P andoh Lake is a fresh water body with susceptibility to the regional phenomenon of weathering and atmospheric precipitation, which controls the major ion chemistry of waters. This study illuminates the seasonal behavior of major ions that directly or indirectly influence the water chemistry and clay mineralogy.

The water quality of the lake is good with respect to DO, pH, EC, and TDS. However, major ions (Cl⁻, PO₄³⁻, HCO₃⁻, NO₃⁻, SO₄²⁻, Na⁺, K⁺, Ca²⁺ and Mg²⁺) show increasing trend from monsoon to winter and then decreasing trends in summer season. The shale, silt, sandstone and quartzite rocks have contributed to the geochemistry of water. The water chemistry is dominated by the congruent dissolution of carbonate minerals and to some extent by incongruent weathering of silicate minerals in the surface sediments. The presence of qualitative amount of NO₃⁻ and PO₄³⁻ shows external inputs in terms of atmospheric deposition and anthropogenic activities. The (Ca²⁺+Mg²⁺)/HCO₃⁻ and SiO₂/(Na⁺+K⁺) ratio reflect the weathering of carbonate minerals and silicate minerals respectively. The (Ca²⁺+Mg²⁺)/T₀⁺ and (Na⁺+K⁺)/T₀⁺ ratios are indicators of dominant cations and support the existence of carbonate minerals in the surface sediments and catchment area. Seasonal variation in these major cation ratios in the Pandoh lake water is indicative of multiple mineral sources. This is supported by the XRD based semi-quantitative analyses of mineral assemblages in the clay fraction (<2 μm) of surface sediments in Lake Pandoh.

The presence of kaolinite / gibbsite infers the impact of seasonal variation on the major ion chemistry of Pandoh Lake. The stability field diagrams for the lake water show that gibbsite and kaolinite are both stable at some point and gibbsite and kaolinite are both found in the lake clay fraction of surface sediments.

Monsoon season shows the contribution of iron compound to inorganic P and total P indicating that Fe-bound P form is the most reactive one in monsoon season and available to lake ecosystem process. The dissolution of detrital apatite into authigenic apatite form is low in monsoon. This study shows that the allogenic origin of most P derived from the sedimentary phosphorus due to active erosion processes. In winter season P was tightly associated with exchangeable and loosely sorbed P, and authigenic P. In summer season P was significantly represented by organic fraction infer that may be due to strong association with silt and clay fractions.
The grain size analysis reveals that not only smaller grain size (< 63 μm) but also larger grain size particles (> 250 μm) play a very important role in the distribution, transport, mobility of metals (Cd, Co, Cu, Fe, Mn, Ni, Pb and Zn) in the Pandoh Lake. The very positively skewed behavior (asymmetry) of surface sediments indicates samples are finely skewed and particles sizes are present in finer fractions. The leptokurtic nature of the sediments indicates the higher kurtosis values and the mixing of a predominant population with minor amounts of coarser materials (winter season). Platykurtic nature indicates poor winnowing without any sorting i.e. all size fractions jumble up. Thus in monsoon and summer seasons, depositional environment is different from the winter season.

The seasonal patterns of metal speciation indicate that in monsoon season all trace metals except Ni, are associated with AFeO, CFeO and Org fractions. However the occurrence of Ni in exchangeable fraction is considered to be weakly bound to surface sediments, consequently easy availability in the system. In winter season, Cd (exch), Cu (carb) and Ni (carb) fractions are high due to shift in pH and DO. Moreover the number of trace metals for exchangeable and carbonate fractions is increasing in summer season i.e. Cd (exch), Cu (exch), Ni (Carb) and Pb (exch). These observations indicate that summer season poses high risk to existing biodiversity in Pandoh Lake ecosystem.

The concentration versus depth patterns showed that all heavy metals are decreasing from top to bottom. The high concentration of heavy metals in upper and middle fractions of core 1 and 2 is attributed to onset of land use changes due to agricultural practices, highway constructions and increasing tourism in this region.

The enrichment factor (EF) for Cd is greater in all seasons while Co is showing high EF only in monsoon and winter. The other potential pollutants that can become problematic in near future are Mn and Pb. Cu, Fe, Ni and Zn are still in the phase of evolution to achieve the threshold limit and act as a pollutant in near future. Maximum \( I_{\text{geo}} \) values for Cd suggests that the Pandoh Lake is polluted with respected this element.

Analysis of polycyclic aromatic hydrocarbon composition in dated sediment profiles from Pandoh Lake reveals differences in intensity and timing of anthropogenic input to each site. Throughout the present century Pandoh Lake has
received input of polycyclic aromatic hydrocarbons derived from fossil fuel, sewage input, road runoff and motor boat use are probable major sources.

Sedimentation rates estimated for the Pandoh Lake are comparable with other Himalayan Lakes. Elemental accumulation rates computed from the sedimentation rates follow the sedimentation rate pattern. Upper and middle layers of core profile shows enrichment of the trace metals. This is attributed to the recent increased input of the elements by anthropogenic activities. Age-depth relationship clearly indicates that sediment layer deposited in 1964 and 1968 contained maximum amount of $^{137}$Cs in Core 1 and Core 2 and coinciding with the year of maximum global fallout (1963). The distribution of total carbon down the core is opposite to $^{210}$Pb$_{ex}$, indicating a poor relationship between them. This also infers that organic matter in Pandoh Lake may be influenced by seasonal variation in the algal biomass production. In Pandoh Lake, the $\text{H}_{\text{org}}/\text{C}_{\text{org}}$ ratio depicts the sedimentary organic matter usually originated from phytoplankton.

In summary, the field and laboratory analysis of physico-chemical parameters of water, heavy metals in bulk sediment, grain size analysis, chemical speciation, PAHs analysis, phosphorus fractionation and sedimentation rate shows that the Pandoh Lake is significantly affected by regional climatic conditions and man-made activities. As it is evident from this study, continuous monitoring i.e. seasonal study is required in order to maintain the ecological balance in Pandoh Lake.