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Principal component analysis of the Phytoplankton interaction with the Environmental factors in Kottakayal (Kerala, India)

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ABSTRACT

In the current examination, we have analyzed the association between the principle ecological parameters and the quantitative characteristics of the phytoplankton networks in Kottakayal for three seasons (November 2015- October 2017). The point of this examination was to recognize the key natural elements affecting the phytoplankton development, by execution PCA investigation dependent on the Pearson correlation matrix. The PCA factors classified into 3 significant segments, for example, PC1, PC2 and PC3 individually. Out of the 23 natural variables 8 elements were found to have positive values and remaining 15 components had negative Eigen values. Just 4 segments like atmospheric temperature, TSS free CO_2, nitrite and silicate had positive values in PC1, PC2 and PC3. The acquired outcomes exhibit the pertinence of the multivariate statistical analysis techniques for the determination of the principle factor impacting the quantitative, spatial and seasonal phytoplankton improvement in water bodies.

Key words: *Principal component analysis, Phytoplankton, Environmental factors, Kottakayal*

Introduction

At present the surface freshwaters around the world, for example, streams, rivers and lakes are experiencing a broad subjective and quantitative, physical, concoction and organic modifications because of hydrological and biogeochemical changes (Carpenter *et al.*, 2011). Their misuse attributes to enormous water level changes, which prompts eutrophication and environmental pressure on the organic networks (Carol *et al.*, 2006). In such manner phytoplankton is a significant pointer of trophic status changes in nature. The structure of the network is an after effect of the incorporated impact brought about by the raised supplement stacking. Thus, they might be increasingly touchy to the joined impacts of the pressure factors than to a solitary pressure source (Cabecinha *et al.*, 2009). Information on the systems that underlie the phytoplankton models can be helpful in executing and arranging the measure to improve water quality. It is essential to dissect the correlation between ecological parameter changes and the phytoplankton elements so as to increase a superior comprehension of the elements, liable for the yearly phytoplankton community fluctuations (Arhonditsis *et al.*, 2004). There are generous challenges in the utilization and translation of huge informational indexes coming about because of observing projects, particularly if the quantity of study parameters is huge. Factor analysis is especially valuable for the depiction of the relationship of a number of observed random environmental variables (Wang *et al.,* 2007). It is actualized for the recognizable proof of the regular changes of the natural components and the phytoplankton groups (Wu *et al.,* 2014). The measurable strategies are valuable for the translation of complex information lattices and the appreciation of the environmental state and water quality in the considered water bodies. Usage of measurable strategies for portrayal and assessment of the surface freshwater quality has demonstrated to be a helpful tool in the examination of fleeting and spatial changes brought about by natural and anthropogenic elements identified with season changes (Shrestha and Kazama, 2007). The point of the current investigation was to actualize principal component analysis so as to diminish the quantity of factors by consolidating the corresponding elements in new principal components and to distinguish the factors with the most grounded sway on the phytoplankton development in Kottakayal.

Materials and Method

The investigation was directed in the Kottakayal that lies between 8°51' to 8°54' North Latitude and 76°40' to 76°43' East longitude near Pallimon-Ithikkara confluence (Figure 1). The wetland has a zone of 2 square km. Test were collected from six sites for pre-monsoon, monsoon and post-monsoon seasons. The water tests were collected and analyzed utilizing standard methods as per (APHA 1995). Statistical PCA analysis was directed to recover the key patterns between variables of the environment and the phytoplankton information. Pearson's correlation matrix, mirroring the interconnection correlation between parameters and their level of significance was created so as to set the quantity of principal components. Statistical information analysis was performed with SPSS v. 13 (IBM Analytics).

Results

The Principal Component Analysis was done for the phytoplankton species abundance, against environmental parameters and nutrients. PCA was applied to the 23 variables collected during three seasons throughout the year. Primary factors under PC1 (Figure 2) which influenced phytoplankton distribution in the lake include atmospheric temperature (0.14072), TSS (0.04437), free CO2 (0.091), nitrite (0.14583), silicate (0.03232), NPP (0.25649), GPP

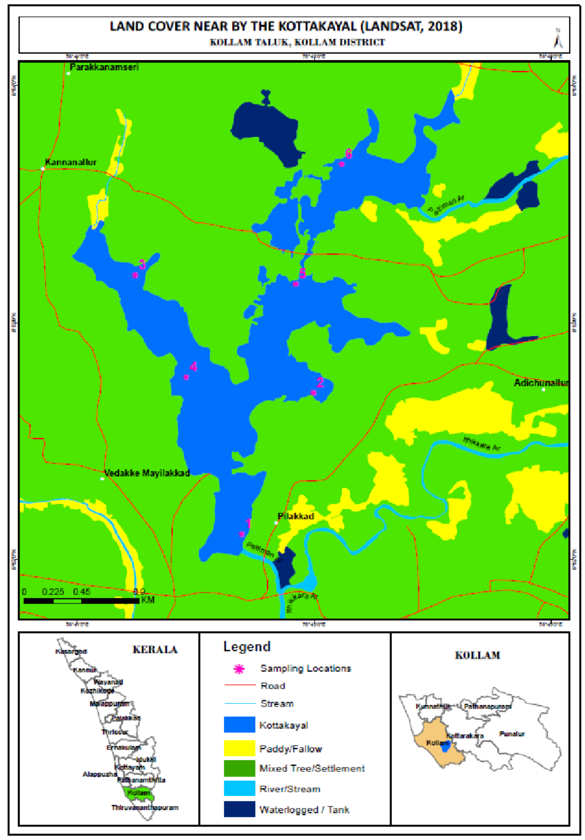


Fig. 1. Location map of the study area with sampling stations

(0.29602) and CR (0.14331). Under PC2 factors such as atmospheric temperature (0.35181), surface water temperature (0.35294), depth (0.2791), transparency (0.30796), TDS (0.09671), TSS (0.28364), TS (0.29969), free CO_2 (0.3291), DO (0.07014), total hardness (0.05913), Ca hardness (0.02857), Mg hardness (0.02037), nitrite (0.11986), nitrate (0.04823), phosphate (0.09567), silicate (0.19693) and CR (0.02078) were found to influence the phytoplankton distribution in Kottakayal. Under PC3 factors like atmospheric temperature (0.0702), TSS (0.28778), TS (0.2545), DO (0.27047), total alkali (0.34386), total hardness (0.05835), Mg hardness (0.06599), nitrite (0.16601), nitrate (0.20176), silicate (0.36663), NPP (0.25961) were found to influence the phytoplankton distribution in the lake. Out of the 23 ecological factors 8 factors were found to have positive values and the remaining 15 components had negative Eigen values. Only 4 components like atmospheric temperature, TSS free CO_2, nitrite, and silicate had positive values in PC1, PC2, and PC3.

Primary factors under PC1 which influenced phytoplankton distribution during pre-monsoon period were atmospheric temperature (0.10993), surface water temperature (0.09831), depth (0.12683), transparency (0.22091), EC (0.21023), TDS (0.21946), TSS (0.12398), TS (0.18911), free CO_2 (0.1553), DO (0.29616), total hardness (0.28225), Ca hardness (0.28625), Mg hardness (0.29443), chloride (0.26351), salinity (0.25294), nitrite (0.11891) and silicate (0.19814) (Figure 3). Principal component analysis of hydro-biological parameters and phytoplankton abundance during pre-monsoon yielded 17 components having positive values and 7 components with negative values. Under PC2, factors like atmospheric temperature (0.09221), surface water temperature (0.40667), depth (0.05204), TSS (0.01751), free CO_2 (0.30723), nitrite (0.14374), silicate (0.06009) and NPP (0.04603) were found to influence phytoplankton distribution during pre-monsoon period. Under PC3, factors such as atmospheric temperature (0.44071), surface water temperature (0.06926), TSS (0.05697), TS (0.09986), free CO_2 (0.15713), total alkalinity (0.16551), Mg hardness (0.06372), nitrate (0.07566), silicate (0.1742), GPP (0.12459) and CR (0.28898) were found to influence phytoplankton distribution in the water body during pre-monsoon season. Only 4 components like atmospheric temperature, surface water temperature, free CO_2, and silicate had positive values in PC1, PC2, and PC3.

Primary factors under PC1 which influenced phytoplankton distribution during monsoon period in the lake included atmospheric temperature (0.14072), TSS (0.04437), free CO_2 (0.091), nitrite (0.14583), silicate (0.03232), NPP (0.25649), GPP (0.29602) and CR (0.14331) (Figure 4). Under PC2 factors such as atmospheric temperature (0.35181), surface water temperature (0.35294), depth (0.2791), transparency (0.30796), EC (0.0291), TDS (0.09671), TSS (0.28364), TS (0.29969), free CO_2(0.3291), DO (0.07014), total hardness (0.05913), Ca hardness (0.02857), Mg hardness (0.02037), nitrite (0.11986), nitrate (0.04823), phosphate (0.09567), silicate (0.19693) and CR (0.02078) were found to influence the phytoplankton distribution in Kottakayal during monsoon period. Under PC3 factors like atmospheric temperature (0.0702), TSS (0.28778), TS (0.2545), DO (0.27047), total alkali (0.34386), total hardness (0.05835), Mg hardness (0.06599), nitrite (0.16601), nitrate (0.20176), silicate (0.36663), NPP (0.25961) were found to influence the phytoplankton distribution in the water body during monsoon period. Out of the 23 ecological factors 8 factors were found to have positive values and remaining 15 components had negative Eigen values. Only 4 components like atmospheric temperature, TSS, free CO_2, nitrite and silicate had positive values in PC1, PC2 and PC3.

Primary factors under PC1 which influenced phytoplankton distribution during post-monsoon period in the water body included atmospheric temperature (0.08186), surface water temperature (0.11871), depth (0.26578), transparency (0.11718), EC (0.1826), TDS (0.19906), TSS (0.2352), TS (0.2831), DO (0.13513), total alkalinity (0.2953), total hardness (0.09576), Ca hardness (0.18667), Mg hardness (0.17346), chloride (0.29431), salinity (0.31024), nitrite (0.18951), nitrate (0.00396) and silicate (0.25497). Eighteen components had positive values and 6 had negative Eigen values. (Figure 5). Under PC2 factors such as atmospheric temperature (0.32004), surface water temperature (0.35003), depth (0.14232), TSS (0.25191), TS (0.03918), free CO_2 (0.32913), total alkalinity (0.09633), nitrite (0.31038), nitrate (0.14692), silicate (0.09987), NPP (0.1773) and GPP (0.07736) were found to influence the phytoplankton distribution in Kottakayal during post-

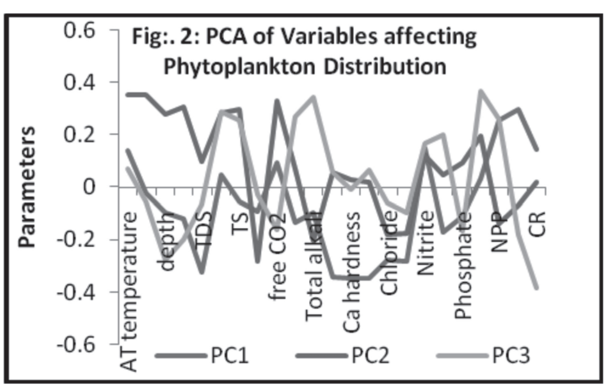


Fig:. 2: PCA of Variables affecting Phytoplankton Distribution

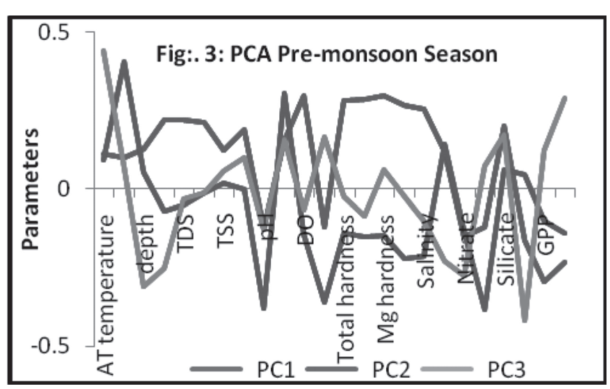
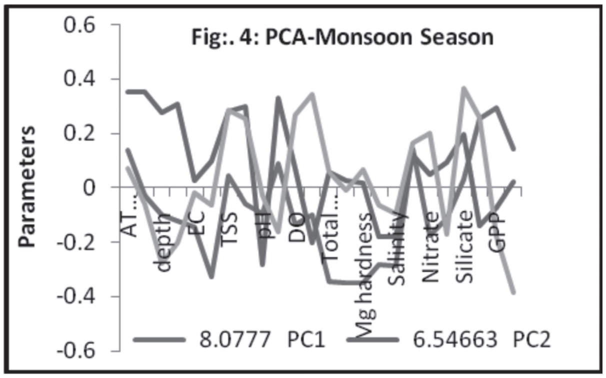
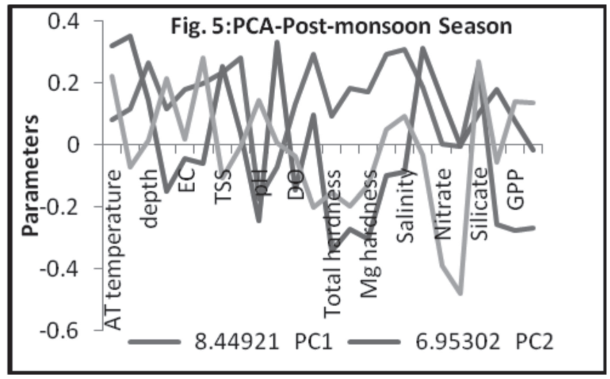


Fig:. 3: PCA Pre-monsoon Season





monsoon period. Out of 23 components 12 had positive values and 11 components had negative Eigen values. Under PC3 factors like atmospheric temperature (0.22554), depth (0.01534), transparency (0.21656), EC (0.0185), TDS (0.28288), pH (0.14539), free carbon dioxide (0.00891), chloride (0.05053), salinity (0.0944), silicate (002698), GPP (0.14127) and CR (0.13874) were found to influence the phytoplankton distribution in the water body during post-monsoon period. Out of the 23 ecological factors 11 factors were found to have positive values and remaining 12 components had negative Eigen values. Only 3 components like atmospheric temperature, depth and silicate had positive values in PC1, PC2 and PC3.

Discussion

The PCA seeks to establish combinations of variables that can describe the main trends for a particular matrix observed during the study. This statistical method is designed to transform the original data set in a new, unrelated to each other indicators, called principal components that are linear combinations of the original variables (Shrestha and Kazama 2007; Wu *et al.,* 2014). The PCA is a useful tool which makes it possible to identify relationships between species and to describe their seasonal changes (Garate-Lizarraga and Beltrones 1998). Based on the correlation analysis, Out of the 23 ecological factors 8 factors were found to have positive values, and the remaining 15 components had negative Eigen values. Only 4 components like atmospheric temperature, TSS, free CO_2, nitrite and silicate had positive values in PC1, PC2, and PC3. Only 4 components like atmospheric temperature, surface water temperature, free CO_2, and silicate had positive values in PC1, PC2, and PC3. During pre-monsoon, 17 components having positive values and 7 components with negative values. In monsoon, Out of the 23 ecological factors 8 factors were found to have positive values, and the remaining 15 components had negative Eigen values. Only 4 components like atmospheric temperature, TSS, free CO_2, nitrite and silicate had positive values in PC1, PC2, and PC3.

The PCA tries to set up mixes of factors that can portray the fundamental patterns for a specific network seen during the investigation. This factual technique is intended to change the first informational index in another, random to one another markers, considered head parts that are straight mixes of the first factors (Shrestha and Kazama, 2007; Wu *et al*., 2014). The PCA is a valuable instrument which makes it conceivable to recognize connections among species and to depict their regular changes (Garate-Lizarraga and Beltrones, 1998). In light of the connection examination, Out of the 23 environmental elements 8 variables were found to have positive qualities, and the staying 15 segments had negative Eigen values. Just 4 parts like climatic temperature, TSS, free CO_2, nitrite and silicate had positive values in PC1, PC2 and PC3 during pre-monsoon season. Just 4 parts like climatic temperature, surface water temperature, free CO_2 and silicate had positive values in PC1, PC2 and PC3 during monsoon season. During pre-rainstorm, 17 segments having positive qualities and 7 parts with negative qualities. In monsoon, out of the 23 natural elements 8 elements were found to have positive qualities and the remaining 15 parts had negative Eigen values. Just 4 segments like climatic temperature, TSS, free CO_2, nitrite and silicate had positive values in PC1, PC2 and PC3 during post-monsoon season.

This perspective is inacceptable concurrence with prior works that they have brought up that these parameters are the most significant factor in controlling the appropriation of phytoplankton abundance in freshwater environments (Long *et al.,* 2013). In post-monsoon, out of 23 ecological factors 12 had positive values and 11 components had negative Eigen values. Out of the 23 natural elements 11 variables were found to have positive values and the staying 12 components had negative Eigen values. Just 3 segments like atmospheric temperature, depth, and silicate had positive values in PC1, PC2, and PC3. The outcomes exhibit the significant role of the macronutrients accessibility for the phytoplankton networks. These outcomes are upheld by comparative investigations (Sahu *et al.*, 2012). Statistical techniques frequently find significant relationships in enormous datasets (Luoma and Bryan, 1982). The current investigation affirms the unwavering quality of the multivariate factual strategies for the examination and translation of complex informational collections utilized for distinguishing proof of the variables with the best weight and effect on the quantitative, spatial and occasional phytoplankton development in isolated water bodies. While examining the between relating factors, connections between's at least two parameters are difficult to set up initially. In this manner, multivariate investigations for the translation of enormous ecological and organic datasets have been utilized in plankton research to distinguish connections among abiotic and biotic components and network understanding.

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