres were all ruined. Although losses caused by floods in this region was also a common experience (Rehman and Kamal, 2005).

The losses were not up to the economic concerns only but these were assumed long lasting in terms of the deterioration of the natural resources including the soils of these affected districts. Generally the agro based economy depends largely on the fertility status of the soils of any area. So if the soils were spoiled than the food security issues would be in dangerous and critical situation. Hence, in order to visualize the gravity of the problem, this study was designed to study the impact of flooded water on the current fertility status of soils of these mentioned districts.

Materials and methods

Site/study area selection

To evaluate the effects of flood water and rains on the fertility status of the cultivated soils of some districts of lower Sindh as Sanghar, Umerkot, Mirpurkhas, and Badin were sampled from seven randomly selected sites with three spots, one as a reference spot which was opted on relatively none or un-flooded water adjacent to the completely inundated soils. The remaining two spots remained under submerged conditions for a temporary or longer duration. All spots were physically confirmed especially for the risks hazards caused by these rains and/or flood before taking samples.

Selection of sampling depths, sampling time and sampling spots

Each spot was excavated for three successive depths 0-15, 15-30 and 30-45 centimeters, so that to thoroughly analyze the effects of flood water deeply in the soil profile. All soil samples were taken after the draining/evaporated or run off of the flooded water over them. However, the spot selection was done few days after the end of flooding but sampling was done many days after the passing off of this calamity.

Soil sample collection and procedure of sample collection

The soil samples were taken from the selected location with the help of soil auger (regular soil auger with 3 1/4" bits diameter). All samples were taken separately by taking the sample from top 15 centimeters followed by mid 30 cm and the last sample up to the limit of 45 cm depth from one core/bore. Every time the sampler (auger) was cleaned manually so that the sample of each fraction may not be mingle with the other layer's portion. Samples were then placed in polyethylene plastic bags with tagged numbering on it for further analysis.

Soil samples preparation for laboratory analysis

Soil samples were brought to the laboratory for chemical analyses of the soil properties and the macro nutrient status of these soils. The samples were air dried in the open air under shades, crushed, ground and passed through 1/8th inches mesh screen sieve.

Methods used for laboratory analysis

The samples were analyzed for some important physico-chemical properties of soil including soil texture by Bouyoucos hydro meter method (Kanwar and Chopra, 1959), pH and Electrical conductivity using 1:5 soil water extract (Rowell, 1994), soil organic matter% by Walkley and Black method (Jackson, 1958), total nitrogen% by Kjeldahl method (Chopra, 1959), available phosphorous and exchangeable potassium by AB-DTPA method (Soltanpour and Schwabe, 1977). The soil textural classes were categorized by Foth (1982), while soil pH, EC, and OM was sorted out as described by NMSU (2000). Macronutrient status categorization for nitrogen was as proposed by Melherbe (1963) and for P and K as reported by Soltanpour (1985).

Results

Texture of soils

The texture of the soils of sampled spots at three depths on different sites is presented in Table 1. The texture of soils in dehs of all tehsils/talukas in these districts had depicted a wide variety of differences. It was also observed that the texture was also varied from the other depths either nearby it or at the top or the bottom depths. However, on overall basis it ranged from sandy loam, silt, silt loam to clay and clay loams in all flooded and reference spots under three depths and thus generally it was from light to medium and heavy at some spots. These findings are in line with the research of many other workers in the same areas including Oad *et al.,* (2003) and Ali *et al.,* (2014).

Soil pH

The soil pH at various soil depth levels is shown in Fig. 1 (a), 1 (b) and 1 (c). The result indicated that generally the pH of all reference soil samples was moderately alkaline (< 8.0) in reaction while, it was highly alkaline (> 8.0) in almost all (except a few) soil samples from flooded spots at all three depths. However, the pH in all reference spots at all sites was in a range of 7.5-7.9 while, it ranged from 7.6-8.8 in all flooded spots at all three depths. Hence an increase in pH is assumed from the results. However, the pH of these areas is remained mostly high as described by Rajput *et al.,* (2014), who reported that the majority of the soils under rice (flooded conditions) cultivation were alkaline in nature.

Table 1. Soil Texture of different Dehs in different Talukas/Tehsils of the districts of lower Sindh before and after flood conditions.

Districts	Talukas/Tehsils	Dehs	Locations	Spots	Sample depth (centimeters)		
					0-15	15-30	30-45
Mirpurkhas	Digri	172	1	1*	Silt	Silty loam	Clay loam
				2	Sity loam	Loam	Clay loam
				3	Silt	Sity clay loam	Silty clay loam
	Jhudo	173	2	1*	Clay loam	Clay Clay	Clay
				2	Clay	Clay loam	Clay loam
				3	Clay loam	Silty loam	Clay
		375	3	1*	Silt	Loam	Silty loam
				2	Silty loam	Silty loam	Silty loam
				3	Silt		Clay
Umerkot	Kunri	Boostan	4	1*	Clay loam	Loam	Clay loam
				2	Loam	Clay	Clay
				3	Loam	Clay loam	Clay
	Samaro	325	5	1*	Silty loam	Loam	Loamy clay
				2	Loam	Silty loam	Clay
				3	Silt	Loam	Loam
Sanghar	Khipro	Kunri	6	1*	Silty sand	Silt	Silt loam
				2	Silt	Sandy loam	Loam
				3	Silt loam	Sandy loam	Sand silt loam
Badin	Matli	Sorahdi	7	1*	Clay loam	Clay	Clay
				2	Loam	Clay loam	Clay loam
				3	Clay	Clay loam	Clay

1* Spot sampled for reference index while 2 and 3 spots were sampled from flooded conditions.

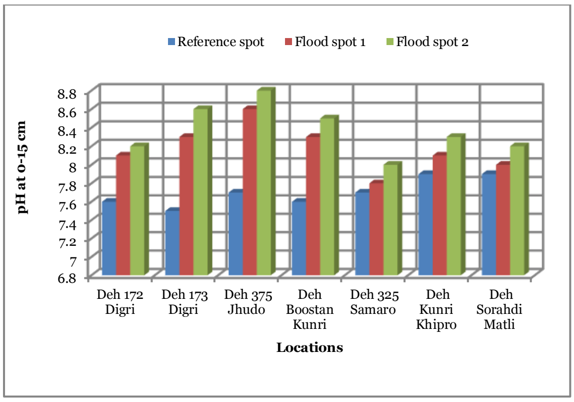

Fig. 1(a). Soil pH at 0-15 cm of reference spots and flood spots at different sites in lower Sindh.

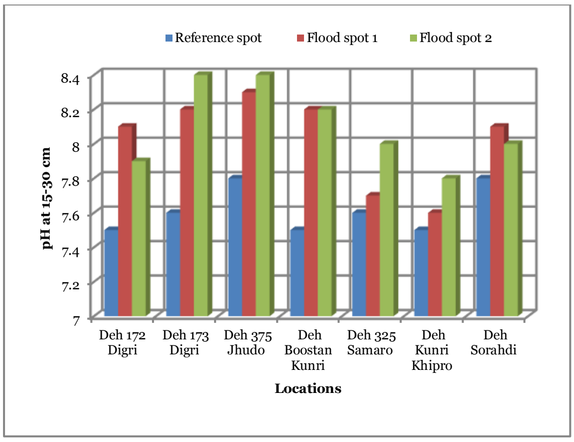

Fig. 1(b). Soil pH at 15-30 cm of reference spots and flood spots at different sites in lower Sindh.

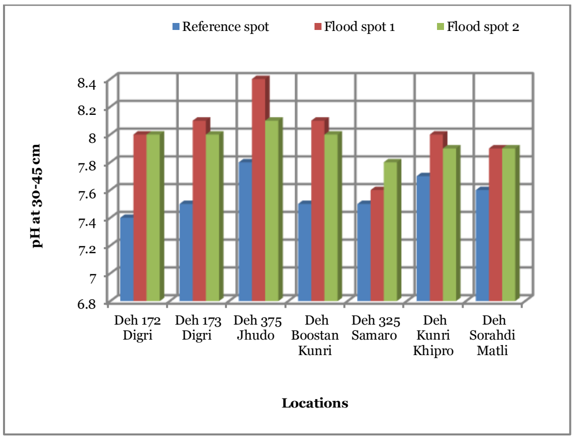

Fig. 1(c). Soil pH at 30-45 cm of reference spots and flood spots at different sites in lower Sindh.

Electrical conductivity

The Electrical conductivity of the sampled spots on three different soil layers is depicted in Fig. 2 (a), 2 (b) and 2 (c). The result showed that the all the reference spots at all 3 depths were non-saline (< 2 dS m^{-1}) but it was slightly saline (< 4 dS m^{-1}) at the spot in deh Sorahdi tehsil/taluka Matli, district Badin. While, all the flooded samples showed an increase in ECe levels at all depths. Moreover, it showed a medium ECe ranged (4-8 dS m^{-1}) at few spots including deh 173, tehsil Digri, district Mirpurkhas and also strongly saline values (> 8 dS m^{-1}) at spots in deh Kunri, tehsil Khipro, district Sanghar and deh Sorahdi, tehsil Matli, district Badin. The higher ECe values at some spots might be due to the deposition of soluble salts present in flood water stood over it for long durations. The result of the study is in harmony by the finding of Kalshetty *et al.,* (2012), who reported that an increase in EC levels in soil samples from flooded spots might be due to the addition of more dissolved salts in the stagnant water over the top soil layers and leached down into the underlying layers.

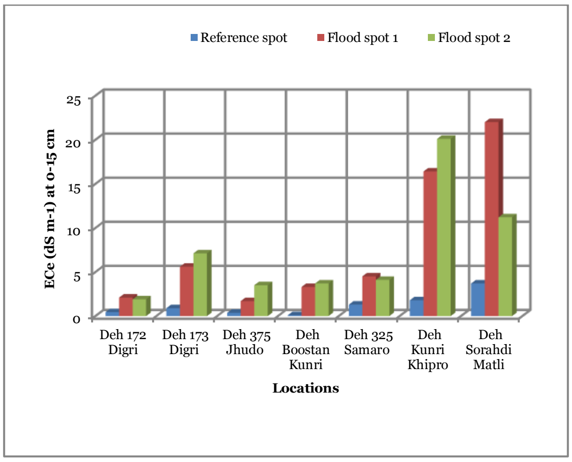

Fig. 2(a). Soil ECe at 0-15 cm of reference spots and flood spots at different sites in lower Sindh.

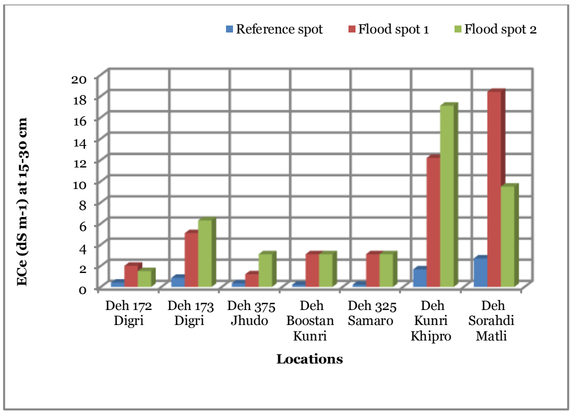

Fig. 2(b). Soil ECe at 15-30 cm of reference spots and flood spots at different sites in lower Sindh.

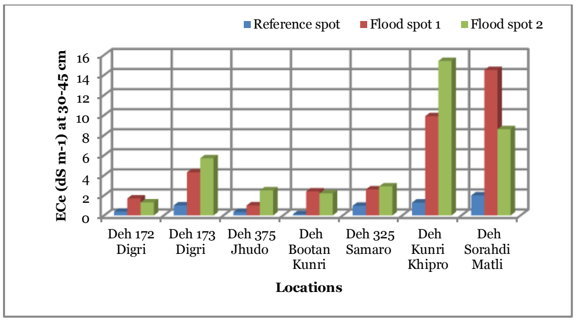

Fig. 2(c). Soil ECe at 30-45 cm of reference spots and flood spots at different sites in lower Sindh.

Soil organic matter %

The result for organic matter % on different depths for reference and flood spots is indicated in the Fig. 3 (a), 3 (b) and 3 (c). It is clearly shown in the results that organic matter % was generally in lower values throughout the soil samples. However, it was nearly 1% in some reference spots only, but it was completely deficient in all flooded spots. It was also noteworthy that the organic matter was relatively higher in the top portions than in the layers beneath. This might be due to the materials or flood water over these spots was deficient in organic matter contents. Thus the findings of this study were also in agreement with the results as obtained by Ahmed (2011).

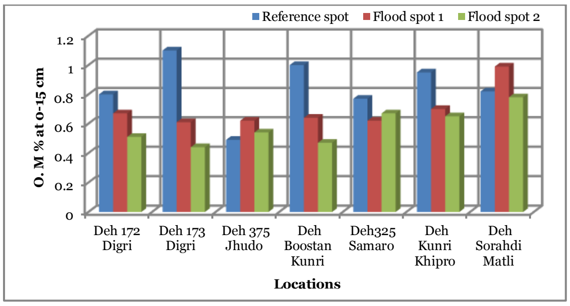

Fig. 3(a). Soil O.M % at 0-15 cm of reference spots and flood spots on different sites in lower Sindh.

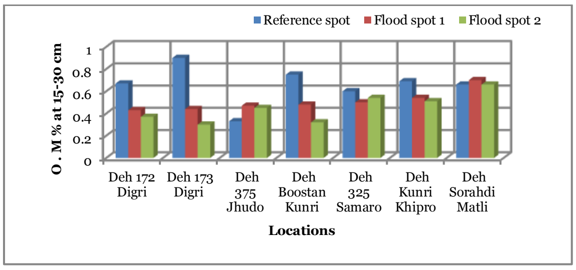

Fig. 3(b). Soil organic matter % at 15-30 cm of reference spots and flood spots on different sites in lower Sindh.

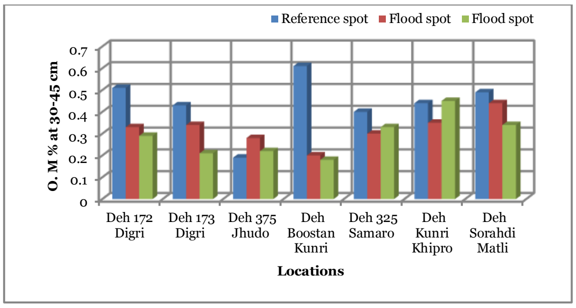

Fig. 3(c). Soil organic matter % at 30-45 cm of reference spots and flood spots on different sites in lower Sindh.

Nitrogen %

The nitrogen % on different soil depth levels is depicted in Fig. 4 (a), 4 (b) and 4 (c). The results revealed that the nitrogen content in all sampled spots was completely deficient in all depths at all spots. However, N% was relatively high in reference spot at 0-15 cm depth but it remained lower in other two depths. Likewise, the nitrogen content in the flooded field spots was very low (< 0.05 %) at all three depths on all sites. These findings are in accordance with the research of Eulenstein *et al.*, (1998), who was of the view that the lower nitrogen content under flood conditions might be due to many possible reasons including denitrification and anaerobic conditions.

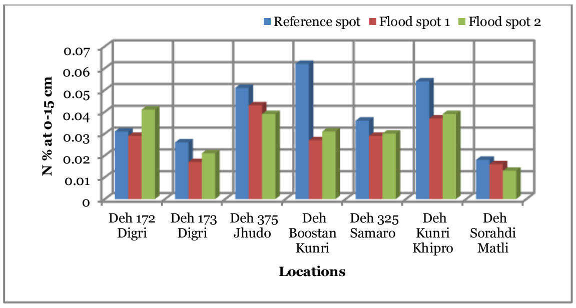

Fig. 4(a). Soil N % at 0-15 cm of reference spots and flood spots on different sites in lower Sindh.

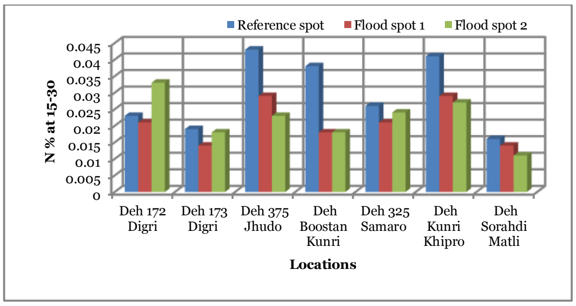

Fig. 4(b). Soil N % at 15-30 cm of reference spots and flood spots on different sites in lower Sindh.

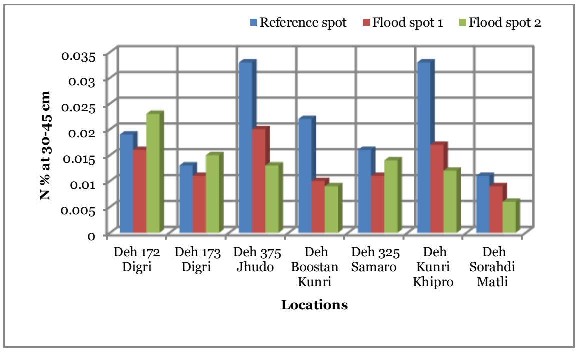

Fig. 4(c). Soil N % at 30-45 cm of reference spots and flood spots on different sites in lower Sindh.

Phosphorous (mg kg-1)

The soil phosphorous content at various soil depths is revealed in Fig. 5 (a), 5 (b) and 5 (c). The results indicated that the phosphorous content of sampled sites was generally low (< 4 mg kg^{-1}) in all soil samples at all three depths in both reference and flooded spots. Hence no specific difference caused by flood was pronounced in results for phosphorous content. Many workers have also reported that the soils of this region were also deficient in phosphorous (Oad *et al.,* 2003; Akhter *et al.,* 2010).

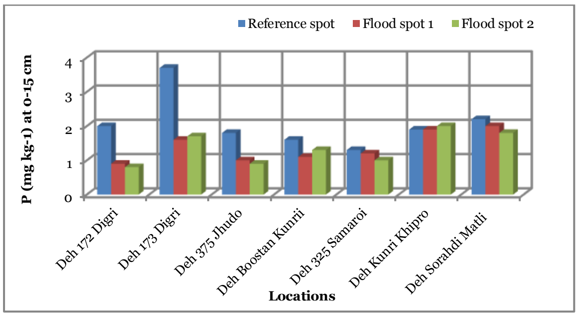

Fig. 5(a). Soil P (mg kg^{-1}) at 0-15 cm of reference spots and flood spots on different sites in lower Sindh.

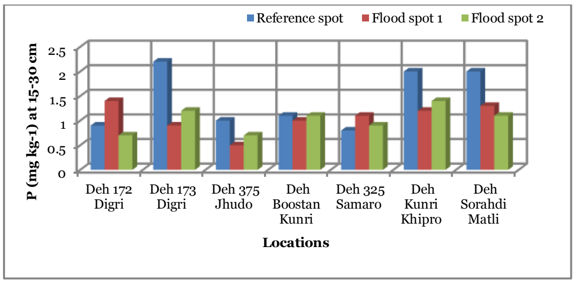

Fig. 5(b). Soil P (mg kg^{-1}) at 15-30 cm of reference spots and flood spots on different sites in lower Sindh.

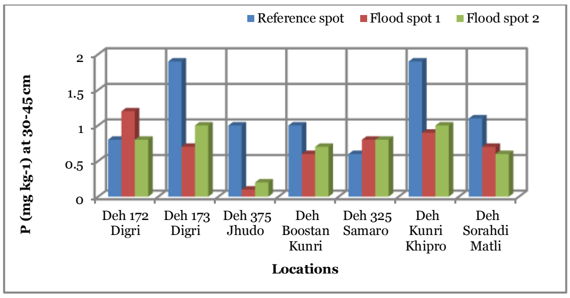

Fig. 5(c). Soil P (mg kg^{-1}) at 30-45 cm of reference spots and flood spots on different sites in lower Sindh.

Potassium (mg kg-1)

Soil test potassium at different soil depths is listed in Fig.6 (a), 6 (b) and 6 (c). The results of the study revealed that the potassium content of the sampled sites was generally high (> 120 mg kg^{-1}) in all samples with no systematic trend. Only few samples showed a medium range (60-120 mg kg^{-1}) but no sample was found in low potassium content throughout the study spots except in deh Bootan of taluka Kunri. On overall basis the potassium content was in a range of 69 to 259 mg kg^{-1}. The results for soil test potassium content are in line with Ahmed (2011), who reported that the potassium content of soils under flood situation was in sufficient levels.

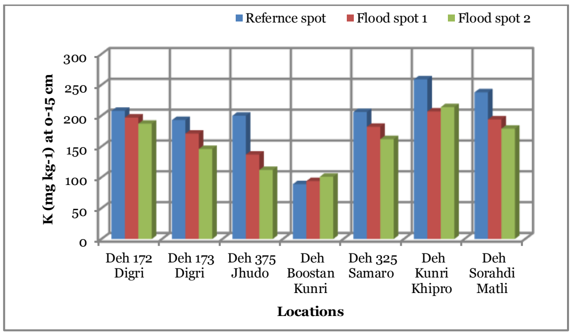

Fig. 6(a). Soil K (mg kg^{-1}) at 0-15 cm of reference spots and flood spots on different sites in lower Sindh.

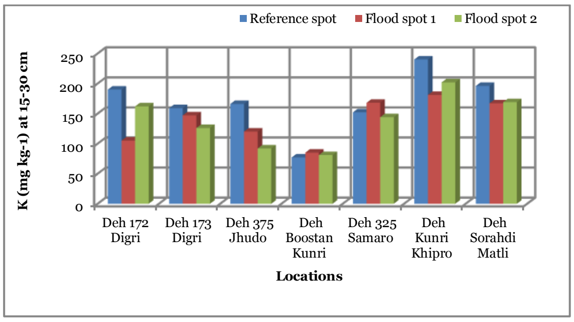

Fig. 6(b). Soil K (mg kg^{-1}) at 15-30 cm of reference spots and flood spots on different sites in lower Sindh.

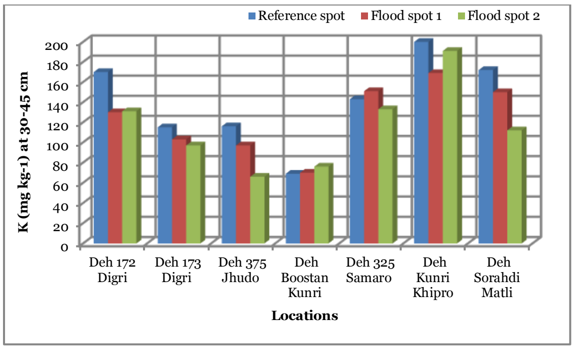

Fig. 6(c). Soil K (mg kg^{-1}) at 30-45 cm of reference spots and flood spots on different sites in lower Sindh.

Discussion

The texture of the soils under study was highly variable in layer wise from top to mid and bottom in the soil profiles. There was also a diverse picture in terms of variability in soil texture among the selected spots at different location in different districts of the province under the effects of flood as well as under the nonflooded soils spot used as reference points for comparisons. Thus, the texture in all seven sites was in range from sandy loam (light textured), silt, silty loam, loam (medium textured) to clay and clay loam (heavy textured).The same findings were proclaimed for the nearby area of the same region by Chohan *et al.*, 2015. There was no specific effect of flood on the texture of these soils, may possibly be due to strong pressure of flooded water to moves out into the drains.

However, the flood had negatively affected the soil properties including soil reaction (pH), electrical conductivity and the organic matter status of these soils by increasing the pH and electrical conductivity and decreasing the organic matter content in all three layers at almost all locations under flooded spots comparing with the spots surveyed as reference (Non-flooded). These results are in line with Chaniho *et al.*, 2010 and Memon *et al.*, 2012 in the same areas.

The nutritional status including N, P and K were found as the total nitrogen % and available (AB-DTPA) phosphorous were deficit in all three layers and in almost all studied spots, while the available potassium was mostly in adequate level except in deh Boostan, taluka Kunri. These findings are in agreement with the results of many other workers (Talpur *et al.*, 2015, Ali *et al.*, 2014.) in the same area including Talpur *et al.*, 2016 who verified that soils in tehsil Kunri especially deh Boostan are in lower limits in AB-DTPA available potassium.

Conclusion

It could be concluded that the findings of present study had evidences of flood water about some sites, which were highly saline and strongly alkaline in reaction as in case of results obtained from the samples of deh Sorahdi, district Badin. It is also assumed the fact that the top portions of these soils were relatively more deteriorated than the layers beneath it. Soil tests showed a decrease in organic matter, nitrogen and phosphorous contents, while potassium content was in adequate levels.

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