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Assessment of Physico-Chemical Characteristics of Sediments of a Lower Himalayan Lake, Mansar, INDIA

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Abstract

Sediments are one of the most important constituent of lacustrine ecosystems. The study was conducted to assess the physico-chemical properties of sediments of Lake Mansar. The texture of sediment was sandy loam with sand (>60%) as dominant particle size class. Organic matter varied from 1.91% - 3.45 % and is significantly related with total nitrogen, pH and moisture content. pH of sediment was mostly alkaline with average value of 7.55 ±0.46. Lake sediment wasmild organic and probably in a process of accumulation of organic load from catchment area due to various natural (erosion) and anthropogenic causes (tourist and construction activities). Total phosphorus was fairly high but not related to organic matter which may be contributed by the domestic discharge, community bathing and washing and agricultural run-off. Thus, environmental surveillance of lake sediments is highly recommended in order to closely monitor the quality of sediments of LakeMansar.

Keywords: Mansar, sediments, physico-chemical, texture, sand, organic matter, total nitrogen.

Introduction

Lakes constitute one of the most important natural resource on Earth. These productive ecosystems are immensely important for any geographical region as they play a significant role in its ecological sustainability. These ecosystems act as vessels for storing nutrients and sediments from flooding waters as well as surface runoff, there by reducing the risk of eutrophication or over enrichment of other natural waters like streams and rivers. During the course of time, these sediments get accumulated and form a very important component of lake ecosystem. They arerecords for tracking changes in the environment of water body and its catchment area[1-2]. In addition to this sediment also impact the quality of water as an outcome of their extremely dynamic nature due to variety of biogeochemical reactions and transformations[3-4]. Bottom sediments are a mixture of material both, organic and inorganic, derived chiefly from the lake and its catchment, but material in trace quantities are also derived from the atmosphere[5]. Being a result of lake life, bottom sediments are extremely important for its nutrient economy, acting as sink or source of nutrients depending upon the redox conditions[6-7].

With the increasing anthropogenic pressure on inland fresh water resources because of sewage pollution, ground water pollution, soil erosion, agricultural and industrial dumping of waste etc., it become highly important to monitor the sediment quality which ultimately accumulate all of these excessive wastes. Plenty of limnological studies have been done on Lake Mansar[8-17] but very few on its sediment quality. An accelerated deforestation and construction activity to develop tourism in the lake catchment and surface run-off from agricultural fields has resulted in higher accumulation of sediments in the lake. Thus, this study was highly important in order to assess the, particle size composition, moisture content, pH, organic Matter, total Nitrogen and total phosphorus. The study of sediments will be a useful tool for future researchers for actual assessment of environmental pollution of this aquatic system.

Material and Methods

Study Area: Lake Mansar is a Ramsar site and one among the oldest lakes of Jammu and Kashmir, India (figure-1). It is a rural lake located in the foothills of lower Siwalik Himalayan ranges (75°5’11.5” to 75°5’12.5’’E longitude and 32°40’58.5’’ to 32°40’59.2’’ N latitude) with an altitude of 666m above MSL. It is a closed, non-drainage lake with a circumference of 3.4 Km and maximum depth of 38.25 m. The entire catchment area is about 2000 ha with two distinct domains i.e. hills and plains, each having its own characteristic land forms like forest canopy, wild life sanctuary agricultural farms and human habitation. It receives sediment from the lower Siwalik ranges which is highly prone erosion due to geological and tectonic set up (sedimentation rate is 0.14-0.34 cm/year[18]). Being of religious and cultural importance the lakehas been facing a very high anthropogenic pressure in terms of various religious practices, increased tourism and developmental activities like construction of roads, buildings etc. near the immediate vicinity of lake. The lake vegetation hasbeen restricted to a few patches characterized by *Polygoniumbarbatum*, *Polygoniumglabrum*, *Alternantherasessilis*, *Nymphoidesindicum*, *N.cristatum*, *Potamogetoncrispus*, *P. lucens* and *P. natans*. Lake is also inhabited by artificially introduced carps (*Cyprinuscarpio*, *Ctenopharyngodonidella*, *Cyprinuscatla*) and other native fishes (*Puntius*sps., *Channa*sps. etc.).

Sediment Sampling and Analysis: Sediment sampling was done with the help of a 0.023 m^2 Petite Ponar Grab sampler, once a month from March 2009-February 2010 at four locations. The sediment samples were immediately placed on ice prior to permanently storage (4ºC). Samples were analyzed for moisture content prior to drying. Sediment samples were then air dried at room temperature in the laboratory. The dried samples were homogenized using Jar mill and then sieved through 2.0 mm mesh. Then, sediment samples were used to measure a suite of physico-chemical properties (sand, silt, clay and organic matter). Physico-chemical parameters were determined according to standard methods: Moisture content: by oven drying method[19], pH: by digital pH meter[20], particle size: by using ASTM 152H-Type Hydrometer[21], Texture: by textural triangle[22], total organic matter: by Walkley and Black rapid titration method[23], total nitrogen: by Kheldahl's method[24]and total phosphorus: by Olsen and Sommers method[25].

Results and Discussion

Average, minimum and maximum values for all the parameters of lake bottom sediments are presented in table-1**.** The particle size composition indicated that sand (71.01 % ±5.2) was the dominant fraction in sediments followed by silt (19.09 % ±3.00) and clay (9.69 % ±2.67). Sediment textural class was recorded as sandy Loam (figure-2). Sand fraction contributed more than 60 % in all the sediment samples while clay was recorded to show minimum of 5.4% (figure-3). Sand fraction is inversely related to silt ($r = -0.9$, $p \le 0.05$) and clay ($r = -0.87$, $p \le 0.05$) while silt and clay ($r = 0.6$, $p \le 0.05$) are positively related to each other (table-2). Particle size distribution in sediments is called as its texture[26]. It gives general physical appearance or character of sediment which strongly influence its properties like porosity, permeability, bulk density and organic matter[27]. The higher contribution of coarse fraction of particles (sand) was primarily attributed to the characteristic topography of the catchment which is highly prone to the weathering and erosion. The rate of sediment delivery in Lake Mansar is comparatively higher than other Himalayan lakes primarily due to the fact that the siwalik terrain is constituted by sandstone which is susceptible to erosion[15]. Moreover, increase in a lot of construction activities to promote tourism all along the lake periphery also resulted in addition of sand (construction material) in the sediments. The significant negative relationship of sand with both silt and clay may probably suggest that the sources for these particles are different though clay and silt may come from same source as indicated by their positive association. Similar relationships among various particle size classes were also observed[28-29,16].

Organic matter varied from 1.91% to 3.45%. The range of organic matter suggested that the sediments are low to moderately organic in nature[26]. Sediments with organic matter values exceeding 1% was usually called organically rich[30]. In the present study, organic matter was also observed to show significant association with sand proportion ($r^2 = -0.79$, $p<0.001$), silt ($r^2 = 0.65$, $p<0.001$) and clay ($r^2 = 0.59$, $p<0.001$) (figure-4). These relationships clearly imply that the finer fractions of sediment have more tendencies to accumulate organic matter rather than larger ones[28, 31]. Mean total phosphorus was recorded to be 120.3 ppm ± 19.46 while mean total nitrogen was recorded to be 1.66 % ±0.56. Only total nitrogen is associated with organic matter significantly ($r^2 = 0.80$, $p<0.001$) and not total phosphorus. Value of phosphorus is fairly high in the lake sediments which is not linearly related to organic matter probably because of the fact that phosphorus may also come from inorganic sources from the agricultural area in the form of fertilizers and detergents etc. from domestic households. Lake Mansar has catchment area with major portion of agriculture (25 %) and urban (11.4 %) land use[15]which release waste in lake as surface run off and/or as see page. Pollution from industrial and domestic waste results in accumulation of high inorganic phosphorus in lake sediments[32]. Strong association of organic matter with total nitrogen suggests that most of the nitrogen come from organic matter as probably bound to it[33-34]. It is well known that organic matter in sediments act as reservoir of nutrients, aids in nutrient holding and chelates (binds) nutrient thereby preventing them from becoming permanently unavailable.

Table-1
Average, Minimum and Maximum values for various physico-chemical parameters of Lake sediments

Parameters	Mean	Min	Max
Sand (%)	71.01±5.2	63.24	78.52
Silt (%)	19.09±3.00	14.44	24.52
Clay (%)	9.69±2.67	5.4	13.09
Moisture Content (%)	34.12±1.07	31.98	35.77
pH	7.55±0.46	6.87	8.29
Organic Matter (%)	2.49±0.55	1.91	3.45
Total Nitrogen (%)	1.66±0.56	0.92	2.7
Total Phosphorus (ppm)	120.3±19.46	93.78	150.64

Average moisture content in lake sediments was 34.12 % ± 1.07. Moisture content was significantly correlated with organic matter ($r^2 = 0.70$, $p<0.001$) (figure-4). Moisture content is the water held in spaces between sediment particles and is usually associated to the bulk density, porosity and organic content[35]. Organic matter improves water holding capacity of sediment as also suggested by positive relationship with moisture content in our study[36]. But, low moisture content in sediments may be a result of sand dominance and medium organic content.

Average sediment pH was recorded to be 7.55 ± 0.46 which is slightly alkaline though the maximum pH has increased to 8.29. pH very often act as an index for reflecting conditions associated with release of nutrients, physical conditions of soil and potency of toxic substances[31,37-38]. pH was related to organic matter ($r^2 = -0.34$, $p<0.05$) though the relationship is not very strong (figure-4). This inverse relationship was possibly because of the fact that decomposition of organic matter release organic acids into the sediments which decrease its pH[39-41].

Table-2
Value of Pearson correlation coefficient (r) for various physico-chemical parameters of Lake sediments

	Sand	Silt	Clay	OM	MC	pH	TN	TP
Sand	-	-	-	-	-	-	-	-
Silt	-0.90*	-	-	-	-	-	-	-
Clay	-0.87*	0.6*	-	-	-	-	-	-
OM	-0.89*	0.81*	0.77*	-	-	-	-	-
MC	-0.87*	0.72*	0.81*	0.84*	-	-	-	-
pH	0.75*	-0.59*	-0.79*	-0.58*	-0.69*	-	-	-
TN	-0.89*	0.83*	0.78*	0.89*	0.85*	0.62*	-	-
TP	-0.17	0.09	0.26	0.24	0.04	0.001	0.30	-

*Significant at 5% level of significance, OM-organic matter; MC-Moisture content; TN-Total nitrogen; TP-Total Phosphorus.

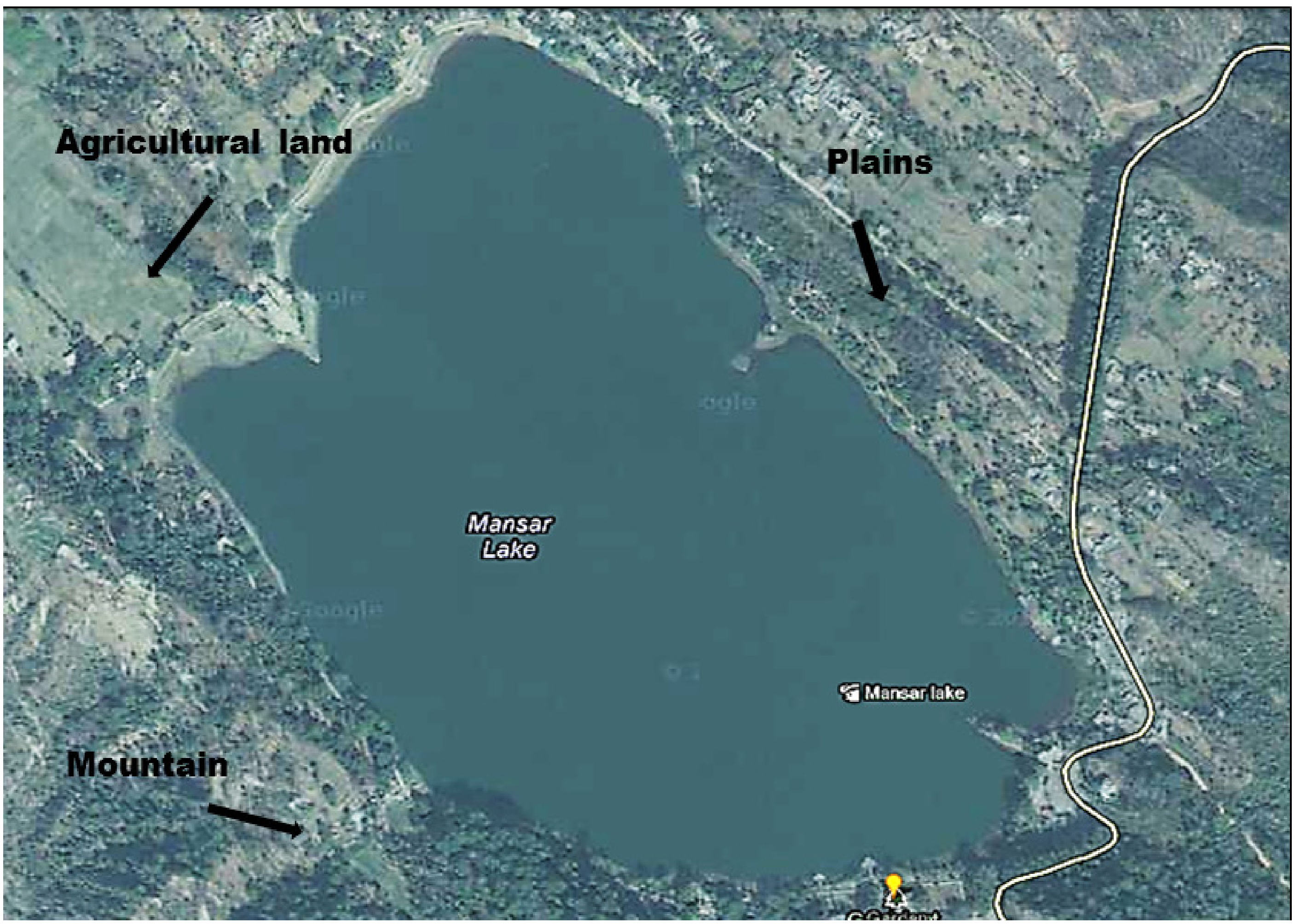

Figure-1
Map of Study Area, Lake Mansar, INDIA

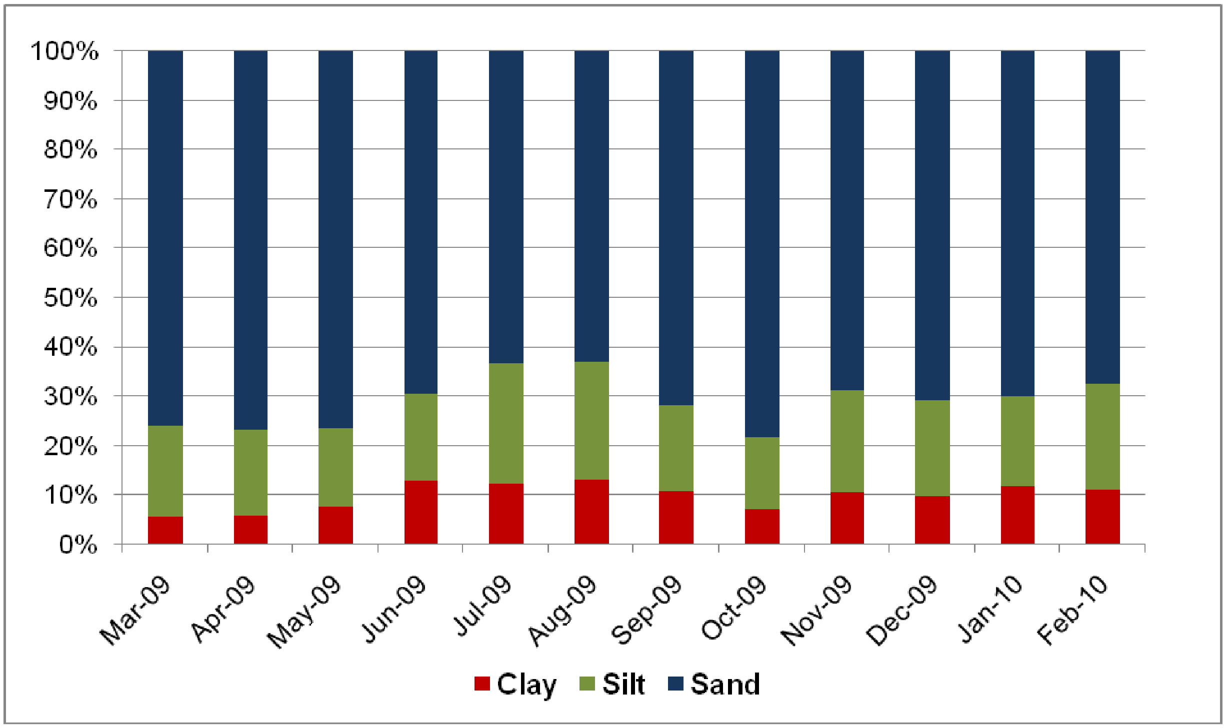

Figure-2
Percentage contribution of different particle size classes in the sediment of Lake Mansar

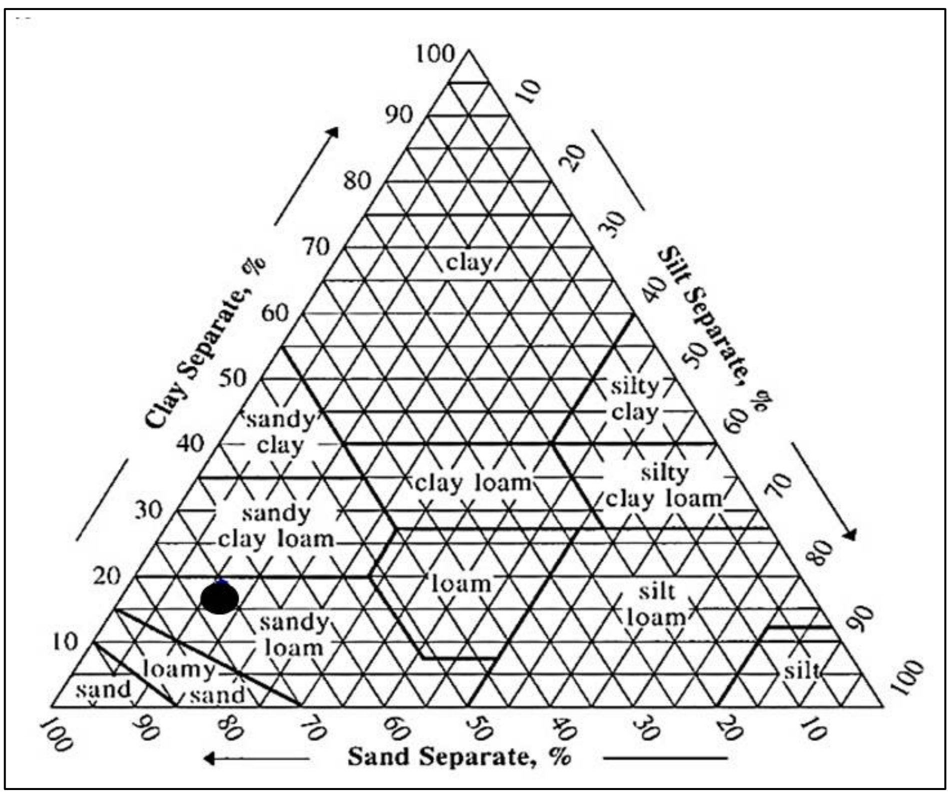

Figure-3
Textural triangle showing textural class for the sediment of Lake Mansar

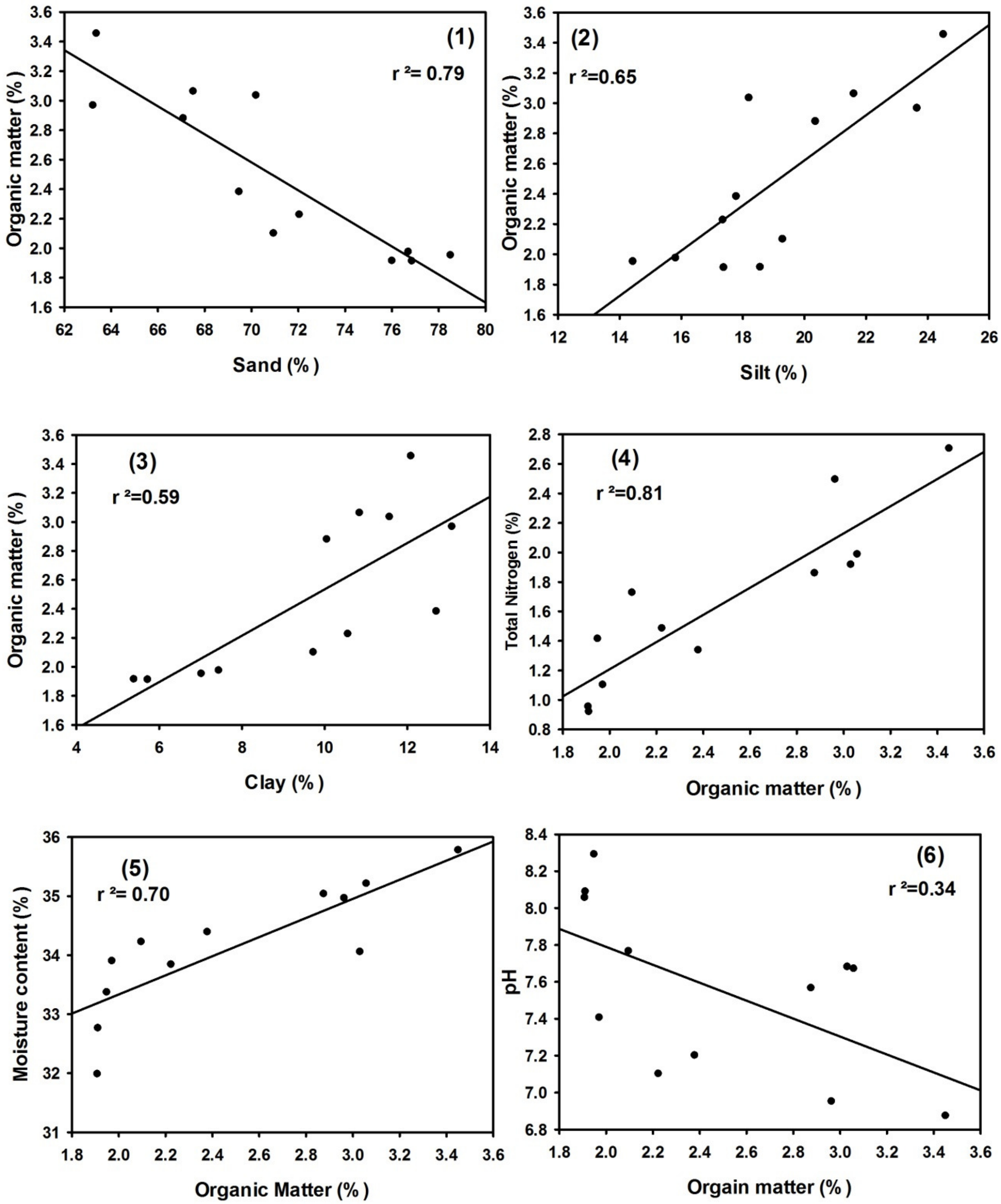

Figure-4
Relationship between various physico-chemical parameters of lake sediments; (1) Sand vs Organic matter; (2) Silt vs Organic matter; (3) Clay vs Organic matter; (4) Organic matter vs Total nitrogen; (5) Organic matter vs Moisture content; (6) Organic matter vspH.

Conclusion

The study of lake Mansar sediments indicated that the dominant particle size class was sand followed by silt and clay. Sediments can be called as mild organic and organic matter was a key factor controlling the moisture content, pH and nitrogen. However, total phosphorus is not related to organic matter of the sediments. The sediments are under pressure from the anthropogenic sources like tourism, construction, sewage and domestic waste, agricultural run-off has resulted in initiation of organic load/build-up in it. Thus, environmental monitoring of sediments for nutrient and textural composition is very important and highly recommended in order to control its further deterioration.

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