

Postprint: Preliminary Study on Lake Morphology in the Badain Jaran Desert

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Abstract

Lake morphology constitutes the foundation of lake research. While lakes in the Badain Jaran Desert have attracted widespread attention from various sectors, studies on their morphological characteristics remain scarce. This paper employs an integrated approach combining ultrasonic echo sounder with RTK-GPS measurement systems to conduct bathymetric surveys of ten relatively large lakes in the Badain Jaran Desert, thereby obtaining comprehensive lake morphological data. Regarding lake dimensions, Buerde distinguishes itself from the other lakes by possessing the largest surface area yet the smallest maximum depth. In terms of morphological characteristics, the ten lakes collectively exhibit features distinctive to shallow, flat-bottomed lakes typical of arid regions. Owing to endogenic tufa and the underlying mobile desert environment, conventional methods for estimating lake volume based on surrounding topography prove inapplicable to Badain Jaran Desert lakes. Consequently, utilizing the acquired measurement data, this study proposes an empirical formula specifically tailored for estimating the volume of lakes in the Badain Jaran Desert.

Full Text

Abstract

Lake morphometry is of fundamental importance for understanding lake ecosystems, but it has been previously neglected in research on the lakes of the Badain Jaran Desert. Here, we conducted a bathymetric survey of 10 large lakes in the desert using an ultrasonic depth finder and RTK-GPS measurement system. Bathymetric data were used to chart relative hypsographic curves. Moreover, morphometric parameters were calculated using detailed lake depth data. In terms of lake size, Buerde Lake was distinguished from the other lakes by having the largest water area but the smallest maximum depth. However, the remaining nine lakes were similar in water area, volume, maximum depth, and

mean depth. Regarding lake shape, the shorelines of most lakes were nearly circular, except for Buerde Lake, Yihejigede Lake, Sumujilin Lake, and Yindeertu Lake. All the lakes can be considered shallow lakes. The method of using peripheral terrain to estimate lake volumes is unsuitable for studying the lakes of the Badain Jaran Desert due to the location of the lakes and the presence of endogenous travertine. Therefore, this study presents a mechanism-based empirical formula for estimating the volumes of lakes in the Badain Jaran Desert in the future.

Keywords: lake morphometry; lake depth measurement; lake volume estimation; Badain Jaran Desert

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Methods

Bathymetric surveys were conducted on 10 large lakes in the Badain Jaran Desert between June 2016 and June 2017. The measurement system consisted of an ultrasonic depth finder coupled with RTK-GPS, achieving an accuracy of $\pm 2 \text{ cm} + 1 \times 10^{-4} D$ (where D represents distance). The WGS-84 coordinate system was employed with a measurement point spacing of 2 m. Shoreline data were extracted from Google Earth imagery, and water level measurements were collected during the survey period. Field measurements in May 2016 revealed water level variations of approximately 0.3 m [35-36].

Results

Statistical analysis of shoreline development indices for the 10 lakes yielded values ranging from 1.35 to 1.60, with most clustering between 1.43 and 1.58. The $Z_{\text{mean}}/Z_{\text{max}}$ ratios varied from 0.55 to 0.70, with an average of 0.66, confirming the shallow nature of these water bodies. The shoreline development index was less than 2% for most lakes, indicating relatively simple geometries. The lakes exhibited similar morphometric characteristics, with Buerde Lake being the exception due to its large surface area and shallow depth.

Discussion

The peripheral terrain method for volume estimation is unsuitable for Badain Jaran Desert lakes due to the presence of endogenous travertine and the unique hydrogeological setting. Comparisons with established methods (Hakanson-Peters [39], Sobek [40], and Heathcote [41]) support the development of a new empirical approach. Sedimentation rates determined from ^{210}Pb and ^{137}Cs dating range from 0.16 to 0.21 $\text{cm} \cdot \text{a}^{-1}$ [48, 49], indicating relatively slow accumulation. The proposed mechanism-based empirical formula provides a more reliable

method for future volume estimation of these lakes, accounting for their specific geological and hydrological conditions.

Figure Captions

Fig. 3 Peripheral terrain, underwater topography and water depth-area curves of the 10 lakes (1)

Fig. 4 Peripheral terrain, underwater topography and water depth-area curves of the 10 lakes (2)

Fig. 5 Peripheral terrain, underwater topography and water depth-area curves of the 10 lakes (3)

Fig. 6 Statistical results of shoreline development, $Z_{\text{mean}}/Z_{\text{max}}$ ratio and relative water depth

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