STUDY OF MAGNETIC SUSCEPTIBILITY,GEOMAGNETISM OF THE SOIL SAMPLE AND CHARACTERIZING PALAEOENVIRONMENT AT SITES OF MANSAR LAKE, MS, INDIA USING REGRESSION ANALYSIS

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Abstract: The sediment particles have inbuilt magnetic properties that often vary with the changes in the *lithogenic* fractions of them and the changes are controlled by multiple factors. Basically environmental magnetism is a measurement of several such mineral fractions from the sediments/ rocks. Magnetic properties of natural materials depend upon the formation, transport, deposition and transformation of magnetic minerals controlled by environmental condition and geological process. The mineral magnetic records therefore provide a sensitive indicator of changing sediment sources. This can be related with the sediment characters, sedimentary process, climatic conditions and the biological activity by the microorganisms Data on low frequency in Hz (LF), high frequency in Hz (HF) and depth of 6 different Mansar (MNS) lake Sites is analyzed by applying linear regression model. The regression coefficients, on the basis of its significant are used to classify the MNS sites. It is found that LF and HF values are highly correlated. Further it is found that out of 6 sites in three sites with the change in depth, changes in LF and HF are very meager or non-significant, whereas in two sites LF and HF values decreases and in one site these are increasing. This classification is useful to understand the changes in magnetic Susceptibility and geomagnetism.

Keywords: Geomagnetism, magnetic susceptibility, mineral influx rate, regression analysis.

Introduction: Lakes act as receptacles for materials, which are removed from their catchments, the majority of which are deposited in the lakebed. In order to overcome the problem of differences in the rate of sedimentation over the bed it is necessary to take multiple cores, typically one per 0.5-1.0 ha of the lake surface. These cores need to be correlated with one another by methods such as magnetic susceptibility. Using magnetic susceptibility profiles it is possible to establish which cores have fast and which have slow sedimentation rates, and to select for detailed dating those with representative sediment profiles. Once dated and correlated, accumulation rates over the lake can be established for different time periods in the past. The mean rate of sediment accumulation over the whole lakebed (usually recorded as gm/cm2/yr) may be used as a measure of the rate of sediment influx into the lake, which in turn can be converted into mean catchments erosion rate [2].

The study of magnetic susceptibility - The analysis of such sediment was of particular value because the exposed profiles at Mansar lake bed were used to reconstruct the past vegetation history, climatic conditions, as well as also could provide the soil erosion rate and sediment influx [1], [2], [4], [5], [6], [7].

Study area-Mansar lake is relatively shallow, situated in an area of predominantly farming. We tried to detect the past erosion rates of soil, by taking 22 trenches, approximately of 2.50 meter deep sediment profile set over the dried lake surface. Mansar lake having area 59.69 ha, water depth 11 feet is situated at 21^0 20'N-$70^0$15'E. The sediment thickness is 2.50 m and maximum sediment date is c.1870-c 1630 yrs. B.P. In order to conduct magnetic susceptibility at the lake Mansar sample from the following trenches were taken for analysis so as to have a correlation between the results obtained.

TRENCHES are : MNS-I, MNS-II, MNS-III, MNS-IV, MNS-V and MNS-VI

Laboratory Methods: After description and photography of the sampling measurements of magnetic susceptibility of MNS-I to MNS-VI sediment samples were measured. The age model couldn't be established since only one valid ^{14}C date is available.c.1870-c .1630 yrs.B.P. The overall straightygraphy of Mansar lake has been given in the composite profile. The position of trenches in the dried lakebed of Mansar Lake is shown. The soil samples were dried in oven and filled in special vials, labeled to take the readings of frequencies. Magnetic susceptibility was measured with automated Barrington point sensor, at low and high frequency. The frequency readings were taken in the laboratory of IGM, Kolaba, Mumbai, under the supervision of Dr. Basavaihya. The data have been analyzed for magnetic susceptibility, influx of the sediment and co-relation with pollen records, in the study area.

Although the data set is preliminary and mainly suffers from lack of high-resolution pollen data and detail geochemical investigations, it was possible to infer few palaeoenvironmental and palaeoclimatic conclusions.

Observations-

Litho unit I (0-40 cm): The minerogenic input is increased, characterized by **high amplitude of frequencies** in magnetic susceptibility, and pollen record is characterized by **rise in NAP** amounts and **drop in semi- humid** pollen percentage. Increase of Poaceae ,Cyperaceae, Chenopodiaceae,and Amarantaceae pollen, reflects a climatic condition with high precipitation rate and more sediment influx due to soil erosion. Autochthonous biogenic deposits have increasingly diluted the allochthonous pollen influx during last 50 years. It may be due to **Eutrophication.**

Litho unit II (40-60 cm): It represents a short period with **high minerogenic input** ,indicated by high levels of amplitude in magnetic susceptibility. The pollen record shows a remarkable **increase in NAP** and **decrease in**

semi-humid plant species . The low resolution of preliminary pollen record did not allow recognition of climatic change, because there is no pollen sample between Litho unit I and Litho unit II(sample 21,MNS-XIV,at 55 cm) .The occurrence of **Microscopic charcoal** have indicated occurrence of **local fire** in the study area. This observation point to a major **climatic deterioration** in last 500 years.

Litho unit III- (60-130 cm): The amplitude of **magnetic susceptibility is very low.** It means the minerogenic input was very low and there was increased clay percentage representing **semi-humid climate** with **high fluvial runoff** and a dense semi humid forest cover. The lake level should have been higher than in litho units I,II and IV, since minerogenic input was low. It represent **deepest part of the lake**. Formation of **carbonate nodules** hints for the precipitation of carbonates in shallow peripheral zone of the lake. It indicates existence of a **humid and warm climate.** The pollen records shows **maximum biodiversity in AP** pollen count, indicators of semi-humid, to humid climatic conditions, lasted more or less **invariable until the onset of terminal Holocene period**.

Litho unit IV and V-130-250 cm): The sediment of Litho unit IV and V are characterized by high frequency value with **high amplitude changes** of magnetic susceptibility.

The palaeoenvironmental conditions seems to be **more variable** with **maximum Holocene summer monsoon ,maximum fluvial runoff** from the tributary coming in the Mansar lake.(Pench river valley-Nagpur).

The pollen record with more Poaceae and Cyperaceae with few arboreal pollen and fungal spores, which are **indicator of primary forest** as well as **humid climatic conditions**, indicate gradual spread of grassland with influx of plant remains, and **scattered minerogenic** particles **mainly MnO_2** concretions, from the surrounding area after damming of the Mansar lake.

Statistical Analysis: The statistical summary of collected data on LF and HF at different depth levels is given in Table 1

Table 1: Statistical Summary of Magnetic susceptibility

MNS Sites	No. of Records	Depth Range (cm)	Mean LF Hz	Mean HF Hz
I	04	65-195	12.00	10.93
II	19	00-210	10.90	09.94
III	10	00-100	10.27	08.72
IV	84	06-174	14.46	13.82
V	63	00-140	10.21	08.95
VI	50	03-170	16.69	16.31

From Table 1 it is seen that in MNS site II depth variation is high and that in I is least. Further average low frequency over the 50 observations in MNS VI is high and that on 63 observations in MNS V is least. Similarly average HF is high in MNS VI and least in MNS III. The graph of LF verses depth and HF verses depth for all sites is shown on

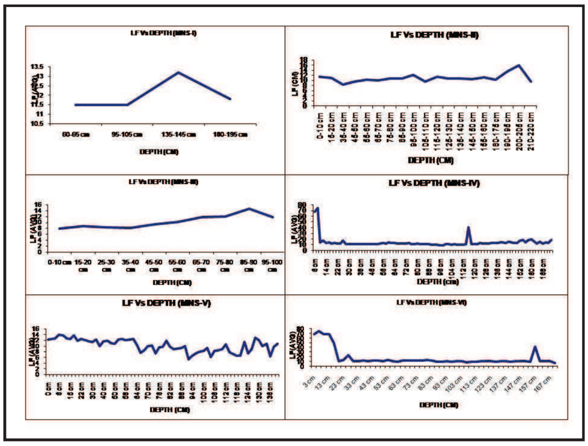

Figure 1: LF Vs Depth of MNS I to VI

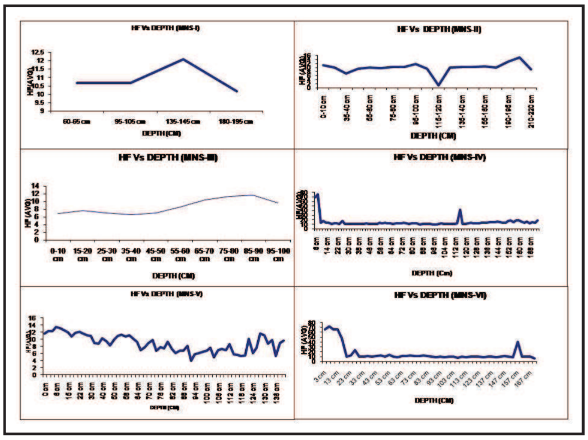

Figure 2: HF Vs Depth of MNS I to VI

From Figure 1 and Figure 2 it is observed that the relationship between LF/HF and depth is linear. Therefore the linear regression (1) is used to quantify the effect of depth on LF and HF [8], viz

$LF = \beta0 + \beta1Depth + \epsilon$ and

$HF = \beta0 + \beta1Depth + \epsilon$,

where $\epsilon \sim N(0,\sigma^2)$ …(1)

The parameters of the model β0 and β1 are estimated using method of least squares and significance of the regression coefficient β1 is also tested by using t-test at 1

% level of significance (LOS). The Table 2 and Table 3 will provide the estimates parameters in the model (1) for LF and HF respectively.

Table 2: Parameter estimates for LF

MNS Sites	β0	β1	R^2
I	11.30	0.0057	0.142
II	09.68	0.0110	0.183
III	06.97	0.0631**	0.776
IV	17.30	-0.031	0.025
V	12.70	-0.034**	0.402
VI	31.20	-0.170**	0.238

(** means significance at 1% LOS)

Table 3: Parameter estimates for HF

MNS Sites	β0	β1	R^2
I	11.00	0.0009	0.004
II	08.89	0.0096	0.051
III	05.98	0.0524**	0.673
IV	16.20	-0.026	0.017
V	11.70	-0.038**	0.437
VI	30.60	-0.167**	0.241

(** means significance at 1% LOS)

Results: From Table 2 and Table 3, regression coefficient and its significance the site wise results are as follows**:**

MNS I: Rate of change in LF is statistically insignificant. It can also be concluded that LF remains constant and it may be 11.3. Rate of change in HF is statistically insignificant. It can also be concluded that HF remains constant and it may be 11.0. Of course this conclusion is based on only 4 observations, and therefore more observations may be revisited to investigate the true picture of change in LF and HF. Slight increase in LF and slight decrease in HF is also seen from the regression.

MNS II: Rate of change in LF is statistically insignificant. It can also be concluded that LF remains constant and it may be 9.68. Further values of LF seem to be unusual (15.8) at the depth of 200 to 205 cm. Rate of change in HF is statistically insignificant. It can also be concluded that LF remains constant and it may be 8.89. It is also observed that values of HF seems to be unusual (1.20) at the depth of 115 to 120 cm. Slight increase in LF as well as HF is noted.

MNS III: Rate of change in LF is statistically significant and per cm rate of increase of LF is 0.0631.Further it is also noted that LF seems to be unusual (14.60) at the depth of 85 to 90 cm. Rate of change in HF is statistically significant and per cm rate of increase of HF is 0.0524.

MNS IV: Rate of change in LF is statistically insignificant. Yet unusual observations on LF are reported at d depth of 6 cm (68.60), 8 cm (75.10) and 116 cm (41.50). Rate of change in HF is statistically insignificant and unusual observations on LF are reported at the depth of 6 cm (67.80), 8 cm (74.80) and 116 cm (40.80).Slight decrease in both LF and HF is also seen from d regression analysis.

MNS V: Rate of change in LF is statistically significant and per cm decrease in LF is 0.0341. Unusual observations on LF are reported at d depth of 92 cm (5.23), 128 cm (12.90) and 130 cm (12.10). Rate of change in HF is statistically significant and per cm decrease in HF is 0.038. Unusual observations on HF are reported at the depth of 92 cm (4.00), 128 cm (11.70) and 130 cm (11.10).

MNS VI: Rate of change in LF is statistically significant and per cm decrease in LF is 0.170. Unusual observations on LF are reported at the depth of 3 cm (67.40), 7 cm (74.00),10 cm (67.60), 13 cm (68.10) and 157 cm (41.30). Rate of change in HF is statistically significant and per cm decrease in HF is 0.167.Unusual observations on HF are reported at the depth of 3 cm (65.90), 7 cm (72.10),10 cm (66.10), 13 cm (66.50) and 157 cm (40.00).

Thus these sites can be classified as MNS I, II and IV meager changes in LF and HF, MNS III increase in LF and HF and MNS V and VI decrease in LF and HF.

The conclusions are as follows,

After studying the sediments of MNS-I to MNS-VI with respect to frequency amplitude of magnetic susceptibility, The profile MNS-I, MNS-II, and MNS-III showed a progressive increase in sediment accumulation, while MNS-IV, MNS-V, and MNS-VI, represented the low sedimentation rate, a low energy lake, except after 400 yrs B.P. with increased land use. Further in this catchments soil losses under recent mining activity and agriculture land use represent increased rate as compared with that under early Holocene forest cover. The main change recorded was an increase in erosion rate during recent time. Study of historical records has shown that it has happened with an expansion of ploughed land in the study area. The agricultural intensification had increased the soil losses from the catchments. Without doubt, land degradation has occurred in Mansar area in recent times due to population growth and aggression pressure.

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