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RESEARCH ARTICLE

AN ASSESMENT OF MORPHOMETRIC CHARACTERISTICS OF COASTAL LAKES OF CUDDALORE DISTRICT, TAMILNADU, SOUTH EAST COAST OF INDIA, BY USING GIS

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Abstract

Morphology of lake means that study of lake forms and form elements, their genesis and their role in a broad physical Limnological perspective. The main purpose of this work is to present a thorough discussion concerning definitions and determinations of morphometrical characteristics of two significant coastal lake system in Tamilnadu. The bathymetry and geometry of Perumal and Veeranamlake play a key role in the processes occurring within the lake. The lakes are elongated oval shaped and the long axis lying in the N-S orientation in Veeranamlake and NE-SW orientation in Perumal lake. Overall, both the lakes are shallow, with a mean depth of 3.1 m and 3.38 m in Perumal and Veeranamlake respectively. The maximum depth of Perumallake is 5.6 m and Veeranam lake is 10.0 m. These two lakes are having a symmetrical bottom bathymetry, which is roughly bowl shaped; with broad shallow lake margins has a gentle slope along NW, and western side. There is a nearly circular shaped deep area in the lake center.

1. Introduction

One of the oldest limnological principles is that basin morphometry influences lake metabolism [(Thienemann, (1925); Neumann, (1932)]. As a consequence, many studies have demonstrated how lake morphometry affects the rates of certain processes and the distribution of certain physical, chemical and biological parameters, such as lake trophic state[(Pinel-Allou*et al.*, (1990)],phytoplankton and submerged macrophyte abundance, structure and production [(Schindler,(1971); Duarte and Kalff, (1986, 1988); Pinel-Allou*et al.*, (1990)], loading, dilution and recycling of nutrients [(Pick and Lean, (1987)], ratio of nitrogen to phosphorous[(Smith, (1982)], light climate [(Sterner,(1990)], sediment focusing[(Blais and Kalff, (1995)], thermal structure [(Robertson and Ragotzkie, (1990)], and dissolved humic matter [(Eloranta, 1986)], among others. In this sense, [Guiral and Pérez (1980)] pointed out the importance of cartography and morphometry of lake ecosystems as a first step in any kind of aquatic research.

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However, most of the morphometric analyses carried out now a days are based on measures of surface dimensions, but this type of study is insufficient to establish a good relationship with the hydrogeochemical and biological parameters of an aquatic ecosystem. That is why in this present study a more detailed analysis of morphometrical parameters of both, surface and subsurface dimensions characters areincluded.Some morphological features of lakes, such as depth and lake volume, have been proved significantly related to nutrient concentration or eutrophication status[(Hamilton et al., (2001); Taranu& Gregory- Eaves,(2008);Wenzhi Liu et al., (2010)].

2. Study area

The study area has chosen for the present study area lake Perumal and lakeVeeranam**,** which are located in the Quaternary formation of the coastal region of the Cuddalore District, Tamilnadu (Fig.1). The Veeranam lake lies between North latitudes 11^0 15' to 11^0 45' N and East longitudes 79^0 30' to 79^0 35' E, forms part of the Survey of India toposheet no. 58

M/11.The Perumal lake lies between North latitudes 11^0 30' to 11^0 45' N and East longitudes $79^0$30' to $79^0$47'30'' E, forms part of the Survey of India toposheet no. 58 M/10. The study area is bounded by Gadilam river in the north and Coleroonriver in the south.

3. Methodology (Bathymetry)

Bathymetry map was prepared using the Garmin GPS Map-178 (Chart plotter / sounder) Surfer 8 and Arc GIS 9.3. The formulae of the morphometric parameters of [Hakanson (1981)]are applied to compute lake volume and slope.

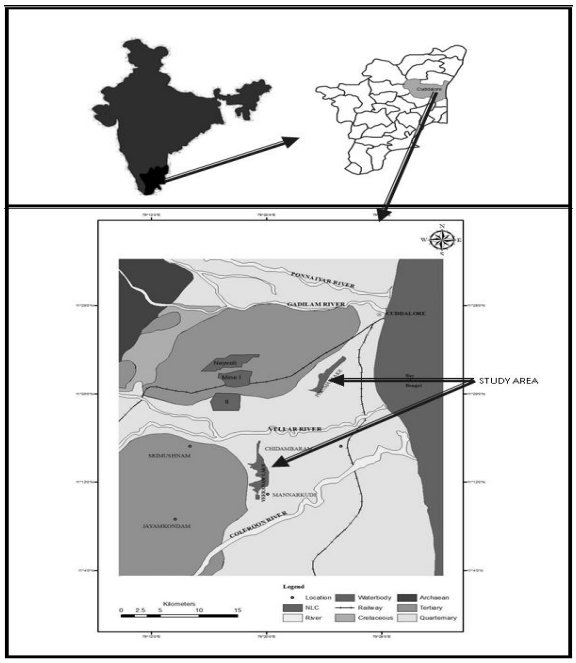

Fig.1. Study area map

4. Results and Discussion

Lake morphometry deals with the quantification and measurement of lake forms and form elements. The comparison of significant parameters of Perumal and Veeranam lakes are shown in table.1.

4.1. Bathymetry

Bathymetric maps are the source of most morphometric data used in limnological, hydrological and sedimentological contexts. The reliability of the morphometric data will depend on the accuracy of the hydrographic map, which in turn will depend on the intensity and accuracy of the hydrographic survey. The bathymetric map of Perumal and Veeranam lakes has been shown in (fig 2). The bathymetric map with 0.3 m interval and of with 0.8 m interval shows that NE-SW orientation and N-S orientation, with sub-oval shape to the Perumal and Veeranam lake correspondingly. In general both the lakes exhibits steeper on the bank and flatter in the middle zone, with the shore line length of 31.64 km in lakePerumal and of 43.64 km in lake Veeranam.

Table.1. Morphometric parameter of the lake Veeranam and lake Perumal [(according to Hakanson, (1981)].

Morphometric parameter	**Morphological Value Veeranam lake**	**Morphological Value Perumal lake**
Area	19.42 km^2	13.24 km^2
Shoreline length	43.64 km	31.61 km
Shore development	0.634	2.45
Maximum length	14.63 km	11.54 km
Maximum width	3.67km	2.07km
Mean width	1.32 km	1.14 km
Maximum depth	10.0 m	5.6 m
Volume	65639.6 m^3	41044 m^3
Mean depth	3.38 m	3.1 m
Relative depth	0.53 m	0.136 m
Median depth	2.7 m	3 m
Mean slope	1.86%	1.86%
Dynamic Ratio	0.25	0.020
Direction of major axis	N-S	NE - SW

The lake surface area (a) is within the limits of shoreline. The total area of the water bodies of Perumal and Veeranam lakes are 13.42 km^2 and 19.42 km^2 respectively. The storage capacity of lake is known as volume. The volume is the linear approximation of the volume with the lakes having the concave relative hypsographic curve, which is determined based on the data on depth and area. The volume of Perumallake is 41044.0 m^3 and for Veeranam lake is 65639.6 m^3

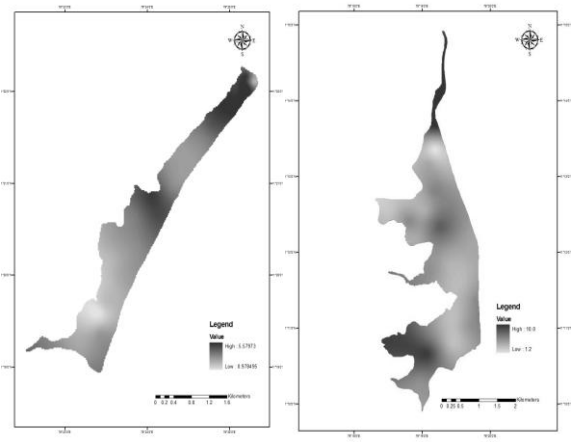

Fig.2. Bathymetry map of study area in lakePerumal and lake Veeranam

4.2. Length

Maximum Length (L_{max}) is defined by the line connecting the two most remote points on the shoreline (Fig.3). In regular basins the line is generally straight and contours with the maximum effective length (Le). The L_{max} is 11.5 Km in lakePerumal and 14.63 km in lake Veeranam. Consequently, the L_{max} cannot always be given a definite value. It has limited Limnological use, and is primarily to be considered as descriptive measure.

Maximum effective length (L_e) is defined by the straight line connecting the two most distant points on the shoreline over which wind and waves may act without interruptions from land or islands. L_e in Perumallake is 6.41 km and in Veeranam lake is 9.15 km. This is an important parameter in many Limnological and hydrological contexts.

4.3. Width

The maximum width B_{max} is defined by the straight line at a right angle to the maximum length (L_{max}), which connects the two most remote extremities on the shoreline (Fig 3. A and B).B_{max} in lakePerumal is 2.07 km and lake Veeranam is 3.67 km. B_{max} is as like L_{max}, primarily a descriptive value in Limnological contexts. The Maximum effective width (B_e) is defined by the straight line on the lake surface, perpendicular to the maximum effective length (Le), which connects the two most distant points on the shoreline. The B_e in lake Perumal is 1.37 Km and in lake Veeranam is 2.48 Km.

Mean width ($\bar{B}$)is defined by the ratio of lake area to $L_{max.}$ The Mean width ($\bar{B}$) of the lake Perumal is1.14Km and in lake Veeranam is 1.32 Km.

4.4. Depth

Maximum Depth (D_{max}) is the greatest known depth. D_{max} in lakePerumal is 5.6 m and in lake Veeranam is 10.0 m. Whereas Mean depth ($\bar{D}$) shows lesser difference in its value for both the lakes as 3.10 m in lake Perumal and 3.38 m in lake Veeranam. According to the definition of median depth (D_{50}), 50% of the lake area below the D_{50} value and 50% above. The D_{50} valuemay be used, to determine the lake bottom roughness (R), which is a useful parameter in sedimentological contexts and in the optimizational model for lake hydrographic surveys. In lakePerumal it falls as 3.00 m and in lake Veeranam it is 2.70 m.

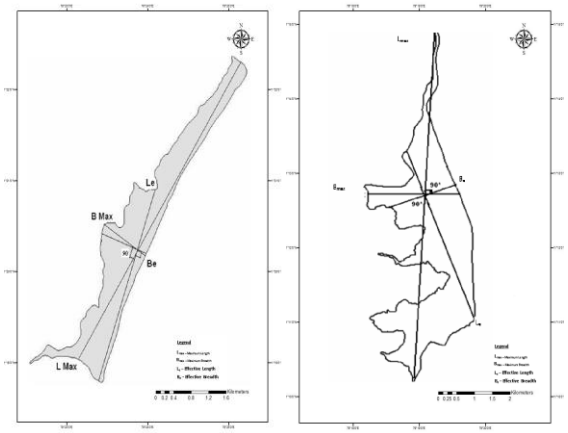

Fig.3. Morphometry map of study area in lakePerumal and lake Veeranam

Relative depth (Dr) is defined by the ratio of D_{max} to mean diameter of the lake. The Dr is 0.14 m in lakePerumal and 0.53 m in lake Veeranam, which is a normal figure for large basins. Small and deep lakes have high Dr-values. The relative depth may be used to describe stability of stratification of lakes. [Neumann (1959)] concluded that the depth ratio provides a useful approximation to lake form. The Depth Ratio value for Lake Perumal is0.553 and for lake Veeranam is 0.340.

4.5. Slope

Wentworth's method of slope determination is a general and easier method to follow. The nature of slope of the Lake Perumal and lakeVeeranam are shown in the (Fig 4).

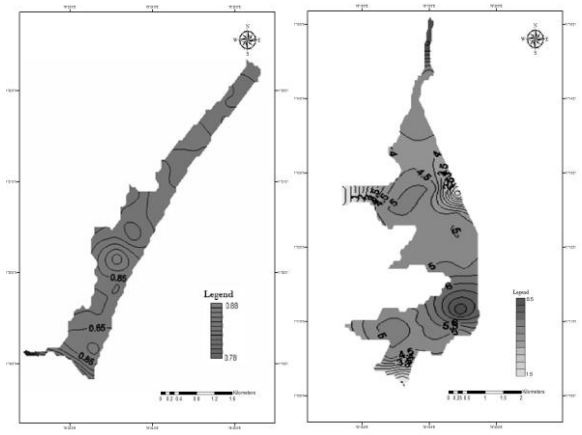

Fig.4. Slope map of study area in lakePerumal and lake Veeranam

The slope for an arbitrary station in lake may be determined with the help of contour difference expressed in the form of height in a particular transect of direction as the major slope axis, which can be determined from the bathymetric map.

The mean slope (α) of the Lake Perumal and Lake Veeranam shows no difference in its value as 1.86%, both lakePerumal and Veeranam has slight shore slope, although there is some dissimilarity between the two shorelines. [Ortega and Guerrero, (2003)] observed that the slight slope nature in lakes allows for colonisation of the sediment by submerged macrophytes and halophytes.

4.6. Dynamic ratio (DR)

Dynamic ratio is a morphometrical parameter designed to represent bottom dynamic conditions. The influence of this parameter over processes such as lake desiccation and other processes related to the water-sediment interface denoted its importance. DR is determined by adopting the formula as is follows,

$DR = \sqrt{(a\ 10^{-6})\ D^{-}}$, where a is total lake area in Km^2. D^{-} is mean depth

The DR value of Lake Perumal is 0.020 and in lakeVeeranam is 0.25. The dynamic ratio values indicates that, both the lakes have lower bottom areas exposed to wind / wave energy which is an useful tool to know the amount of sediment available for re-suspension on the erosion and transportation areas, the fraction that goes to deep waters, and the fraction that goes to surface waters. The values obtained indicate that 65.3% of the matter available can be assumed to be transported to deep waters and 34.7% to surface to surface waters.

4.7. Lake bottom roughness(R)

Lake bottom roughness (R) is a measure of the degree of irregularity of the bottom. This value is only defined for whole Lakes,

$$R = \frac{0.165 \times (Ic + 2) \times (Lo + 1)}{D_{50} \times \sqrt{a}}$$

Where, R is the normalised lake bottom roughness
Ic is the contour line interval in m
D_{50} is the median depth in m

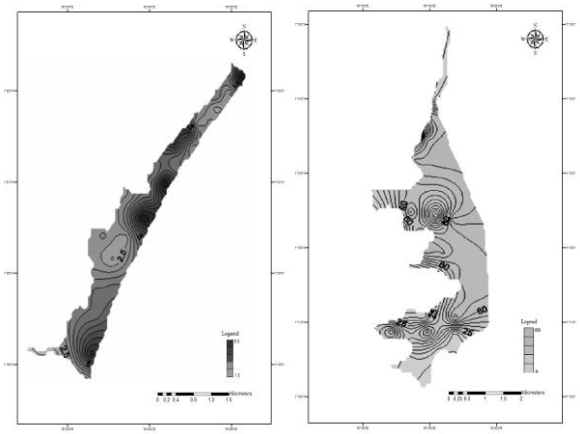

Fig.5. Lake Bottom Roughness map of study area in lakePerumal and lake Veeranam.

The bottom roughness of the Perumallake is 16.27 and for Veeranam lake is 33.6. Form roughness (Rf) is a preferable measure to compare the degree of bottom irregularity in lakes, which is determined by adopting the following formula;

$$Rf = \frac{0.165*(Ic+2)*Lo+ 1}{a}$$

Where

Rf is form roughness
Ic is the contour line interval in m
Lo is the shoreline length in Km.
a is the lake area in Km^2

The bottom irregularity in Perumal and Veeranam lakes are shown in (fig.5) to illustrate in quantitative terms of the areal distribution of the Rf values. The form roughness shows the relative differences in bottom irregularity within the lake area.

5. Conclusion

The bathymetry and geometry of Perumallake play a key role in the processes occurring within the lake. The bathymetric map

prepared in the present study will be useful to compare changes in lake surface area and storage capacity in future. Mean depth of both lakes are greater than median depth, as it is characteristic of a slightly convex basin. Perumal and Veeranam lakes are showed the DR value of 0.55 and 0.34 respectively, similar to an elongated ellipsoid form and it is characteristic of shallow lakes with bottoms [Carpenter, 1983)]

The most important human impact affecting Veeranam lake ecosystem is mainly due to an inadequate vegetative matter on its shorelines. This implies changes in morphometry parameters and destruction and substitution of littoral plant communities around the lake. The important anthropogenic impact affecting the Perumallake is Neyveli Mine water with good amount of suspended sediment causes Siltation. This leads to changes in depth and roughness of the lake. Hence in the present attempt it is emphasized the importance of morphological study in terms of possible future changes in morphometrical parameters as a consequence of human impact.

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