Acta Ecologica Sinica xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Acta Ecologica Sinica

journal homepage: www.elsevier.com/locate/chnaes

Hydrogeochemical characterization of Yercaud lake southern India: Implications on lake water chemistry through multivariate statistics

V. Gopal [a], Hema Achyuthan [a,*], M. Jayaprakash [b]

[a] Department of Geology, Anna University, Chennai –25, India
[b] Department of Applied Geology, University of Madras, Chennai –25, India

ARTICLE INFO

Article history:
Received 10 May 2017
Received in revised form 3 November 2017
Accepted 13 November 2017
Available online xxxx

Keywords:
Hydrogeochemistry
Multivariate statistical analysis
Surface and deeper water
Quality risk assessment
Agriculture

ABSTRACT

In this paper, a study on the surface and deeper waters of the Yercaud Lake, Tamil Nadu, South India, was carried out to understand the geochemistry of the lake waters and also to determine its utility for agricultural purposes. Totally, 50 surface and deep water samples were collected from Yercaud Lake. Major ion and heavy metals were measured. The data obtained were interpreted using the lake water composition. The mean concentration of physicochemical parameters and heavy metals for the surface and deep waters have the following values, pH (7.6), EC (263.4), Ca^{2+}(16.3), Mg^{2+}(7.4), Na^{+}(19.2), K^{+}(1.5), Cl^{-}(18.2), NO_3^{-}(1.5), SO_4^{2-}(1.5), HCO_3^{-} (97.9), Fe (1.3), Mn (0.1), Cr (0.4), Cu (0.005), Pb (0.31), Zn (0.01), Co (0.095) and Ni (0.075). The data generated reflects that the water samples are dominated by recharge process, especially due to the monsoonal rains and natural springs within the lake. The geochemical data reveals that the lake water is suitable for the agricultural purpose and the chemistry of water is mainly influenced by the weathering of bedrock, especially the charnockites bedrock. The sodium adsorption ratio and sodium percentage (%Na) values indicate that the lake water is suitable for irrigation. Dominant heavy metals in the lake waters are mainly because of the lithogenic as well as through minor anthropogenic inputs. Based on our data it is noted that proper management plans are required to monitor the pollution source in the lake, with strict policy measures.

1. Introduction

Lakes are the one of the most adaptable ecosystems in the world and also they are most sensitive system to environmental pollution and anthropogenic impacts [1]. In India, the lakes and reservoirs are varying in degrees of environmental degradation and contamination, encroachments, eutrophication (input from the domestic and industrial effluents) and also by silting. The increase of sudden population during the previous century around the lakes and reservoirs become the sink of contaminants. Lakes are being stagnant water bodies are more susceptible to pollution than the rivers, but lakes are the self-purification process are less effective than rivers. The contamination in the lakes affects the flora and fauna and also in human health if the water is used for irrigation and domestic supply. The quality of lake water depends not only on natural processes such as rainfall, weathering of crustal and surrounding rock matrix, etc., but also depends on anthropogenic activities like urban, industrial, and agricultural activities [2]. In recent years the growth of population, agricultural practices and sewage runoff from surrounding urban areas have increased the nutrient inputs which results in accelerated eutrophication [3,4].

Freshwater lakes situated at the higher elevations are more vulnerable to atmospheric inputs than lowland lakes due to factors like climate, shallow soils, small watersheds and rapid flushing rates [5–8]. Generally the hydrochemistry of a lake depends on the surface inflows or/and precipitation and rock weathering of its catchment [9], climatic changes [10,11], and human activities [12]. Heavy metal pollution in lake water is the significant environmental distress due to their toxicity, persistence, bioaccumulation and biomagnification in the food chain [13,14]. For human society, lakes are important sources for water and food. Thus, heavy metals in lakes possess adverse biologic effects on human health through drinking and irrigation water and consuming aquatic products [15,16]. A number of recent studies have been discussed in the distribution and sources of heavy metals in various freshwater systems [17–19].

The monitoring of heavy metal pollution and hydrogeochemistry of lake water is essential in order to provide the baseline data which is very useful for the authorities for environmental management and water planners. Most of the lake water is used for agricultural purposes in the surrounding areas. A very few studies on the water quality of the fresh water lakes are available that are located at the highest elevation of the South Indian region [20]. Several studies on the various hydrogeochemical parameters of the high-altitude freshwater lakes of India have been carried out [21–31]. A study has been carried out in such on a freshwater Yercaud lake situated at an altitude of about 1515 msl,

* Corresponding author.
E-mail address: hachyuthan0@gmail.com (H. Achyuthan).

https://doi.org/10.1016/j.chnaes.2017.11.003
1872-2032/

Tamil Nadu, South India. The main objective of this paper is to identify the sources of the dissolved ions and the hydrogeochemical processes regulating the major ion chemistry with special emphasis on agricultural purposes and heavy metal concentration in this freshwater lake.

1.1. Regional setting

Yercaud lake is located (11°13′15″N and 77°28′07″E) in the Servarayan range (anglicized as "Shevaroys") of hills in the Eastern Ghats near Salem, Tamil Nadu. It is located at an altitude of 1515 m from the above mean sea level (Fig. 1) [32]. The geological formation of this region comprises both basic and acid types of Charnockite bedrock of the Archaean age, weathered into the rugged masses of hills. The Shevaroy range is extensively covered with green grass and has no dense forest cover. The area is under the influence of both the southwest and northeast monsoons but the northeast monsoon chiefly contributes to the rainfall in the district (1500–2000 mm/year). The climate of Yercaud is the moderate one with the maximum temperature is 34 °C during summer (March to May) and the minimum is 16 °C during the winter, winters are fairly mild, starting in September and ending in December. During winter, the hills are covered in mist. Winters range from 12 °C to 25 °C, and Summers from 16 °C to 30 °C. The coffee bushes blossom in April and offer a spectacular view. The climate is also particularly pleasant. The Shevaroy hills experience a contrasting climate. Humid climate at the hill top and semi-arid climate at the foot hills humidity between 68% and 87%. The bathymetry of the lake floor has a maximum depth of 5.1 m and a minimum depth of 1.5 m [33].

2. Materials and methods

A total of 50 samples of surface and bottom water (25 samples from each) was collected from the lake during December 2015, so as to assess the overall water quality of the study area. Sampling and analyses were carried out using the standard procedures [34]. 500 ml of water samples were collected for major ions in a clean polyethylene bottle and the deeper samples were collected with depth ranges from 1 m to 2 m. Then the samples were sealed, labelled and brought to the laboratory and stored at 4 °C, and then it was filtered using 0.45 μm filter paper. pH, EC (Electrical conductivity), TDS (total dissolved solids) was measured in situ using a portable multi-parameter (HACH-Sension 156). The coordinates of the sampling locations were measured using a handheld GPS. 100 ml of water samples were collected for heavy metals and it was acidified in the field using nitric acid.

Major anions (Cl^-, NO_3^-, SO_4^{2-}, HCO_3^-, precision ±5–10%) and major cations (Ca^{2+}, Mg^{2+}, Na^+, K^+, with the analytical precision of ±5–10%) were measured using ion chromatography (DX-120). The accuracy of the results was determined by the ionic balance of water and a 5–10% was noted. Trace metal concentrations (Fe, Mn, Cr, Cu, Pb, Zn, Co and Ni) were determined by graphite furnace atomic absorption spectroscopy (GFAAS) Varian Model AA-700, using air-acetylene flame. The accuracy of the analysis was tested using the certified reference material MESS-1 from the National Research Council of Canada. The precision of the metal analysis was controlled by including triplicate samples in analytical batches and blanks. The relative standard deviation of the mean of triplicate measurements was <5%. Then the results were categorized for hydrogeochemistry using Aquachem software (version 5.1). Correlation and principal component analysis were performed using the Statistical Package for Social Sciences (SPSS) software (Version 21.0).

3. Results and discussion

Maximum, minimum, and the average concentration of pH, EC, major ions and heavy metals are presented in Table 1.

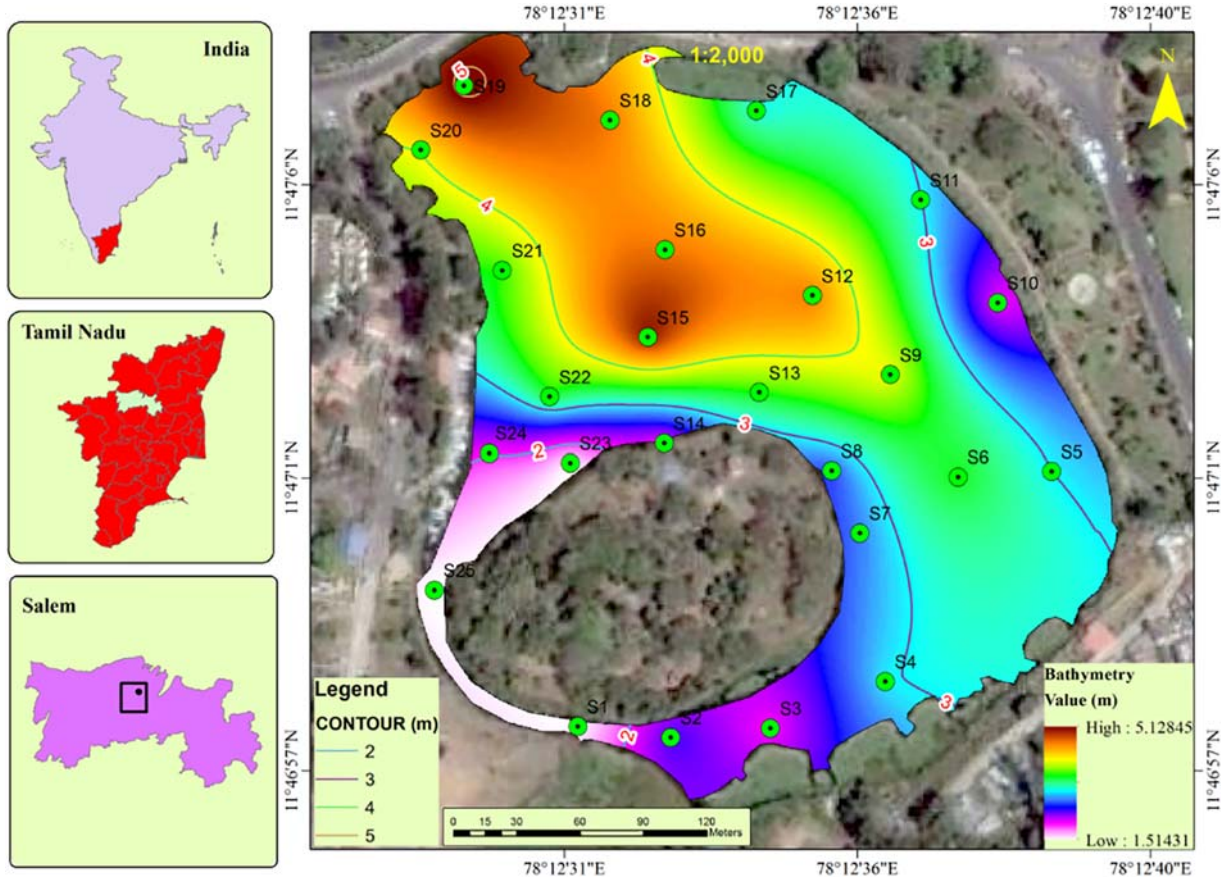

Fig. 1. Location map of the Yercaud Lake.

Please cite this article as: V. Gopal, et al., Hydrogeochemical characterization of Yercaud lake southern India: Implications on lake water chemistry through multivariate statis..., Acta Ecologica Sinica (2017), https://doi.org/10.1016/j.chnaes.2017.11.003