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Correlation between Soil Organic Matter, Total Organic Matter and Water Content with Climate and Depths of Soil at Different Land use in Kelantan, Malaysia

***1AZLAN, A; 2AWENG, E.R; 3IBRAHIM, C.O; 4NOORHAIDAH, A.**

[1]Department of Environment, Malaysia
[2]Faculty of Earth Science, Universiti Malaysia Kelantan (UMK)
[3]Director of UMK Jeli Campus
[4]Faculty of Science, Universiti Putra Malaysia (UPM)
Corresponding Author: Aweng, E.R., Faculty of Earth Science, Universiti Malaysia Kelantan (UMK)

***KEY WORDS*:** Soil organic matter, total organic carbon, clay, silt, depth, temporal, Kelantan.

ABSTRACT : A total of four sites distributed in different soils of Kelantan State, Malaysia was identified for the study. Soils were collected by depth interval of 0-10cm, 10-20cm and 20-30cm. The correlation of soil organic matter (SOM) content, total organic carbon (TOC) content, water content and soils texture for industrial area at Pengkalan Chepa, township of Kota Bharu district, agricultural area at Banggu and forested area in UMK, Jeli were investigated. These data sets were also correlated to temporal event in Kelantan State. Correlation analysis indicated that,generally, SOM and TOC concentration and soil classes had a positive correlation with temporal patterns and no significance effects with depth of the soils. The relationships between SOM content, TOC content and clay + silt content, were also studied. The results showed that, SOM concentration was lower ($P < 0.05$) at Pengkalan Chepa area (1.96%) compared to Kota Bharu (2.06%), Banggu (2.77%) and Jeli (7.39%). At the same time, the TOC level also showed that Banggu area recorded the lowest concentration (0.42%) followed by Kota Bharu (0.71%), Pengkalan Chepa (0.76%) and Jeli (3.73%). The temporal factor ($p < 0.05$) showed that TOC content higher during dry season (1.76%) and lower during pre monsoon (0.48%) and lowest in monsoon season (0.25%). Similar results were obtained for SOM content, higher during dry season (4.00%) followed by pre monsoon (2.12%) and lowest in monsoon season (1.67%). The lowest TOC and SOM content in soil during monsoon season was believed to be due heavy rain which detaches all the organic matter from soil particles into river. © JASEM

Several studies determined the importance and effect of soil texture on soil organic matter (SOM), total organic matter (TOC) and moisture. Burke *et al.* (1990) found that soil clay content and total soil organic matter was positively correlated across large regions of the Great Plains. Soil texture have significant relation on SOM and TOC in many of decomposition models and organic matter formation (Rastetter *et al.,* 1991; Raich *et al.,* 1991). This study was conducted in Kelantan soil ecosystem of various soil texture in the Kota Bharu, Pengkalan Chepa, Banggu and Jeli area, to evaluate the temporal and depths effect of TOC, SOM and moisture in this soil type

SOM is the soil nutrient pool and the changes will affect the quality and quantity of soil fertility. SOM stabilize soil pH, which plays an important role in controlling the supply of nutrients and their availability for plant intake (Campbell *et al.,* 1996). The level of SOM accumulation depends basically on tillage methods and residue management practices (Kong *et al.,* 2009). Haas *et al.* (1957) reported that, about 42% average decrease in soil organic carbon (SOC) in the surface 15 cm of the soil after 30-40 years of dry land crops across the Great Plain of the United States.

Concentrations and turnover of SOM is affected by the formation of a large number of factors, such as climate (Ganuza and Almendros, 2003), topography (Burke, 1999), vegetation (Finzi *et al.*, 1998), the parent material (Spain, 1990) and management (Yang and Wander, 1999). Most studies recognized that climate, particularly temperature and precipitation, are the most important factor regulating SOM (Sims and Nielsen, 1986; Homann *et al.,* 1995; Alvarez and Lavado, 1998). Seasonal factor determines a great extent of vegetation cover, quantity and quality of organic matters in soil, the rate of SOM mineralization and litter decomposition (Quideau *et al.,* 2001; Heviaa *et al.,* 2003). Jenny *et al.* (1949) showed that decomposition of organic compounds was related to climatic parameters in the America. To date, the quantitative relationship between SOM and temperature and precipitation has been recognized (Callesen *et al.*, 2003). In general, SOM is

**Corresponding Author E-mail: aweng@umk.edu.my*

increases with precipitation and decreases with temperature (Burke *et al.,* 1989; Ganuza and Almendros, 2003). Alvarez and Lavado (1998) also reported that SOM content in the 0-50 cm soil layer significantly related with the precipitation/temperature ratio in the Pampa and Chaco soils in Argentina. However, the relationship between SOM and climate variables on a large scale is relatively weak, which makes it difficult to predict changes in the SOM as a function of projected climate change on the continental scale (Kern *et al.,* 1998). To quantitatively assess the potential influence of climate change on SOM on a regional scale and/or global, it is important to identify the main factors regulating climate SOM, and to develop relationships among the main factors and SOM whole different scale of land and the area different.

The relationship between SOM/TOC and altitude has also been investigated and positive correlations were reported (Sims and Nielsen, 1986). Altitude also influences SOM/TOC by controlling soil water balance, soil erosion and geologic deposition processes (Tan *et al.,* 2004).

In Malaysia, soil-formation factors such as climate, parent material, topography, vegetation, time and human activities are very complex and vary significantly. A few studies have been dedicated to quantifying the relationship between SOM/TOC and climate and depth on a regional area in Kelantan State of Malaysia. The objectives of this paper is to quantify the relationship between SOM/TOC concentration with climate and depth by different area and land uses in Kelantan, Malaysia

MATERIALS AND METHODS

The study area was based on land-uses in Kota Bharu District namely industrial, township, agricultural and remote area (located about 90km from Kota Bharu). The sites are situated in industrial park at Pengkalan Chepa near Road Transport Department, Kelantan, southwest of township area of Kota Bharu in Kampung Pauh Kubor, agricultural area in Kampung Baru Bukit Merak, Banggu and untouched land of Universiti Malaysia Kelantan, Jeli Campus. The four sites was selected were fairly flat with elevation of 10m (Pengkalan Chepa and Kota Bharu), 3m (Banggu) and 92m (Jeli). The longitudes and latitudes of sampling stations were measured by using GPS Garmin 60CS (Table 1). The study area has characteristically uniform temperature, high relative humidity, abundant but seasonal precipitation, little wind and intermittent sunshine and clouds. The climatic condition is representative of the high temperatures, between 22ºC and 34ºC, with the annual mean of 28ºC. Mean annual rainfall in the Kota Bharu district area is 2,700mm in 2010 (MMS, 2010). Annual surface water resources for Kelantan is 1405mm (DID, 1982). November, December and January are months with maximum rainfall, while June and July are the driest months in Kota Bharu, Kelantan

Kota Bharu is located in the district of 6º 5' 20" to 6º 7' 0" N latitude and 102º 13' 60" to 102º 16' 42.66" E longitude. Its overall land area is about 169km² with maximum width 13km (west to east) and a maximum length of about 13km (north to south).

The study area containing different sizes of gravel to clay silt mixture of both materials. The study area topography is flat and horizontal, where it is covered by the sediment coast quaternary sediments and granite paving stones. Geological data for Kota Bharu district showed that between 0 to 1.5m depth of soil containing mostly silt + clay type of soil (MGD, 1985). According to Structured Plan for State of Kelantan (2009), Kota Bharu District soil contained clay, silt sand and graveled. Location maps of the sampling site were also shown in Figure 1 and Figure 2

Table 1: Sampling Location

Area	Site	Position	Location
Pengkalan Chepa (Industrial Area)	1	102.30067ºE 6.13814ºN	Road Transport Department, Kelantan
SW of Kota Bharu (Township Area)	2	102.22882ºE 6.13117ºN	Kampung Pauh Kubor
Banggu (Agricultural Area)	3	102.31821ºE 6.04244ºN	Kampung Baru Bukit Merak
Jeli (Remote Area)	4	101.87198ºE 5.74288ºN	Universiti Malaysia Kelantan, Jeli

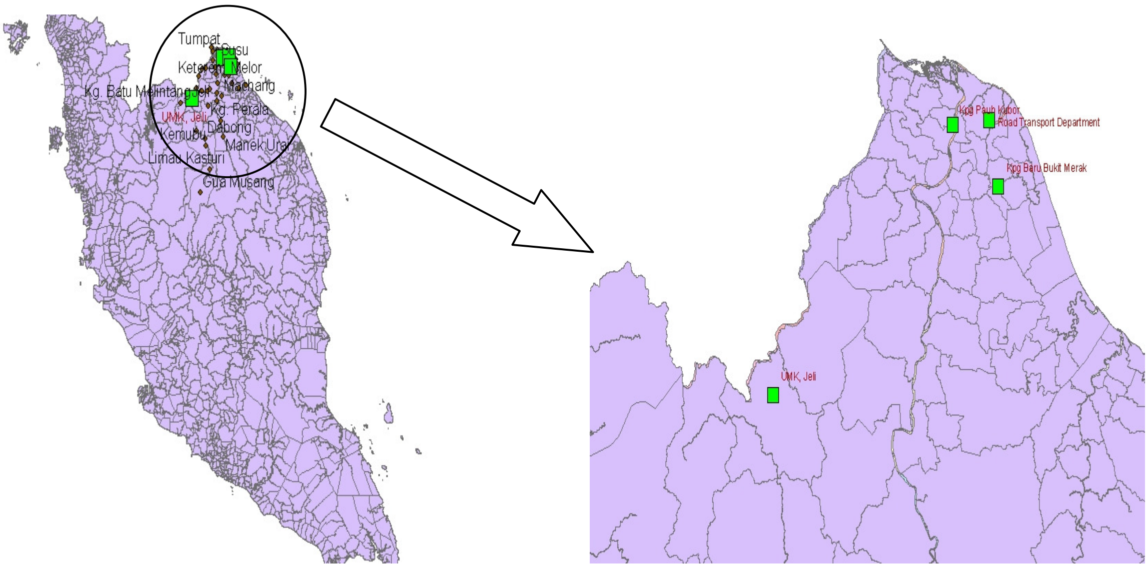

Fig. 1 : Location Map of Sampling Site in Kelantan

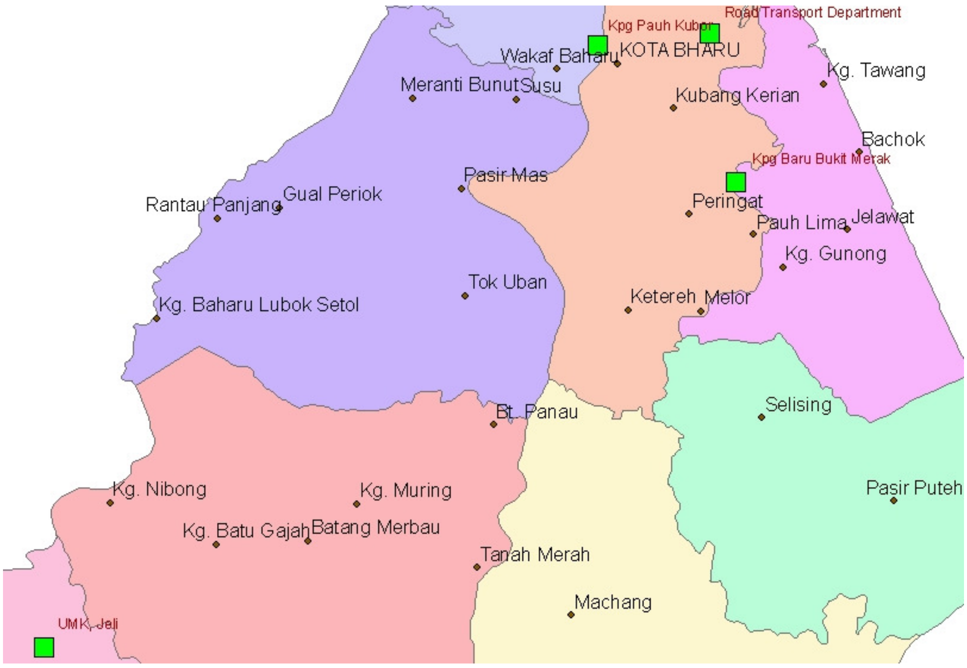

Fig. 2 : Study area and sampling stations

Sampling was done around the urban and suburban area of Kota Bharu District during pre monsoon (August-September), monsoon (November-December) and dry season (Mac-April). Sampling in Jeli for remote area was done during dry season in April. Samples were collected using metal spade from the depths intervals of 0-10cm, 10-20cm and 20-30cm of soil. At each station, three soil samples were taken within the depths intervals and composited as one sample. The samples were then transported in sealed aluminum foil to the laboratory and once in the lab, they were freeze dried. Only soil fractions of 2mm were used for further analysis

The determination of organic matter content was carried out on the oven (model MEMMERT) dried sieved (80^{o}C; <2mm) soil samples. 15grams of samples were weighed (initial weight) using an electronic balance model AND ER–180A and inserted into crucible cups. The samples in the crucible cups were then placed in a furnace (model CARBOLITE) and heated at a temperature of 500°C for 4 hours. The loss-on-ignition (LOI) method for the determination of organic matter involves the heated destruction of all organic matter in the soil (Blume *et al.*, 1990). After heating, the samples were left to cool in desiccators for 1 hour. The final weight of the samples was later recorded. Organic matter content was determined by the percentage loss of sample weight (done by subtracting final weight from initial weight) after combustion at 500°C for four hours (Mucha *et al.*, 2003; 2004). As a precaution, it is noted that the soil samples for the different sampling stations were separately heated in the furnace to avoid sample contamination.

The determination of soil moisture content was carried out using gravimetric method on the oven (model MEMMERT) dried. 15grams of soil sieved (<2mm) samples were weighed (initial weight) using an electronic balance model AND ER–180A and inserted into crucible cups. The samples in the crucible cups were then placed in oven and heated at a temperature of 105°C for 12 hours.

Concentration of organic carbon (TOC) was measured in soil by drying the sieved sample (<2mm) at 60ºC for 12hours and then 1.5g of samples were mixed with 2ml of HCl 1M to eliminate inorganic carbons and dried at 105ºC for 10hours to remove HCl. The TOC percentage was analyzed by using carbon analyzer LECO CR-412 (Nelson *et al.,* 1996, Bernard *et al.,* 2004)

Soil samples dried on the oven (model MEMMERT) at 100ºC for 12hours and then sieved at 2mm opening sieve. 25g of sample was mixed with 100mL diluted sodium hexametaphosphate in 250mL beaker and allowed to sit for 24h. The soil particles size was measured using pipette method (Day, 1965).

All laboratory equipments used were washed with phosphate-free soap, double rinsed with distilled water and left in 10% HNO_3 for 24h. The equipments then rinsed two times with double-distilled water and left semi closed to dry at room temperature. These procedures are to preclude uncertain contamination.

All statistical analyses were computed by using Statistical Package for Social Science (SPSS) version 17. The Pearson Correlation coefficient analysis was used to examine correlation between percentage of K water content (WC), total organic carbon (TOC), soil organic matter (SOM) and soil texture (clay, silt and sand) compared to the depth of soil, seasonal variation and soil classes of the different land-uses collected from area of Kota Bahru District and Jeli District. A Student-Newman-Keuls test was used to compare a soil texture (clay, silt and sand), WC, TOC and SOM of the different land uses and depth intervals in the area.

RESULTS AND DISCUSSION

Table 2 shows some physical properties of four representative soil sites. Sand was a dominant soil class in Pengkalan Chepa Industrial Park and southwest (SW) of Kota Bharu Township. The percentage of sand was higher towards 30cm depth for Pengkalan Chepa area from 94.44% to 95.41% but in contrast the percentage is lower towards 30cm for Kota Bharu township from 96.02% to 90.26%. The trend of soil texture (silt and clay) in Pengkalan Chepa shown that lesser percentage toward 30cm where silt from 3.26% to 2.52% and clay from 2.17% to 1.19%. The different between soil texture percentages in Pengkalan Chepa almost constant at 1% (silt 0.74%, clay 0.98% and sand 0.95%).

SW of Kota Bharu township and Banggu area have almost the same trend where the silt and clay showed the increasing percentage from 0cm to 30cm depth. In contrast the sand at both area showed the decreasing trend towards 30cm depth. Banggu has a sandy loam of soil class and the township area has the same pattern to sandy loam class.

The remote area in Jeli District has constantly shown the sandy clay loam texture regardless the depth of soil. The Jeli area is typically very rich of particulate organic materials comprising fresh plants, as the area still covered of virgin's forest.

Soils permeability for the studied areas are also classified based on hydrologic soil groups (HSGs) to indicate minimum rate of infiltration obtained for bare soil after prolonged wetting. For the area such as Pengkalan Chepa, Kota Bharu and Banggu showed HSG A with high infiltration rates greater than 0.30in/hr and have very low runoff potential. In contrast, for site in Jeli area showed HSG C, has low infiltration rate and consist of soils with layer that impedes downward movement of water and with moderately fine to fin texture. These soils have a low rate of water transmission (0.05-0.15in/hr).

Table 2 : Percentage of soil texture of different depth from selected land-uses of Kota Bharu District and Jeli District, Kelantan

Area	Site	Depth(cm)	Clay(%)	Silt(%)	Sand(%)	Soil Class
Pengkalan Chepa	P19PC10	0-10	2.17	3.26	94.44	sand
(Industial Park)	P19PC20	10-20	1.93	2.54	95.39	sand
HSG A	P19PC30	20-30	1.19	2.52	95.41	sand
Kota Bharu	P1KB10	0-10	3.79	0.20	96.02	sand
(Urban Area)	P1KB20	10-20	5.99	0.84	92.97	sand
HSG A	P2KB30	20-30	7.71	1.81	90.26	sand
Banggu	P2B10	0-10	6.01	0.20	93.79	sand
(Agricultural)	P2B20	10-20	13.85	9.70	76.29	sandy loam
HSG A	P2B30	20-30	16.21	14.82	68.80	sandy loam
Jeli	J10	0-10	22.66	25.15	52.06	sandy clay loam
(Remote Area)	J20	10-20	23.31	25.46	51.10	sandy clay loam
HSG C	J30	20-30	22.99	24.91	51.98	sandy clay loam

Table 3 : Mean value ± standard errors of soil content by temporal from Kelantan Soils

	Temporal Event		
	Pre Monsoon	Monsoon	Dry
Water Content(%)	11.29±2.10^{a}	16.04±1.45^{a}	15.58±1.51^{a}
Total Organic Carbon(%)	0.48±0.09^{a}	0.25±0.03^{a}	1.76±0.23^{b}
Soil Organic Matter(%)	2.12±0.81^{a}	1.67±0.11^{a}	4.00±0.41^{b}
Clay(%)	3.99±1.14^{a}	3.99±0.92^{a}	9.28±1.70^{b}
Silt(%)	6.54±1.21^{a}	6.54±0.98^{a}	10.65±1.41 79.88±3.06$^{a\ a}$
Sand(%)	89.26±2.24^{a}	89.26±1.81	

Note : Student-Newman-Keuls test comparisons of the three analyzed depth intervals. Means with different letters are significantly different at P<0.05

Results in Table 3 showed that TOC and SOM concentration significantly different ($p<0.05$) during dry season. The positive results also affected the content of clays during heavy rain in monsoon season and deposited in dry event.

The distribution of rainfall at the study site is presented in Figure 3, indicating a severe drought in February and April 2011. The total amount of rainfall was 1,634.17 mm during the study period, between August 2010 and April 2011. The main showers were concentrated in November and December 2010 with 372.11 and 389.12 mm, respectively, accounting for 28.2% of the total annual rainfall. Accordingly, soil moistures at three sampling locations, Pengakalan Chepa, Banggu and Jeli, were found to be constant and significant ($p<0.05$) at 15.40% to 19.92 % (Table 4), but no significant different were found in the soil moisture in Kota Bharu due to the downpour was moved toward cropland of Banggu area and hilly area in Jeli during study period after Pengkalan Chepa.

Table 4 shows that, the higher the clay compositions the higher the water content. This could be further strengthened by comparing between station Kota Bharu and Jeli, where the composition of clay in Kota Bharu is 0.95% with water content of 9.38%, meanwhile in Jeli the composition of clay is 25.17% with water content of 19.92%. So, station Jeli has small pores which results in an increase of water holding capacity and of the humidity needed for bacterial growth which eventually increased the TOC and SOM content. The presence of large pores results in a decrease of the water holding capacity and of the humidity needed for bacterial growth (Hassink *et al.*, 1993a).

Numerous studies have described the relationship between clay (or clay + silt) content and SOM in soils from different sites in the tropics (Feller and Beare, 1997). These studies have shown that clay (or clay + silt) content is a relatively important determinant of SOM or TOC level in soils. This relationship appears to hold equally well for cultivated soils as for Banggu as well as for those under native vegetation in Jeli where the situations covering a wide range of mean precipitation around 2,700mm per year. The temporal effect was significantly suggested for Jeli

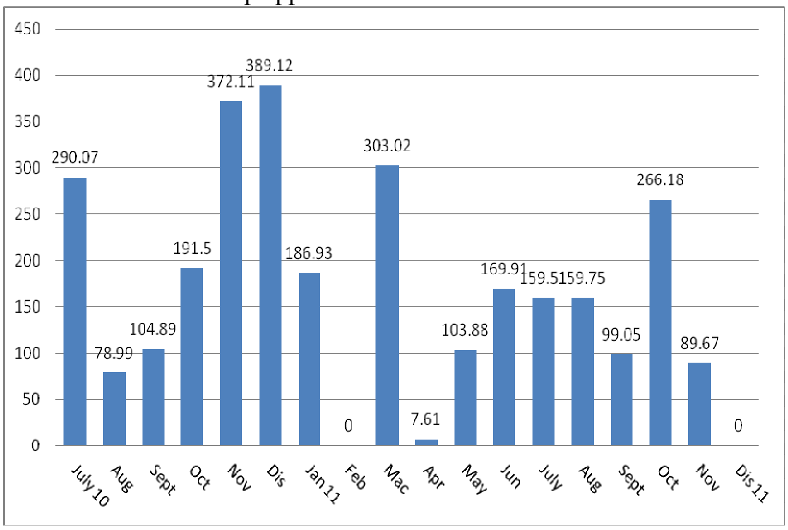

Fig. 3 : Distribution of rainfall (mm) in Kelantan between July 2010 and December 2011 (Meteorological Station, Pengkalan Chepa Airport)

Table 4 : Mean value ± standard errors of soil from different areas of Kota Bharu District and Jeli District

	Area			
	P. Chepa	**K. Bharu**	**Banggu**	**Jeli**
Temporal	2.13±0.16[a]	2.13±0.16[a]	2.13±0.16[a]	3.00±0.00[b]
Water Content(%)	15.40±1.88[b]	9.38±1.68[a]	17.64±1.52[b]	19.92±0.76[b]
Total Organic Carbon(%)	0.76±0.13[a]	0.71±0.10[a]	0.42±0.07[a]	3.73±0.48[b]
Soil Organic Matter(%)	1.96±0.11[a]	2.06±0.17[a]	2.77±0.24[a]	7.39±0.85[b]
Clay(%)	2.77±0.07[a]	0.95±0.14[a]	8.24±1.26[b]	25.17±0.08[c]
Silt(%)	1.76±0.09[a]	5.83±0.33[b]	12.02±0.91[c]	22.99±0.09[d]
Sand(%)	95.08±0.09[a]	93.08±0.49[a]	79.63±2.18[b]	51.71±0.15[c]
Soil Class	1.00±0.00[a]	1.00±0.00[a]	1.67±0.10[b]	3.00±0.00[c]

Note : Student-Newman-Keuls test comparisons of the three analyzed depth intervals. Means with different letters are significantly different at P<0.0

area instead of other areas. The more vegetative production the greater are the inputs of SOM or TOC. In climatic condition, TOC normally greater in areas of higher rainfall, and become lower in areas of higher temperature. The rate of decomposition of SOM doubles for every 8ºC or 9ºC increases in mean annual temperature.

The effect of climatic conditions on SOM accumulation rate has been established by different authors. As in Jeli area, tree coverage affects soil temperature and moisture. Tree coverage can create a microclimatic condition which can potentially affect SOM pools (Buschiazzo *et al.*, 2004). Correlation between tree

coverage and SOM become significant when the amount of organic matter reduce by disturbing factors such as burning and grazing (Buschiazzo *et al.*, 2004). Soil water holding capacity is influenced by the SOM level in soil. Soils with high level of SOM

will hold more plant available water than lower SOM soils.
Buschiazzo *et al.*, (2004) also suggested that SOM depends more on silt + clay content when tree coverage is dense and uniform, and the coverage is sparse and heterogeneous. The influence of soil texture on SOM could be attributed to its effect on the water retention capacity of soils. Forest clearing can increase the maximum temperature, while erosion in cleared areas can affect the texture, and the water retention capacity of soils. The potential deterioration of both temperature and soil water regimes, in turn can diminish the capacity of the soil to accumulate SOM (Buschiazzo *et al.*, 2004)

Table 5 : Mean value ± standard errors of soil content by depth from Kelantan Soils

	Depth (cm)		
	0-10	**10-20**	**20-30**
Water Content(%)	16.21±1.77[a]	13.17±1.46[a]	14.96±1.75[a]
Total Organic Carbon(%)	1.27±0.31[a]	0.92±0.20[a]	0.73±0.12[a]
Soil Organic Matter(%)	2.97±0.54[a]	2.73±0.31[a]	2.71±0.27[a]
Clay(%)	3.88±1.50[a]	6.70±1.48[a]	8.44±1.59[a]
Silt(%)	6.06±1.19[a]	9.04±1.35[a]	9.99±1.45[a]
Sand(%)	90.01±2.64[a]	84.09±2.77[a]	81.17±2.94[a]

Table 6 : Mean value ± standard errors of soil for different soil classes of Kota Bharu District and Jeli District

	Soil Class		
	Sand	Sandy Loam	Sandy Clay Loam
Area	1.71±0.09[a]	3.00±0.00[b]	4.00±0.00[c]
Temporal	2.13±0.11[a]	2.13±0.20[a]	3.00±0.00[b]
Depth	1.86±0.11[a]	2.50±0.13[a]	2.00±0.29[a]
WC	12.99±1.28[a]	18.16±1.13[a]	19.92±0.76[a]
TOC(%)	0.70±0.07[a]	0.38±0.07[a]	3.73±0.48[b]
SOM	2.02±0.10[a]	2.98±0.29[b]	7.39±0.85[c]
Clay	1.62±0.15[a]	12.26±0.66[b]	25.17±0.08[c]
Silt	4.11±0.31[a]	15.03±0.30[b]	22.99±0.09[c]
Sand	94.04±0.25[a]	72.55±0.97[b]	51.71±0.15[c]

Note : Student-Newman-Keuls test comparisons of the three analyzed depth intervals. Means with different letters are significantly different at P<0.05

Table 6 shows that there are significant different between soil classes(soil texture), TOC and SOM in different area. The sandy soils of Kota Bharu, Pengkalan Chepa and Banggu have less TOC and SOM than the sandy clay loam soil of Jeli area (Table 3) regardless the land use in the area. Clay helps protect SOM/TOC from breakdown, by binding strongly and create physical barrier to protect microbial access. In most cases, clay soils in the same soils condition under the same land uses will tend to retain more carbon than sandy soil

Most of the authors found that, the topography factor was also affect accumulation of TOC/SOM. Soils at the slope toe have higher carbon because the area generally wetter and have higher clay contents.

Note : Value given are the correlation coefficient (r) and their level of significance (**P<0.01 & *P<0.05)

(Temp-Temporal; WC-Water content; TOC-total organic carbon; SOM-soil organic matter; SC-Soil Class)

The data shows that soil organic matter, clay and soil classes showed positive correlation to temporal ($p < 0.01$). SOM, clay, silt and soil classes showed positive correlation to TOC. These results suggested an increasing effect of protection mechanisms for TOC in soil with increasing fine fraction content (Galantini *et* *al.,* 2004). In soils richest in fine fractions, soil pore size is reduced and makes difficult for bacteria to access to the organic substrate (Van Veen and Kuikman, 1990). In wet condition, pore space in soils retains enough moisture to allow microorganism development (McGill and Myers, 1987), whereas under dry conditions, pore space can be reduced (Van Veen and Kuikman, 1990; Verberne *et al.,* 1990). High levels of biological activity in a soil require a significant amount of SOM. Soils with low level of SOM will have reduces biological activity.

Table 7 : The Pearson Correlation coefficient analysis between landuses, season, depth, water content(%), total organic carbon(%), soil organic matter, soil classes and soil texture collected from various area from Kota Bharu District and Jeli District

	Area	Temp	Depth	WC	TOC	SOM	Clay	Silt	Sand	SC
Temp	0.221*	1								
Depth	0.000	0.000	1							
WC	0.212	0.168	-0.059	1						
TOC	0.437**	0.497*	-0.188	0.067	1					
SOM	0.618**	0.435**	-0.053	0.261**	0.857**	1				
Clay	0.731**	0.292**	0.233*	0.299**	0.644**	0.780**	1			
Silt	0.904**	0.258*	0.229*	0.204	0.537**	0.724**	0.926**	1		
Sand	-0.823**	-0.281*	-0.246*	-0.262*	-0.605**	0.768**	-0.985**	-0.977**	1	
SC	0.809**	0.287**	0.177	0.309**	0.614**	0.771**	0.981**	0.956**	-0.988**	1

Overall, seasons exhibited significant effects on TOC ($p<0.01$, Table 7) and SOM, clay+silt ($p<0.05$, Table 7). A multiple range test for variables based on season resulted in significant differences ($p<0.01$, Table 7) for different soil areas, Pengkalan Chepa, Kota Bharu, Banggu and Jeli for TOC, SOM and soil texture, although no significant difference in soil moisture was observed for different areas. No significant difference was found during pre-monsoon, monsoon and dry season for TOC, SOM, and soil texture. A correlation matrix of all parameters studied revealed that temporal TOC was not significantly correlated with soil moisture. Soil moisture was positively and significantly correlated to SOM and soil texture ($P<0.01$, Table 7).

Plant residues above- and below-soil account for most fractions of SOM (Foth, 1990). Seasonal patterns in organic carbon and nitrogen might be important for understanding the relationship between plant growth and carbon and nitrogen dynamics (Xie and Steinberger, 2001). Xie and Steinberger (2001) showed that seasonal patterns affected the overall trend of soils under canopies have the highest TOC levels in autumn and the lowest in summer in responding to changes in soil moisture.

The significant relationship of soil texture (silt + clay) and TOC reflects the importance of plant residues inputs in the formation of soils in Kelantan. Bechtold and Naiman (2006) and Cabezas and Comín (2010) also observed that TOC storage in the soils were strongly correlated with the concentrations of fine particles

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Studies in Spanish semi-arid Mediterranean bare soils have shown different SOM mineralization rates for different soil textures (GarcõÂa and HernaÂndez, 1996) indicated the importance of the physical and chemical properties, which may play an important role in soil water availability. It has been suggested that fine particles with high surface activity may physically and chemically protect soil organic matter from decomposition (Tisdall and Oades, 1982; Hassink *et al.,* 1993b). Xie and Steinberger (2001) have found that soils between shrubs, soils under shrub canopies had significantly higher concentrations of organic carbon and nitrogen, between which there were different temporal dynamics with nitrogen levels being governed mainly by soil moisture.

The study also showed that, SOM has a correlation with soil texture. Soil texture influence the rate of SOM decomposition. Soils with a high clay content may have higher SOM content, due to slower decomposition of organic matter. SOM has an association with degradation of soil and environmental conditions in tropical and subtropical regions. SOM storage in sandy clay loam was largely dependent on tillage and cropping systems (Bayer, *et al.,* 2000). SOM in soils varies horizontally and vertically in the soil profile (Jobbágy and Jackson, 2000). Quantities and composition of SOM are attributed to several natural factors that control soil formation, such as climate, vegetation, topography, parent material organisms, land use and time (Jenny, 1980; Schwanghart and Jarmer, 2011). In cultivated soil and some uncultivated soils, human activities and management also affect SOM concentration greatly (Dai and Huang, 2006). Integrated effect of these natural factors and human activities on soils makes the quantities of SOM maintain a steady dynamic balance in each giving eco climatic zone (Dai and Huang, 2006). Wang *et al.,* (2000) have also found that SOM in the surface layer has a lower concentration due to the sparse vegetation and aggressively cultivation (such as steep slope cropping system) which induced severe soil erosion and degradation.

Dai and Huang, (2006) found that SOM concentration was not very high in the humid and warmer climate regions. The vegetation grows fast with a higher cultivation, and thus higher litter volumes inputting into the soil. The authors also found that the native SOM transformation and litter decomposition by active soil microorganism in this climatic–ecological system are great.

Conclusion: A significant positive correlation was found between SOM/TOC in soil with soil classes(soil textures) and season factor. Other than that, the amount of SOM/TOC in soil depends also on vegetative growth or soil cover which included agricultural activities. On the other hand, there were no correlation between SOM/TOC content with soil depths, this probably due to the topsoil thickness and rainfall intensity.

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