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Research Article

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Evaluation of Soil Physico-Chemical Properties in Pre and Post Flood Conditions at Thatta Sindh Pakistan

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Abstract

Heavy rainfall on a scale unprecedented to 100 years caused massive floods in Pakistan during 2010. Due to climate change, heavy rainfall brought the biggest ever natural rain flood to River Indus. Agricultural area on the lower Indus plane is frequently flooded. Floods damage soil properties, lower agricultural productivity, and worsen food shortages. This study observed changes in soil physico-chemical properties and nutrient status under pre and post flood conditions. In pre- and post-flood conditions, 13 locations were sampled (0-15 cm and 15-30 cm). Clay was dominant in pre-flood conditions with 69.24%, while sandy clay was higher with 53.80% in post-flood conditions. Soil reaction was moderately (pH 8-8.5) and strongly alkaline (pH >8.5-9.0) in pre-flood and post-flood conditions, respectively. The EC was low to moderate (2-8.0 dSm-1) and severely saline (8.00-16.00 dSm-1) in pre and post-flood conditions. SAR hazards increased from 11.15 to 17.09 in post-flood conditions. Organic matter was poor (<0.5 %) and lime content was in moderate category (10-15%) in post flood conditions. N, P, Ca and Mg content showed decreased trend of 20, 42, 19 and 23%, respectively in post flood conditions, whereas K content was increased by 19 %. In post flood conditions, the pH and SAR were highly positively and significantly correlated (r=0.53) with each other indicated the dispersion and deterioration of soil with decreasing nutrients availability to plants. The information obtained from this study will be helpful to develop flood qualification strategies for proper soil management.

Key word: Flood, Lower Indus plane, Soil properties, Soil deterioration, Nutrients status

Introduction

Heavy rainfall persuaded the flooding disasters that occur repeatedly in many areas of world and often cause extraordinary harm to crop production. The alteration of soil physical and chemical properties during flood could considerably decrease crop stand, growth and yield of crops. Under present climate conditions, the decline in crop yields are unsettled to overload rainfall actions and have been extensively, harmfully influencing the grain supply and creating food insecurity (Xi *et al.*, 2022). The heavy rain (above normal annual rainfall 87.5%) in the northern parts of Pakistan, caused the biggest ever flood in River Indus and estimated that 4.5 million acres of crop were destroyed (Rehman *et al.*, 2021, Bhatti *et al.*, 2010). The chemical changes may alter the soil nutrients availability and exerts negative impact on food sustainability (Nancy *et al.*, 2011). The effect of flood for farmers consisted of changes in soil physico-chemical properties, decrease availability of nutrient to crop and harvest losses (Visser and Voesenek 2004). Floods bring some unfavorable or beneficial effects on soil physico-chemical properties (Abubakar *et al.*, 2012, Kalshetty *et al.*, 2012, Saint-Laurent *et al.*, 2010). The soil properties differed significantly with each other according to area in flood water and fine silt is a common feature of flood deposits, along with a reduction in organic carbon, while increase in pH that may lead to harvest losses from soil (Saint-Laurent *et al.*, 2010 and Baker, 2006). Lida *et al.* (2012) reported non-significant differences for soil SAR before and after flood conditions, while a decrease in electrical conductivity (EC) after flood conditions. Whereas, Xi et al., 2022, Abubakar *et al.*, 2012, Tavasoli, 2001; Kowsar 1992, found that when floodwater spreading on plains caused to an increase in pH, EC and sodium adsorption ratio (SAR). Flood can reduce the productivity of soils by causing nutrient loss due to erosion (Abubakar *et al.*, 2012). The change in soil properties in conjunction with an increase in Na^+ and pH, decrease the yields considerably (Wahid 2004, Ashraf and Sarwar 2002). There is a growing need for information on soil quality following rapid land use changes taking place after flood. The different studies are available regarding the impact of different management practices of soil and crop, however very limited work has been reported regarding the effect of pre and post flood on soil physic-chemicals properties. Hence, the study was conducted to determine the impact of flood on soil properties and fertility status of the flooded soils in order to work out the immediate estimation of flood effects on the soil conditions for agricultural production in flooded area of Thatta, Sindh.

Material and Methods:

Study area: The historic city of Sindh province "Thatta" (23° 43' to 25° 26' N and 67° 05' to 68° 45'E) is the part of lower Indus plane was hit by flood. The sub-district Thatta is situated on right bank of River Indus, hit by flood waters due to breach on *Bijora* dike during the year 2010. The sub-district's soil are diversified by the mountains in its west north and plain agricultural land on east south (District Govt. Thatta 2006). The soils, heavy textured, alkaline-calcareous and contain high amounts of soluble salts; with low organic matter, N, P and adequate in K (Qureshi, 1996). The crop like rice, sugarcane, oil crops, wheat and vegetables extensively growing in the area.

Rainfall periods remains increasing or decreasing and becoming more erratic in recent years, suggest the evidence of climate change. Climatic conditions are semi-arid and sub-tropical continental with average minimum and maximum temperature in ranges of 10.41-39.00ºC. However, humidity and wind velocity are in ranges of 41.04-76.13 % and 13.57-30.23 kmh^{-1} with a mean of 59.06% and 21.63 km h^{-1}, respectively. The rainfall has an erratic nature and monsoon starts in the July and ends in October with in ranges of 152.0 to 383 mm.

Soil sampling and analysis methods: Before flood, soil samples collected in just before flood at 0-15 and 15-30 cm depth for analysis of soil during August 2010. It was also expectations that flood water could breach the dykes near Thatta city. It was decided that flooded soil should be sampled. After flood the soil sampling carried out at same 13 sorted spots where the sampling had been done before in pre flood conditions shown in figure 1. Samples were air dried under shadow, ground, passed through 2 mm sieve and stored in the plastic bags. Physico-chemical properties like particle size distribution (soil texture) were carried out according to Bouyoucos Hydrometer method (Bouyoucos, 1936), EC and pH in 1:2 (soil water extract) as suggested by McLean (1982). Organic matter and $CaCO_3$ (lime content) were determined by Walkley-Black method (Jackson, 1969) and acid neutralization method (Soltanpour and Workman, 1981). The analysis for fertility status comprised of total Nitrogen (%) by Kjeldahl's apparatus (Jackson 1969) and available Phosphorus (mgkg^{-1}) by Olsen method (Olsen *et al*., 1954). Potassium and Sodium extracted with AB-DTPA and determined by the method of Soltanpour and Schawab (1977). Exchangeable bases calcium and magnesium determined by EDTA titration method (Mclean, 1965). Sodium adsorption ratio (SAR) was determined by the formula SAR = $\frac{Na^+}{\sqrt{Ca+Mg)/2}}$ of (USSL 1954).

Statistical analysis: The categorization of soil for pH, EC, OM and lime content carried out according to NMSU (2000) and soil textural classes identified as suggested by Foth (1982). The soil data so collected was subjected to descriptive mean minimum, maximum, standard deviation, and coefficient of correlation (r), by using Microsoft statistix 8.1 program.

Results and Discussion:

Soil texture: The individual soil sand and clay particles showed significantly wide range of variability at (p>0.05). The individual soil particle values presented in Table1 indicated that in pre-flood sand silt and clay were with mean ± standard deviation values 36.22±1.83, 11.17±3.12 and 49.15±2.75 % respectively at 0-15 cm depth. However, in post flooded condition, the values of sand, silt and clay were 45.31±5.21, 14.29±6.73% and 42.52±5.75% respectively. Similarly at 15-30 cm depth Table 2 the sand, silt and clay were 40.15±0.68, 14.64±3.69 and 48.52±3.31% in pre flood soils, whereas, the values 43.89±5.01, 14.29±6.73 and 41.67±5.13 were found in post flood soils. The soil texture class wise results presented in figure 2 stated that clay soil texture was observed to be dominant in pre-flood conditions with 69.24% followed by sandy clay 15.38 % and clay loam 15.38 %. In post-flood conditions, soil texture sandy clay was observed to be higher with 53.84 % as compared to clay (38.45 %) and clay loam (7.71 %). The soil clay particle was found predominant in pre flood conditions as compared to sand and silt. In the post flood conditions the clay was decreased significantly (p>0.05) and sand was increased indicated the deposition of sand during the flood water. Flood conditions comparatively changed texture from clay to sandy clay and developed soil became coarser that may improve infiltration rate of soils. The improvement of texture in post-flood soil was reported previously by Zolfahgeri *et al.,* (2013) and Lida *et al*., (2012).

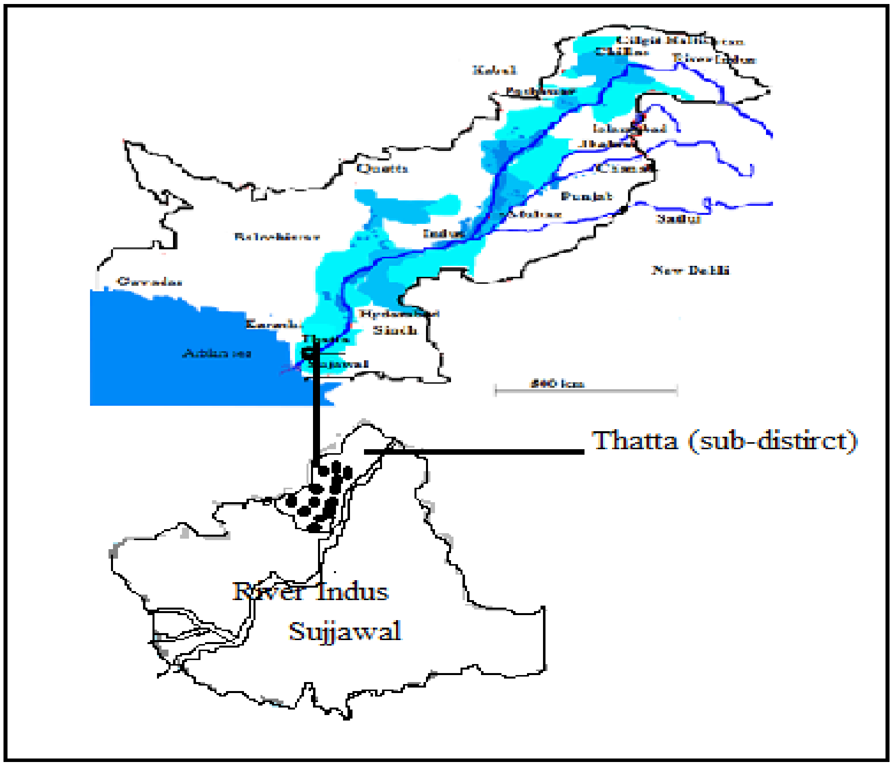

Figure 1. Map showing the study sampling area of sub-district Thatta Pakistan

Soil Chemical Properties: The soil chemical parameters like pH, EC, SAR, organic matter and lime ($CaCO_3$) are most important properties that have direct or indirect effect on soil fertility and productivity. The values presented in Table 1 indicated that pH and SAR showed significant, wide range of variability at ($p>0.05$). The mean±standard deviation values of pH, EC, SAR, organic matter and lime were 8.35±0.13, 6.68±3.34 dSm^{-1}, 11.15±4.01, 0.68±0.44 % and 12.74±2.65% respectively at 0-15 cm soil depth in pre-flood conditions. However, in post-flood conditions the pH, EC, SAR, organic matter and lime were with mean values 8.78±0.17, 9.68±7.15 dSm^{-1}, 17.09±4.68, 0.66±0.30 % and 11.62±3.27% at 0-15 cm soil depth. Similarly at 15-30 cm soil depth (Table 2) the pH, EC, SAR, organic matter and lime were with mean± standard values 8.33±0.18, 6.75±3.84 dSm^{-1}, 8.64±2.32, 0.69±0.46 % and 12.18±3.18% respectively in pre-flood conditions. Whereas, in post-flood conditions the pH, EC, SAR, organic matter and lime content were 8.70±0.20, 5.51±5.64 dSm^{-1}, 16.70±5.70, 0.54.66±5.70 and 13.42±2.27% respectively.

Soil pH results indicated that majority of soil samples remained moderately alkaline in pre-flood conditions and strongly alkaline (pH >8.5-9.0) in post-flood conditions. The soil EC and SAR generally indicated for the salt concentration in soils and found that most soils were low to moderately saline (2-8.00 dSm^{-1}) in pre-flood conditions and in post-flood conditions EC was found to be highly to severe saline (>8.00-16.00 dSm^{-1}) categories. Similarly SAR hazard was increased from 11.15 in non-flood to 17.09 in post-flood conditions. Organic matter was fall in poor (<0.5 %) and lime was found in the moderate category (10-15%) category in post flood.

The values of soil pH, and SAR were increased 5 and 53 % in post-flood as compared to pre-flood at surface 0-15 cm depth and 4 and 57% in sub-surface 15-30 cm depth indicated increasing soil alkalinity with high deposition of sodium. It might be due to evaporation of water leaving behind salts and Na^+. The results were with the conformity of Papadopoulos (1986) who revealed that when irrigation water containing SO_4, Na and Cl applied to soil, it increased the soil EC levels. It may later on increase SAR of soil solution. Whereas, increased trend of SAR was also observed by Naderi *et al*. (2000), stated that SAR was increased by 73% under flooded conditions.

Soil nutrients status: Fertility status of study area in Table1 indicated that significant differences were observed for N, P, K, status at ($p>0.05$) in pre and post flood conditions. The macronutrients N, P, K, mean±standard deviation values were 0.05±0.02 %, 10.73±8.80 and 162.±26.97 mg kg^{-1} respectively at 0-15 cm depth in pre-flood. Whereas, in post flood conditions the mean values were 0.04±0.02 %, 4.65±2.34 and 201±69.65 mg kg^{-1}. Similarly at sub-surface depth 15-30 cm the NPK values were 0.03

±0.02%, 7.21±6.61 and 211 ±59.40 mg kg^{-1} in pre flood and in post flood th values were 0.03±0.01, 6.37 ±4.82 and 228±74.70 mg kg^{-1}. Secondary macro nutrients i.e. Ca and Mg mean±standard values were 7.62± 2.58 and 7.08±2.55 mg kg^{-1} at 0-15 cm depth and in post flood the values were 6.12 ±1.86 and 5.41±2.83 mg kg^{-1}. At depth 15-30 cm Ca and Mg mean values were significantly increased and found to be 7.44± 1.48 and 7.98±1.75 mg kg^{-1} in pre flood and in post flood the values were 4.44 ±1.68 and 4.88±1.57 mg kg^{-1}. It was estimated that N, P Ca and Mg, showed decreased trend of 20, 42, 19 and 23% respectively in post flood conditions, whereas K was increased by 19 % at surface soil. Whereas at sub-surface soil there were no significant difference were observed for mean values of NP and K. The results also indicated a positive increase in K while N, P, Ca and Mg were declined in post-flood conditions. It can be assumed that the depletion of N, P Ca and Mg might be due to leaching or run off of nutrients by the heavy load of water. The nitrogen lower values in post flood conditions could be as a result of losses of N through different sources. N is very mobile element is prone to be loose easily through percolation and leaching and volatilization once when the flood water recede. The increase in K content might be possible due to saturation of soil may have effect on smectitic minerals thus release of previously fixed K or deposition of K occurred from river flood water contained considerable amount of K. The results were also in conformity with (Ahmad *et al*., 2012, Naderi *et al*., 2000 and Eulenstien *et al*., 1998).

Relationship of physico-chemical Properties: The relationship in soil properties between pre and post-flood indicated that sand, silt, clay, OM and N showed a slight negative correlation with each other in both conditions (Table1). The pH and SAR were negatively correlated (-0.4). EC, lime and Ca had slight positive correlation, P highly significantly positive (0.45) and Mg least significantly negative relationship (-0.30) in both conditions.

In post-flood conditions, OM was least negatively correlated with EC, pH, SAR, and soil nutrients (Table 3). The EC was highly positive correlated with clay (0.40) indicated that flood left salts therefore salt deposited and removed ratio (1:0.84) by flood was found high in flooded soil. SAR was highly positive with pH (r=0.53) and indicated that deposition of Na^+ aggravated the pH by 28% (Table 3). On the same time, pH was negatively correlated with EC indicating neutrality of salts. The negative effect of pH on N, P and Ca suggested removal or leaching of nutrients under flooded conditions. The soil properties like clay, pH and lime were negatively correlated with mineral nutrients (Ali *et al.*,2000) and may decrease the availability of plant nutrients by fixing or formation of insoluble compounds (Chaudhry *et al.,* 2012)

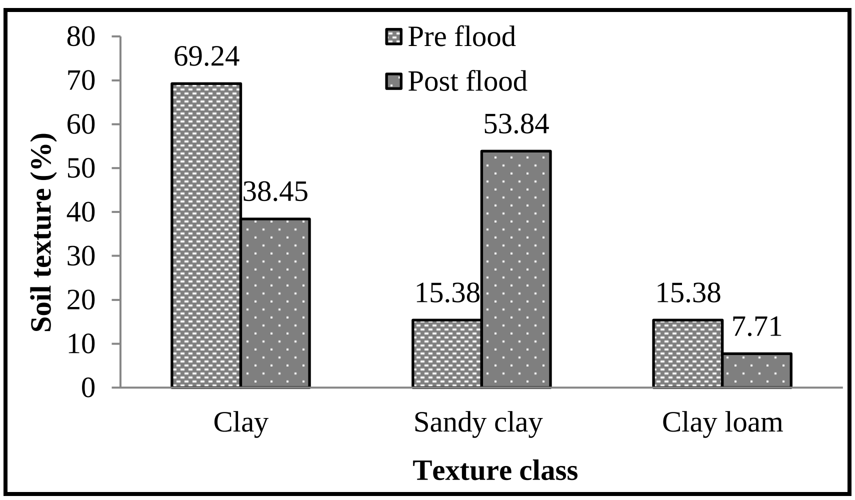

Figure 2. Soil textural classes in pre and post flood conditions

Table- 1 Statistically determined parameters for different soil properties in pre and post flood conditions at surface 0-15 cm soil

Source	**Sand**	**Silt**	**Clay**	**pH**	**EC**	**SAR**	**OM**	**Lime**	**N**	**P**	**K**	**Ca**	**Mg**
	----------(%)--------				**(dSm^{-1})**		**---------(%)--------**			**---------($mg\ kg^{-1}$)-----------**			
	-----Mean (n=13)-----												
Pre-flood	36.22b	11.17	49.15a	8.35b	6.68	11.15b	0.68	12.74	0.05a	10.73a	162b	7.62a	7.08a
Post Flood	45.31a	14.29	42.52b	8.78a	9.68	17.09a	0.66	11.62	0.04b	4.65b	201a	6.12b	5.41b
	-----Minimum-----												
Pre-flood	33.10	6.25	44.85	8.16	3.93	6.50	0.20	9.90	0.02	3.00	120	4.20	3.20
Post Flood	36.10	7.85	34.90	8.40	2.40	9.60	0.27	7.00	0.01	1.62	120	3.20	1.80
	-----Maximum-----												
Pre-flood	38.65	17.05	55.10	8.56	13.80	22.30	1.38	17.60	0.09	27.00	204	12.30	12.00
Post Flood	53.55	25.58	54.55	8.95	18.20	25.75	1.24	15.60	0.08	8.75	300	9.00	9.80
	-----Standard deviation-----												
Pre-flood	1.83	3.12	2.75	0.13	3.34	4.01	0.44	2.65	0.02	8.80	26.97	2.58	2.55
Post Flood	5.21	6.73	5.75	0.17	7.15	4.68	0.30	3.27	0.02	2.34	69.65	1.86	2.83
SE	1.53	2.05	1.76	0.055	2.43	1.71	0.14	1.16	0.006	2.71	6.80	1.16	1.19
Correlation (R)	-0.04	-0.1	-0.12	-0.4*	0.14	-0.4*	-0.14	0.06	-0.12	0.45*	-0.04	0.01	0.30*

Means within same columns followed by different letters are significantly different at ($p> 0.05$), SE = Standard Error , *=significant

Table- 2 Statistically determined parameters for different soil properties in pre and post flood conditions at sub-surface 15-30 cm soil.

Source	**Sand**	**Silt**	**Clay**	**pH**	**EC**	**SAR**	**OM**	**Lime**	**N**	**P**	**K**	**Ca**	**Mg**
	----------(%)---------				**(dSm^{-1})**		**--------- (%)--------**			**-------($mg\ kg^{-1}$)---------**			
	-----Mean (n=13)-----												
Pre-flood	40.15b	14.64	48.52a	8.33b	6.75	8.64b	0.69	12.18	0.03	7.21	211	7.44a	7.98a
Post Flood	43.89a	14.29	41.67b	8.70a	5.51	13.60a	0.54	13.42	0.03	6.37	228	4.44b	4.88b
	-----Minimum-----												
Pre-flood	39.20	10.00	42.35	8.10	1.14	5.60	0.13	4.80	0.01	1.50	126a	4.20	4.20
Post Flood	35.90	7.85	32.57	8.34	2.10	2.40	0.13	8.00	0.01	1.50	102b	2.50	2.40
	-----Maximum-----												
Pre-flood	41.15	22.05	53.85	8.56	13.50	13.50	1.79	16.00	0.07	23.00	318	10.0	11.0
Post Flood	53.25	28.58	49.00	9.00	18.40	17.20	0.76	16.50	0.04	16.75	324	8.20	9.10
	-----Standard deviation-----												
Pre-flood	0.68	3.69	3.31	0.18	3.84	2.32	0.46	3.18	0.02	6.61	59.4	1.48	1.75
Post Flood	5.01	6.73	5.13	0.20	5.64	3.64	0.18	2.27	0.01	4.82	74.7	1.68	1.57
SE	1.40	2.12	1.69	0.074	1.89	1.86	0.16	1.08	0.02	2.37	8.75	0.70	0.71

Means within same columns followed by different letters are significantly different at ($p> 0.05$), SE = Standard Error

Table-3: Correlation matrix of soil physico-chemical properties post flood conditions

Soil properties	Silt	Clay	pH	EC	SAR	OM	Lime	N	P	K	Ca	Mg
Sand (%)	-0.5*	-0.1	0.25	-0.21	-0.10	0.2	0.2	-0.36*	0.21	0.17	-0.14	0.01
Silt (%)		-0.57*	-0.38*	-0.31*	-0.00	0.1	-0.01	0.59*	-0.23	-0.43*	0.1	-0.32
Clay (%)			0.25	0.40*	0.02	-0.27	0.12	-0.24	0.2	0.18	0.01	-0.03
pH (1:2)				-0.38	0.53*	-0.1	-0.38*	-0.36*	0.15	0.1	-0.36*	0.03
EC (dSm^{-1})					-0.12	-0.42*	-0.21	-0.24	-0.34*	0.07	-0.21	0.30*
SAR						-0.12	-0.21	0.26	0.38*	0.17	0.04	0.01
OM (%)							-0.07	-0.15	-0.12	-0.22	0.1	-0.37*
Lime (%)								0.29	0.17	0.18	-0.1	0.39*
N (%)									-0.08	-0.14	0.08	0.05
P ($mgkg^{-1}$)										0.35*	0.12	-0.15
K ($mgkg^{-1}$)											0.25	0.37*
Ca ($mgkg^{-1}$)												0.39*

*= Significant < 0.05 probability levels

Conclusion:

It is concluded that flood had negative effects on soil physico-chemical properties. In the post flood conditions the clay was decreased significantly and sand was increased indicated the deposition of more sand. Flood conditions comparatively changed texture from clay to sandy clay and developed soil became coarser that may improve infiltration rate of soils. The PH and SAR of post flood soils were increased and showed significant positive relationship with each other indicated the disbursement of soil. The high pH affects the nutrients availability to plant. The nutrients i.e. N, P, Ca and Mg values of post flood soils showed decreased trend. Over all it can be implicit that flood conditions increase the soil pH and SAR and depleted the essential nutrients considerably, making soil unproductive for cultivation. To improve crop production on crop term basis the mineral green manuring practices, application of organic matter and fertilizers, are may be recommended

References

Abubakar, G. A., Dikko, A. U., Audu, M., & Chinyere, O. (2012). Physico-chemical properties of the Sokoto Rima River flood-plain soils after 2010 flooding. Advances in Agriculture, Sciences and Engineering Research, **2**(12), 550-554.

Ahmad, S., M.A. Farooq, M. Zubair and A. Rasool. 2012. Water quality of tube wells located in sugarcane cultivated areas of Sargodha and Jhang districts. Pak Sugar Jour. **117**(1): 2-8.

Ali, M., Sarir, M. S., Shirazi, M. U., Alam, S. M., & Ansari, R. (2000). Phosphorus mineralization in some soil series of Peshawar valley. Journal of Soil Science, **18**(14) 13-18.

Ashraf M., G. Sarwar. 2002. Salt tolerance in some members of rossiaceae, physiological study on water relation and mineral content. In prospect for saline agriculture (edition) Kluwar academic Netherland. pp 237-245.

Baker, V.R., 2006. Paleo flood hydrology in a global context. Catena **66**, 161-168.

Bhatti, A.J., Sario, P., N.Z. Bhatti and Z. Abbasi. 2010. Flood Assessment of district Thatta. Flood Thatta Web Relief Report.pdf Accessed on 01 March, 2018.

Bouyoucos, G.J. 1936. Directions for making Mechanical Analysis of Soils by the Hydrometer Method Soil Sci. **4**:225-228.

Chaudhary, P.R., D.V. Ahire and V.D. Ahire. 2012. Correlation between physico-chemical properties and available nutrients in sandy loam soils of Haridwar. Jour Chem Bio Physio Sci.**2**(3):1493-1500.

Dist. Govt. Thatta. 2006. District Government Tando Mohammad Khan. @ www. Thatagos. Pk. Accessed on **11**-12-2015.

Eulenstein, F. L. Muller, and K. Helming. 1998. Odra 1997 flood effects on sol properties of cultivated areas in Germany. Agrophysics. 12. 241-247.

Foth, H.D., 1982. Fundamentals of Soil Science,6th edition John Wiley & Sons, Inc. USA *pp*: 287–315.

Jackson, M.L. 1969, Soil Chemical Analysis. Advanced course. (2nd ed.) Published by author, Madison, WI.

Kalshetty B.M., T.P. Girradi, R. C. Seth, M.B. Kalashetti. 2012. River Kirshna flood effects on soil properties of cultivated areas in Bagalkot district Karnataka State. Glo Jour Sci. Fron. Res. Chem. **12**(6): 23-28.

Kowsar A., 1992. Desertification control floodwater spreading in Iran. Unasylva, An Int. Jou. Fore Forest Indus. 43:27-30.

Lida E. R. Sakouti, E. Pazira. 2012. Impact of flood water spreading in some chemical soil properties. Int Jour Agro Plant Prod. **3**(S): 771-774.

Mclean, E.C. (1965). Alluvium. In the Method of Soil Analysis (ed.) C.A Black. *Agronomy* Am. Soc. Agro. - Madison Wisconsin.pp.**9**: 978-998.

McLean, E.C. (1982). Soil pH and lime requirement. Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties. (2^{nd}ed.) Number 9(Part 2) In series, American Society of Agronomy. Medison WI. 199-224.

Naderi, A. A., S. A. Kowsar, A. A. Sarafarz. 2000. Reclamation of sandy desert through flood water spreading: L sediment-Induced changes in selected soil chemical and physical properties. Jou. Agri. Sci Tech. **2**:9-20.

Nancy, M.W., A.M. Njue, S.G. Abaya, A.H. Vuai Said and J.D. Ibmebe.2011. Periodic flooding and land use effects on soil properties in Lake Victoria basin. African Jou. of Agri. Res. **6**(9): 4613-4623.

Papadopolous I. 1986. Effect of high sulphate irrigation waters on salinity and crop yields. Jour. Agro.**78**:429-432.

Qureshi S.A. 1996. Status of available phosphorus, potassium and sulphur in soils of district Thatta, Sindh. MSc. (Agri) Hons. Thesis Department of Soil Science, Sindh Agriculture University, Tandojam.

Rehman A., L. Jingduan , Y. Du. Y. R. Khatoon. S.A. Wagan, S.K. Nisar. 2015. Flood disaster in Pakistan and its impact on agriculture growth (A Review). J. of Eco. And Sustain. Devel. **6**(23): 39-42.

NMSU. 2000. NMSU Soil Test Interpretations Guide A-122 Electronic Distribution, New Mexico State University (NMSU) and the U.S. Department of Agriculture cooperating.*aces.nmsu.edu/pubs/_a/a-122.html* (accessed 13-09-2012).

Olsen. S.R., C.V. Cole, F. S. Watnabe and L.A. Dean. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S. Deprt. of Agri. Inc. 939.

Saint-Laurent, D., L. Lavoie, A. Drouin, J. St-Laurent, B. Ghaleb. 2010. Floodplain sedimentation rates, soil properties and recent flood history in Southern Quebec. GloPlana Change. **70:**70-91.

Soltanpour, P.N. and A.P. Schawab.1977. A new soil test for the simultaneous extraction of macro and micro nutrients in alkaline soil. Communication in soil Science and Plant analysis **8**:195-207.

Soltanpour, P.N., and S. Workman. 1981. Modification of the NH_4HCO_3- DTPA soil test to omit carbon black. Communication Soil Science Plant Analysis, **10**:1411-1420.

Tavasoli, A.M., A. H. Mahdian, B Yaghoobi, G.H. Asadian. 2001. The investigation of flood water spreading on infiltration rate in Kaboodarahang flood water spreading of Tehran. 2^{nd} conference of consequences of flood water spreading pp51-54.

USSL. 1954. Diagnosis and Improvement of Saline and Alkali Soils. USDA Hand book 60, Washington D.C. pp. 69-75.

Visser, E. and L., Voesenek. 2004. Acclimatization to soil flooding. **4**:197-214.

Wahid, A. 2004. Analysis of toxic and osmotic effects of sodium chloride on leaf growth and economic yield of sugarcane. Bot. Bull. Acad. Sin. **45**:133-141.

Xi. W. Liu Z. and Chen H. 2022. Investigating flood impact on crop production under a comprehensive and spatially explicit risk evaluation framework. Agriculture. **12**(484) 10.3390/agriculture12040484.

ZolfagheriF., V. Abdollahi, M. Jabbary, M.R. Deghan. 2013. Crescent pond's effect on some chemical properties of soil. Intl. J. Agri. Crop Sci. **5**(10):1120-1124.