INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 9, No. 4, p. 87-101, 2016
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Spatial and temporal variability of soil organic matter and its association with the availability of nutrients in ten different agricultural fields

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Article published on October 30, 2016

Key words: Soil, Organic matter, Seasons, Locations, Soil depth, Nutrient availability

Abstract

The agriculture production in soil system of Pakistan is low due to calcareous and alkaline nature of soil with low organic matter status. The availability of nutrients to crops in this type of soil is a problem. For this purpose, a field study was conducted aiming to monitor fluctuation in soil organic matter for its association with nutrient availability during two years. Soil sampling was performed across four seasons viz February 2009+2010 and August 2009+2010 at two soil depths (0-06 and 06-12 inches) in ten different agricultural fields of district Quetta. The study was based on two factorial arrangements (season and soil depth) with 4 replications. The results showed that soil OM varied significantly ($P \leq 0.05$) across season, soil depth and their interaction. Among the locations, higher OM (1.70%) was found in location 9 in first season (Feb.2009) which were decreased linearly upto 4th season (August 2010). In case of soil depth, the upper soil depth revealed higher OM in in all location except in location 5. Location 3 manifested maximum OM (1.37%) followed by 1.35% OM in location 9 but minimum (0.49%) was recorded in location 8 at upper depth. Linear regression analysis indicated that the soil N, P, Fe and Zn concentration were positively and significantly correlated with O.M in each location. From this study, it is concluded that OM is quickly lost from our soil system within short period of two years and positive correlation confirm the link between nutrients availability and soil OM.

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Introduction

Soil is an inert material without organic matter and driving force behind ecosystem services including soil fertility and productivity is the soil organic matter. The fluctuation in SOM will influence soil fertility because it works as soil conditioner as well soil nutrient pool. One of the major roles of SOM is soil pH stabilization and regulation of nutrients availability to crops (Campbell *et al.,* 1996). The intensification of agriculture the world over including Pakistan has resulted in low soil organic matter contents leading to poor soil structure with low level of iron and zinc concentration (Nizami and Khan, 1989). In soil of Pakistan, the availability of overall plant essential nutrients is poor and cannot upkeep crop productivity to optimum levels (Rafiq, 1996; Ahmed and Rashid, 2003). According to Zia *et al.* (1994) that in the existence of low SOM, the applied nutrients did not revealed greater availability and now most of them are becoming deficient gradually. In addition, anthropogenic activities like tillage practices and crops residue management have affected the buildup of soil organic matter in soil (Kong *et al.,* 2009). It is evidenced that the continuous cultivation trends triggered loss of SOM leading to decline in yield (Juo *et al.* 1995). There are number of factors affecting the level and throughput of SOM including the soil parent material, topography, climate, vegetation and soil management practices (Spain, 1990; Burke, 1999; Ganuza & Almendros, 2003; Finzi *et al.*, 1998; Yang & Wander, 1999). Among them, the climate is considered as one of utmost significant factor controlling the status of SOM particularly temperature and moisture (Sims and Nielsen, 1986; Homann *et al.,* 1995; Alvarez and Lavado, 1998). Furthermore, the temporal variation regulates the magnitude and level of vegetation cover, status of SOM and its mineralization rate (Quideau *et al.,* 2001; Heviaa *et al.,* 2003).

Researchers the world over have been expressed concern about changes in SOM storage (Wang *et al.,* 2002; Zhang *et al.,* 2007; Yang *et al.*, 2008; Baumann *et al.*, 2009; Tan *et al.,* 2010; Wu *et al.*, 2012; Dörfer *et al.,* 2013).

Although the spatial and temporal variability of SOM status across large scale have been investigated in some studies (Zhang *et al.*, 2007; Tan *et al.,* 2010), but such studies have not been well documented on small scale. Seasonal variation of soil organic carbon is affected by both external factors (temperature, precipitation, type of vegetation and soil type) and internal factors like microflora and activity (Ravindranath and Ostwald 2008; Kawahigashi *et al.*, 2003). In addition, for better understanding of changes in SOC the differences in plant available nutrients is recognized equally important. According to Xie and Steinberger (2001) that dynamics of SOC and N and its association with plant growth can be perceived properly when the seasonal pattern of SOC and N is well investigated. The seasonal variability of SOC in response of soil moisture revealed that soils under canopy during autumn season revealed greater total organic carbon (TOC) which was decreased in summer season (Xie and Steinberger, 2001). The temporal and spatial variability of soil O.M. was studied by Hossain and Mohammad (2016) and found that soil O.M. of surface sediments of mangrove forest was varied significantly across season at different sampling points. The higher O.M. contents and total N was noted in monsoon season and minimum in winter season. They recorded positive and highly significant correlation between O.M. and total N.

The assessment of available nutrients in soil has pedological and ecological significance (Iwara *et al.,* 2011). Nutrients in soil vary spatially as influenced by natural as well as by anthropogenic activities. Soil parent material, topography, precipitation and vegetation work interactively and control the distribution of nutrients in vertical, horizontal and temporal dimensions in a particular area. Together with that the transformation of nutrients and soil fertility is affected by patterns of land use and type of plant flora. Man-made disturbances brought several fluctuations in overall soil characteristics such physical, chemical and biological properties including soil organic matter (Zeng *et al.,* 2009).

According to Olojugba and Fatubarin (2015) that soil characteristics included pH, SOM, total N and available P varied significantly across seasons.

Presently, the concern is rising regarding the time-based and three-dimensional unevenness of soil organic matter and nutrients in cultivated environments (Goovaerts, 1998; Sun *et al.*, 2003). A lot research work has been conducted to explore the soil changeability of SOM and nutrients particularly N on spatial basis (Stark *et al.*, 2004; Evrendilek *et al.*, 2004; Bai *et al.*, 2005; Liu *et al.*, 2006). The literature indicated that spatial variability of SOM and nutrients have been mostly covered on large scale of a region. (Mapa and Kumaragamage, 1996; McGrath and Zhang, 2003; Liu *et al.*, 2006). However, very limited number of studies of spatial variability of SOM have been found focusing on small scale except with some temporal based studies encompassing the variability with limited time intermissions (Wang and Gong, 1998; Sun *et al.*, 2003).

The study of SOM across spatial and temporal changeability along with other relevant dynamics is imperative for betterment of soil use management on sustainable basis (Mc Grath and Zhang, 2003) which furnishes sound base for evaluation of succeeding and upcoming measurements (Huang *et al.*, 2007). Furthermore, the decrease of SOM in soil to greater extent will cause decline of soil physical properties and affects availability of nutrients to plants that will ultimately reduce soil productivity and lead to overall stagnation of agricultural production system (Loveland & Webb 2003). The objectives of this study were to examine seasonal and spatial changeability of SOM in various agricultural fields at district Quetta, Balochistan, Pakistan during 2009 and 2010. The study involves the affiliation between soil organic matter and nutrient availability across different agriculture fields as a function of soil depth and seasons. The study could offer valued understandings for other similar areas of the province.

Materials and mehtods

This study was conducted during 2009 and 2010 at Quetta district to evaluate the soil physic-chemical and biological properties of ten different agricultural fields as affected by various seasons and soil depths.

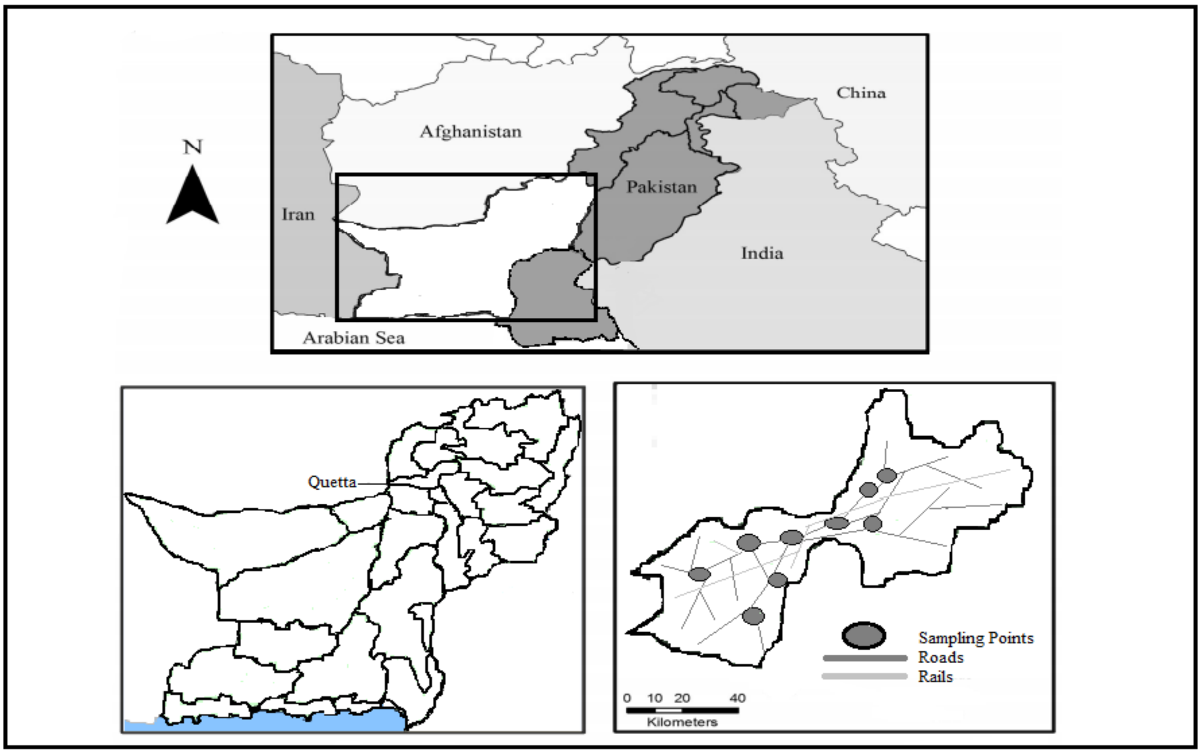

Fig. 1. Site of soil sampling in Quetta district of Balochistan province, Pakistan

The agro-climatic condition of Quetta district is quite conducive for the production of fruits such apple, grapes, peach and plum; vegetables, and cereal crops particularly wheat. In this study, five apple orchards, one grape vine yard and four different field crops, vegetables and floriculture fields were selected. From these various agricultural fields which were referred as locations in this study, soil sampling was conducted across four seasons such as S1 (February, 2009), S2 (August, 2009), S3 (February 2010) and S4 (August 2010) with two depths (0-06 and 06-12 inch) which were analyzed for texture, soil organic matter, EC, pH, total N, P, K, Cu, Fe, Mn and Zn. However, only organic matter data as temporal and spatial variability of each location is provided and the other data is described as an overall mean as well as their correlation with soil organic matter is worked out to assess the role of O.M. in nutrient availability.

Study area

The study area encompassed the district Quetta, the capital of Balochistan province (Pakistan), where 10 different agricultural fields comprising of five apple orchards (location 6-10), one grape vineyard (location 5) and four different crop fields such as wheat crop field (location 3), vegetable field (location 4), floriculture field (location 1) and botanical garden (location 2) were selected. While, the study site is illustrated in Fig. 1 showing map of the country with Balochistan province highlited and district Quetta map isolately demonstrating sampling points.

Soil sampling

Soil sampling was conducted during four seasons such as S1 (February, 2009), S2 (August, 2009), S3 (February 2010), S4 (August 2010) with two depths (0-06 and 06-12 inch) from all locations at three position 20 feet apart as replicates. The composite soil sample was made from each replicate with two depths and put in polythene bag properly labeled and delivered to the Soil and Water Testing Laboratory at Agriculture Research Institute Sariab Quetta for the determination of soil physical and chemical properties.

All the samples were air dried, grind and sieved through 2 mm mesh and analyzed for the target physic-chemical properties by standard methods. The soil physical properties were investigated in the form of three soil separates such as sand, silt and clay, Textural Class and O.M. contents. Chemical properties were analyzed for electrical conductivity (EC), pH, total N (N), available P (P), K (K), copper (Cu), Fe (Fe), manganese (Mn) and Zn (Zn).

Soil analysis for physic-chemical properties

All the samples were air dried, grind and sieved through 2 mm mesh and analyzed for some physic-chemical properties by standard methods. Particle size distribution was determined by Bouyoucos hydrometer method (Bouyoucos, 1962). Soil EC and pH were determined in 1:2 soil water extract using EC meter and pH meter respectively. O.M. was determined by oxidation method (Walkley and Black, 1934) which involved oxidation of organic C by K dichromate ($K_2Cr_2O_7$) and subsequent determination of the unutilized dichromate by oxidation-reduction titration with ferrous ammonium sulfate. Kjeldahl's N as described by Jackson (1962), while P, K, Cu, Fe, Mn and Zn by AB-DTPA extraction method (Soltanpour and Schwab, 1977).

Statistical analysis

The data regarding soil physical (three soil separates i.e. Sand, Silt and Clay as well as O.M. contents) and chemical (EC, pH, total N, P, K, Cu, Fe, Mn and Zn) were subjected to statistical analysis using software SPSS (Sigma Plot, San Rafael, CA). These properties were measured in ten agricultural fields (locations) across four seasons and two soil depths. The data regarding soil organic matter and its association with nutrient availability were independently analyzed for each location in two factorials for seasons and soil depths as well as their interactions. The LSD tests for mean comparison were conducted at 5% probability level to find out the significant differences among seasons and soil depths. For the determination of nutrients status in each location as affected by season and soil depth, each nutrient was compared to its critical value for its low, medium and high level.

Linear regression analysis was conducted on raw data of each location under the influence of seasons and soil depths and worked out into correlation between soil organic matter and nutrients where possible.

Results

This study was conducted during 2009 and 2010 at Quetta district to evaluate the soil organic matter status of ten different agriculture fields as affected by various seasons and soil depths. The availability of nutrients was assessed as a function of organic carbon across temporal and spatial variability. The ten agriculture fields were considered as ten locations comprising of five apple orchards (location 6-10), one grape vineyard (location 5) and four different crop fields such as wheat crop field (location 3), vegetable field (location 4), floriculture field (location 1) and botanical garden (location 2). Soil samplings were carried out during four seasons including February 2009 (S_1), August 2009 (S_2), February 2010 (S_3) and August 2010 (S_4) with soil depths of 0-06 inch and 06-12 inch.

Table 1. Interactive effect of season x depth on soil organic matter contents of ten different agricultural fields at district Quetta

Interaction		Different agricultural fields									
Seasons x	soil depths	1	2	3	4	5	6	7	8	9	10
February 2009	0-06 inch	1.23 a	1.30a	1.75a	1.05a	0.87a	1.22a	1.50a	0.76a	1.81a	1.56a
	06-12 inch	1.04 b	1.22ab	1.44c	0.85b	0.85a	1.20a	1.40a	0.71ab	1.58c	1.47ab
August 2009	0-06 inch	1.07 ab	1.16bc	1.62b	0.93ab	0.70a	1.00b	1.23b	0.62bc	1.67b	1.32bc
	06-12 inch	0.91 bc	1.06c	1.29d	0.65c	0.63ab	0.88b	1.17b	0.56c	1.40d	1.26c
February 2010	0-06 inch	0.74 cd	0.87d	1.29d	0.63c	0.43bc	0.65c	0.92c	0.41d	1.10e	0.95d
	06-12 inch	0.62 d	0.74de	1.11e	0.46d	0.38bc	0.53cd	0.72d	0.32de	0.99f	0.84de
August 2010	0-06 inch	0.64 d	0.67e	0.82f	0.29e	0.25c	0.46de	0.60de	0.19ef	0.80g	0.68ef
	06-12 inch	0.40 e	0.48f	0.72f	0.21e	0.43bc	0.37e	0.49e	0.12f	0.63h	0.51f
S.E.		0.08	0.06	0.05	0.07	0.122	0.065	0.066	0.063	0.040	0.088
LSD at 0.05		0.17	0.14	0.11	0.14	0.261	0.138	0.141	0.134	0.860	0.189

The soil physical properties were investigated in the form of three soil separates such as sand, silt and clay, Textural Class and O.M. contents. Chemical properties were analyzed for electrical conductivity (EC), pH, total N, available P, K, Cu, Fe, Mn and Zn. The data of nutrients are not provided but correlation between soil organic matter and nutrients on raw data of each location were worked out.

The overall mean of EC and pH of ten locations revealed that the electrical conductivity of all soils were less than 4 or slightly higher than 4 and pH was between >7.5 and ≤8.3 which mean that these soils were normal with non-saline characteristics and alkaline in nature. The overall mean of higher non-significant soil total N concentration of 0.071 and 0.073% was exhibited by location 3 and 9 followed by 0.06 and 0.059% in location 10 and 7. While, the minimum total N concentration (0.031%) was recorded in location 8. In case of P concentration, higher P concentration of 2.37 ppm in location 6 followed by 2.00 and 1.92 ppm in location 9 and 10 ppm respectively. Similarly, the overall mean concentration of micronutrients (i.e. Cu, Fe, Mn and Zn) of ten locations exhibited greater Cu and Zn concentration of 0.74 and 1.29 ppm in location 9 followed by 0.60 ppm Cu in location 7 and 1.19 ppm Zn in location 3 while minimum Cu concentration of 0.33 ppm was recorded in location 4 and Zn concentration of 0.72 ppm was shown by location 5. But, in case of Fe and Mn, their higher overall mean concentration of 3.87 and 3.48 ppm was observed in location 3 followed by 3.45 and 3.24 ppm in location 7 while their minimum concentration of 2.67 and 2.58 ppm was noted in location 8 respectively. Statistically, the location 5, 6 and 8 revealed at par Mn concentration as well as location 5 and 8 were found at par in case of Fe concentration.

The soil mechanical analysis as given in Fig.1 revealed that the higher mean sand contents (65.8%) was observed in location 3 followed by 64.7, 64.7 and 65.6% in location 1, 5 and 8 respectively. While, minimum sand contents (36.0%) was recorded in location 9. In case of clay and silt contents, location 9 exhibited greater clay (33.2%) and silt contents (30.8%) followed by location 6 with clay contents of 31.0% and silt contents of 29.4%. While, minimum clay contents (12.8%) were found in location 2 and silt contents (15.6%) in location 10. Statistically, location 1, 3 and 4 were at par in clay contents. Likewise, silt contents in location 1 and 3 were also at par.

Table 2. Correlations between soil organic matter and total N, P, Fe and Zn concentration in ten different agricultural fields under the influence of seasons and soil depths.

Location	Coefficient of variance (r)				T-test value			
	OM vs N	OM vs P	OM vs Fe	OM vs Zn	OM vs N	OM vs P	OM vs Fe	OM vs Zn
1	0.87**	0.37NS	0.67**	0.79**	8.43	1.86	4.28	6.24
2	0.92**	0.57*	0.74**	0.80**	16.18	5.40	7.86	9.32
3	0.93**	0.59*	0.71**	0.75**	11.61	3.42	4.69	5.29
4	0.95**	0.67*	0.20NS	0.86**	13.55	4.36	0.95	7.81
5	0.91**	0.61*	0.26NS	0.63*	14.42	5.87	1.29	3.84
6	0.93**	0.75**	0.58*	0.77**	11.51	5.30	3.35	5.58
7	0.96**	0.72**	0.79**	0.90**	16.27	4.86	6.02	9.50
8	0.93**	0.62*	0.75**	0.91**	11.79	3.67	5.31	10.40
9	0.96**	0.75**	0.70**	0.76**	15.48	5.36	4.65	5.43
10	0.96**	0.70**	0.81**	0.88**	17.06	4.67	6.56	8.70

The soil of ten locations was classified into textural class using International texture triangle which showed that out of 10 locations, 6 were found sandy loam (i.e. location 1-5 and 8), 2 were clay loam (location 6 and 9) and the other two were sandy clay loam (location 7 and 10) respectively.

Analysis of variance regarding soil organic matter contents in ten agriculture fields revealed significant differences across seasons and soil depths. The overall O.M. contents were ranged from 0.36 to 1.36% with mean value of 0.83% in location 1, 0.36 to 1.44% with mean value of 0.94% in location 2, 0.53 to 1.88% with mean value of 1.26% in location 3, 0.12 to 1.18% with mean value of 0.63% in location 4, 0.14 to 1.00% with mean value of 0.57% in location 5, 0.30 to 1.35% with mean value of 0.79% in location 6, 0.41 to 1.66% with mean value of 1.01% in location 7, 0.08 to 0.89% with mean value of 0.46%, 0.35 to 2.01% with mean value of 1.25% in location 9 and 0.34 to 1.80% with mean value of 1.08% respectively.

The LSD test for mean comparison ($P \leq 0.05$) of soil organic matter as affected by temporal and spatial variability showed significant differences which were linearly decreased from season 1st to 4th in all locations (Fig.1). Among them, location 9 revealed higher O.M. status comparatively over all seasons followed by location 3 and 10 but location 8 expressed lower O.M. status across all four seasons. In case of season 1st (i.e. February 2009), the maximum O.M. contents (1.70%) were recorded in location 9 followed by 1.59 and 1.52% in location 3 and 10 while minimum (0.78%) was noted in location 8 immediately followed by season 2nd (i.e. August 2009) with similar pattern of O.M. status. However, in season 3rd and 4th, abrupt decrease in O.M. status in all locations were occurred with lowest in season 4th (August 2010) respectively (Fig.1). When compared to critical ranges it was found that out of ten locations, three location (3, 9 and 10) expressed O.M. in medium range in season 1st to 3rd and low in 4th season, four locations (1,2, 6 and 7) exhibited O.M. status in medium range in season 1st and 2nd and low in 3rd and 4th while two locations (4 and 5) manifested O.M. in medium range in 1st season only and low in all three seasons with declining trend but location (8) showed soil O.M. in low range across all season in gradual declining pattern.

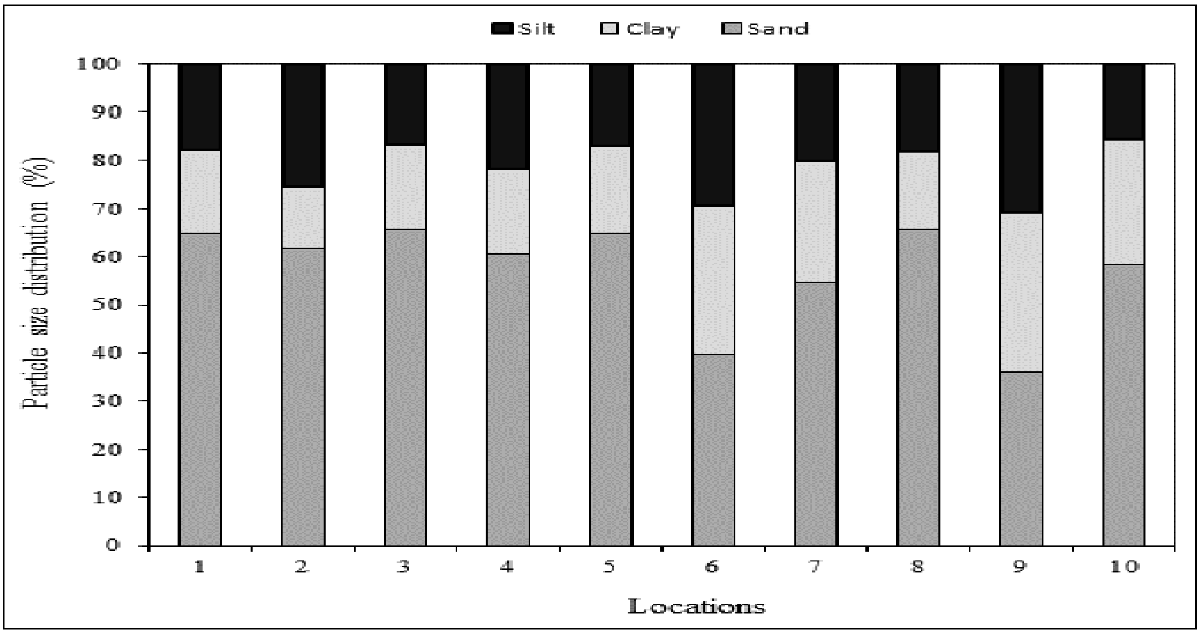

Fig. 2. The influence of seasons and soil depths on the overall mean of particle size distribution of different 10 locations (agriculture fields)

Note: (soil textural class of ten locations)

Location (1-5, and 8)	= Sandy loam
Location (6 and 9)	= Clay loam
Location (7 and 10)	= Sandy clay loam

The statistical analysis showed significant differences in soil O.M status of ten agricultural fields across two soil depths (Fig.2). All the locations showed higher O.M. in upper soil depth of 06-12 inch except in location 5 which revealed non-significantly similar level of O.M. at both depths. In case of O.M. status in upper soil depth, the maximum O.M. (1.37%) was noted in location 3 followed by 1.35% O.M. in location 9 while minimum (0.49%) was recorded in location 8 at upper depth. Among the locations, lower O.M. status at both soil depths was found in location 8 (Fig.2). In comparison to critical ranges it was observed that out of ten locations, five locations (2, 3, 7, 9 and 10) manifested O.M. status in medium range over both soil depths while location 1 showed medium O.M. in upper soil depth and low O.M. in lower soil depth but four locations (4, 5, 6 and 8) exhibited O.M. in lower range in both depths.

The interactive effect of seasons x depths showed significant differences for soil organic matter status across ten different agricultural fields (Table 2). All the locations expressed maximum O.M. contents in upper soil depth during first season (February, 2009) followed by second season (August, 2009). While, the interactive effect of August 2010 x 06-12 inch soil depth manifested lower O.M. contents. Among the ten locations, the higher O.M. (1.81%) was recorded in location 9 followed by location 3 (1.75%) and 10 (1.56%) at the interaction of February 2009 x 0-06 inch soil depth.

The availability of nutrients in ten different agricultural fields were assessed in term of linear regression analysis which were performed between soil organic matter contents and macro and micro nutrients on raw data under the influence of temporal and spatial variations. The correlations results revealed that in all locations O.M. was positively and highly significantly correlated with N and manifested r value >0.9 except in location 1 which exhibited r value of 0.87. Similarly, the correlation between O.M. and AB-DTPA extractable P was also positive and highly significant in location 5, 6, 7, 9 and 10 while positive and significant in location 2, 3, 4, 5 and 8 but positive and non-significant in location 1 respectively.

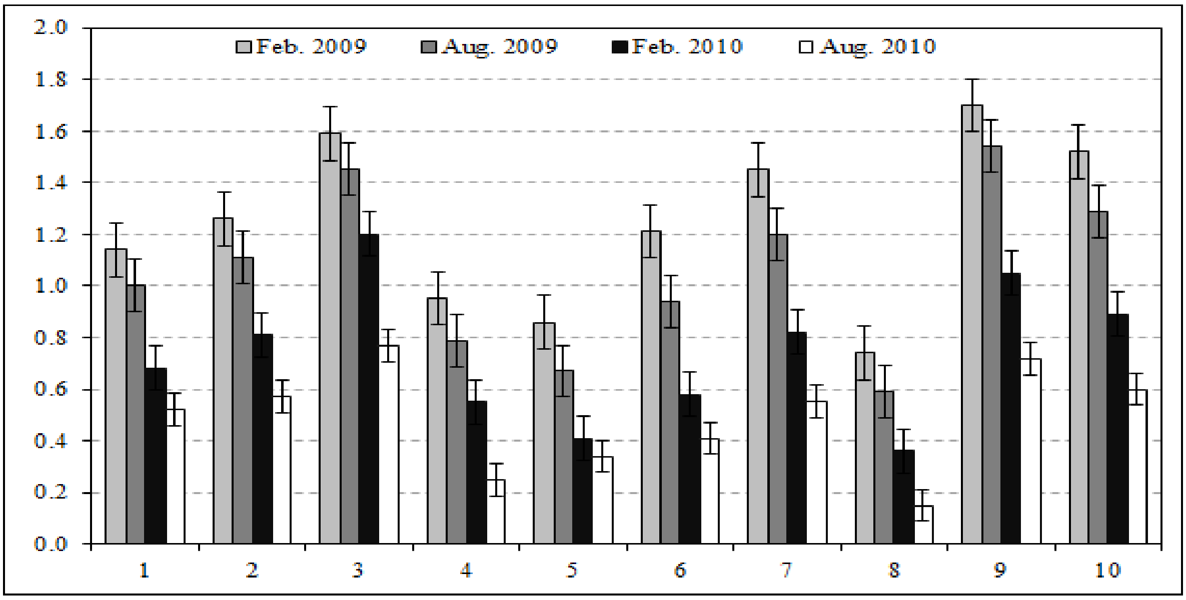

Fig. 3. Temporal variation in soil organic matter contents of ten different agricultural field district Quetta.

In case of micronutrients, only Fe and Zn expressed positive correlations with soil O.M. Out of ten locations, two locations (4 and 5) showed positive but non-significant correlation between soil O.M. and Fe contents.

Furthermore, organic matter was positively and high significantly correlated with AB-DTPA extractable Zn and higher extent of relation (r = 0.90 and 0.91) between O.M. and Zn was observed in location 7 and 8 while in case of Fe, the greater extent of relationship (r = 0.81) was noted in location 10.

The student t-test was conducted on those soil properties which had exhibited correlations and the calculated T value as given in Table 3 revealed that these T values were greater than book value as calculated at 5% probability level which indicate that the correlations are highly significant.

Discussion

This study was aimed to monitor changes in soil organic matter contents as soil quality indicators in soil of ten different agriculture fields and orchards (locations) under the influence of seasons and soil depths at Quetta district during two year span that was stretched from February 2009 to August 2010. The various components of soil system responsible for controlling soil quality are the entire soil physical, chemical and biological properties and their interactions (Papendick and Parr, 1992). These properties directly or indirectly encompass the soil fertility and productivity that resulting in improving or deteriorating the sustainable crop production (Chaudhari *et al.,* 2012). Among the soil physical properties, soil texture play an important role in the growth and development of plant by controlling the nutrient supply, water retention capacity, aeration, water infiltration rate, hydraulic conductivity and accumulation and decomposition of O.M.. The result of this study regarding soil texture showed significant differences in sand, clay and silt separates across different locations. The soil of Quetta valley is developed from the deposition of debris that were transported from the surrounding mountains during raining and flooding and deposited in the bottom of the valley and consequently different patches of textural classes were developed. But in some locations within the valley, there are gravels and premix only.

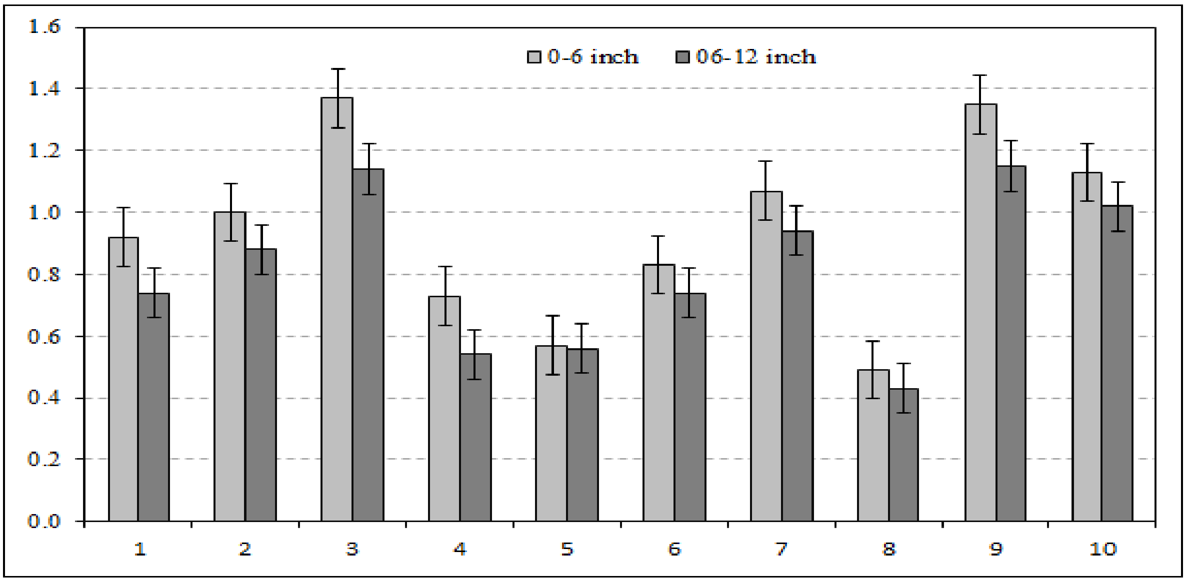

Fig. 4. Spatial variability in soil organic matter contents of ten different agricultural field district Quetta.

As in case of Hanna Urak (location 9), the people have transported the clay loam soil from the nearby minidams and put them on the underlying gravels and premix land where most of the apple orchards are standing now. As the case of location 1, 2 and 8 also show such features of land and soil from the other places have been transported and used for the establishment of floriculture field (Rani bagh-location 1), apple orchard (SAKA-location 2) and botanical garden (University of Balochistan-location 8) as well. So, from this study, three different textural classes such as sandy loam, sandy clay loam and clay loam soil were found with varying degree of sand, clay and silt percent. Similar study was conduct by Sharma *et al.* (2003) who evaluated different site of Nagauar district of Rajasthan for soil properties and reported the clay and silt percent which was in the range of 7.9 to 21.8% with average of 12.9% and Bansal *et al.* (2003) in India also described soil physical property particularly soil texture in Ludiana and Jalandhar districts. They reported that the soil of these districts were loamy sand to sandy lam, and loam in texture. According to schoenholtz *et al.* (2000) that soil texture and its depth is the basic quality parameter required for matching the nature of different soils in a region as it helps to determine the pre and post effect of any management strategies adopted so far. They further explained that soil texture is the dominant property influencing other soil characteristics and processes and would alter slight through time for a particular soil.

Soil O.M. is the driving force of all physical, chemical and biological functions and processes occurring in soil ecosystem which are highly vulnerable to seasonal and space variability. The results of this study regarding O.M. contents of ten locations under the influence of seasons and soil depth exhibited varying levels. Among them, the overall mean soil O.M. status of three locations (3, 9 and 10) were found non-significantly higher in O.M. of 1.26, 1.25 and 1.10% followed by 1.01% in location 7 which were in medium range. But poor O.M. (0.46%) was recorded in location 8.

This high O.M. contents in these soils might be due to their association with medium soil Textural Class as it was clay loam in location 9 and sandy clay loam in location 7 and 10 except in case of location 3 which was sandy loam. The location 3 had received O.M. in the form of farm yard manure one year before this study. Because, the rate of decomposition of O.M. in medium texture soil is slow as compared to light texture soil. As reported by Tisdall and Oades (1982) that the higher soil clay contents in soil save readily decomposable components of O.M. from microbial attack through the process of encrustation and entrapment. Other researchers like Giller *et al.* (1997) described the role of clay contents that provide protection to O.M. against decomposition in the form complexes development between metal ions and O.M. on clay surfaces. Similar explanations were quoted by Mtambanengwe *et al.* (2004) that medium or fine texture soil often holds more O.M. as compared to light texture or sandy soil.

The influence of various seasons and soil depth on the contents and distribution of O.M. contents of ten locations reflected same pattern of degree of declining but decreasing with increment in medium texture soil. The comparison of Ten locations in respect of O.M. contents across four seasons such as S1 (February, 2009), S2 (August, 2009), S3 (February, 2010) and S4 (August, 2010) revealed higher O.M. contents during S1 in all locations as compared to other seasons. During S1, the O.M. contents of location 3, 7, 9 and 10 was found in higher range, location 1, 2, 4, 5, 6 were in medium range and location 8 revealed poor O.M. contents. While, its contents were decreased in S2, S3 and S4 in all locations. It means that location 3, 9 and 10 retain O.M. contents in medium range in S3 but all the other locations in this season exhausted in O.M.. However, its contents were gradually declined upto poor range in S4 irrespective of the location. This scenario of O.M. contents suggests that in the climatic conditions of Quetta valley soil O.M. are not stable which might be due to high temperature during summer. Among these locations, those locations where orchards were standing exhibited comparatively more O.M. contents over open fields like vegetables, field crops and others which are substantially susceptible to O.M. decomposition. Even in S4 where all locations showed O.M. in poor range but the comparatively more O.M. were observed in locations 3, 7, 9 and 10 respectively. Nonetheless, the effect of soil depth (i.e. 0-06 and 06-12 inch) on the patter of O.M. distribution in ten locations were same. O.M. contents at the surface depth of 0-06 inch were higher in all locations except in location 5 which showed similar O.M. contents at both depths. These findings are in line with results of Blume *et al.* (2002) who reported that the soil O.M. were influenced by season and depth with significant interaction between them. Similar status of O.M. contents at two soil depths were also observed by Wei *et al.* (2006) who found that the plow layer showed 61% higher O.M. than plow sole which indicated 33% under the 18 year study of cropping and fertilization's effect on soil properties. The pattern of seasonal influence on O.M. distribution in all locations mirror uniform trend of decline. The findings of Berg *et al.* (1998) also suggested that the variation in soil O.M. of forest ecosystem due to seasons reflected similar trend of pattern.

The association of soil organic matter with nutrient availability is evidenced from linear regression analysis that demonstrated that nitrogen was positively and significantly correlated to soil O.M. contents in all locations (i.e. from location 1 to 10) with r value of 0.87, 0.92, 0.93, 0.95, 0.91, 0.93, 0.96, 0.93, 0.96 and 0.96 respectively. As total N and P revealed correlation with soil O.M. but no correlation was observed between soil K concentration and O.M. which clearly depict the scenario of K bearing mineral which is already found in these soils and its weathering considered responsible for higher K concentration in the studied area. This result is also resemble with finding of Yumnam *et al.* (2013) who found that soil total N and P concentration were positively correlated with soil O.M. (r = 0.520 and 0.162) but K was negatively correlated with soil O.M. contents (r = -0.097).

It is evident from the existing relationship between AB-DTPA extractable soil micronutrients and soil O.M. contents as revealed in the extent of relationship where Fe and Zn were positively and significantly correlated with soil O.M. in location 1 (r = 0.67 and 0.79), location 2 (r = 0.74 and 0.80), location 3 (r = 0.71 and 0.75), location 7 (r = 0.79 and 0.90), location 8 (r = 0.75 and 0.91), location 9 (r = 0.70 and 0.76) and location 10 (r = 0.81 and 0.88) respectively. While location 4 and 6 indicated correlation between soil O.M. and Zn concentration only with r value of 0.86 and 0.77 but location 5 showed no such relationship respectively. This result is in agreement with Wei *et al.* (2006) who observed that the application of O.M. in the form of manure as well P fertilizer resulted in the enhancement of availability of Fe, Mn and Zn but indicated no impact on Cu. Their correlation and path analysis revealed that O.M. has direct influence on the availability of these micronutrients except Cu. Similar correlations were also reported by Yadav (2008) who found that the available micronutrients including Cu, Fe, Mn and Zn were significantly and positively correlated with soil O.M. Yadav and Meena (2009) revealed the extent of relationship between Zn and soil O.M. (r = 0.896) and with clay (r = 0.60). Another researchers like Mathur *et al.* (2006) observed correlation between DTPA extractable Zn and O.M. (r = 0.74). This relationship between soil organic matter and nutrients demonstrates that in our soil system the availability of nutrients is directly linked with degree of organic matter present.

Conclusion

The pooled data suggested that soil O.M. of most soil was poor and its distribution was influenced by season and soil depth that reflected same pattern of declining trend in all locations. As compared to field crops, the orchard soil were less subjected to perturbation and showed more O.M. contents like apple orchard in location 7, 9 and 10 with more available nutrients. From this study, it is concluded that the soil with medium texture retain more O.M. than light texture soils and such soils indirectly depicted more available nutrients as reflected in positive and significant correlations between soil O.M. and nutrients.

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