Article

Heavy Metal Estimation and Quality Assurance Parameters for Water Resources in the Northern Region of Pakistan

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Results

Physical Parameters

The pH values range from 5.1 to 9.9, slightly higher than those set by Pakistan Environmental Protection Agency, World Health Organization (WHO) and the United States Environmental Protection Agency (US-EPA) [85]. The highest pH value (9.9) was obtained from a sample in Village Lala Right Bank of River Neelum (DNLM). In contrast, the lowest (5.1) value was obtained from a sample from Mohallah Narr, Vawrragi. EC values ranged from 974.60 µS/cm to a minimum of 6.60 µS/cm (Islampura Kundalshahi.), and the average was 77.05 µS/cm in local drinking water samples studied in DNLM. Some values exceed the permissible level of 400 µS/cm (WHO limit). The EC 912.10 µS/cm was the highest value found in Village Challeana near Challeana bazaar. Other high values were found as 566.60 µS/cm in Janawai, 506.30 µS/cm Kalalot, 486.30 µS/cm Dudgi (Taobutt), 476.50 µS/cm Gurase main, 456.60 µS/cm Kinari Spring, 448.0 µS/cm Dawarian near the bridge and 446.30 µS/cm Sharda main (DNLM). The temperature ranged from 9 °C to 27 °C (mean = 17.79 °C) in the sampling locations. Similarly, TDS values ranged from 912.10 mg/L to 0.07 mg/L. there was a significant difference in TDS values for drinking water samples collected from DNLM. The recommended WHO value for the TDS dose is 385.90 mg/L. The turbidity parameter was also analyzed during the current study. It varied from 0.0 NTU to a maximum of 8.3 NTU in the sample from Gran Kundal Shahi (DNLM). The average turbidity value was 0.97 NTU.

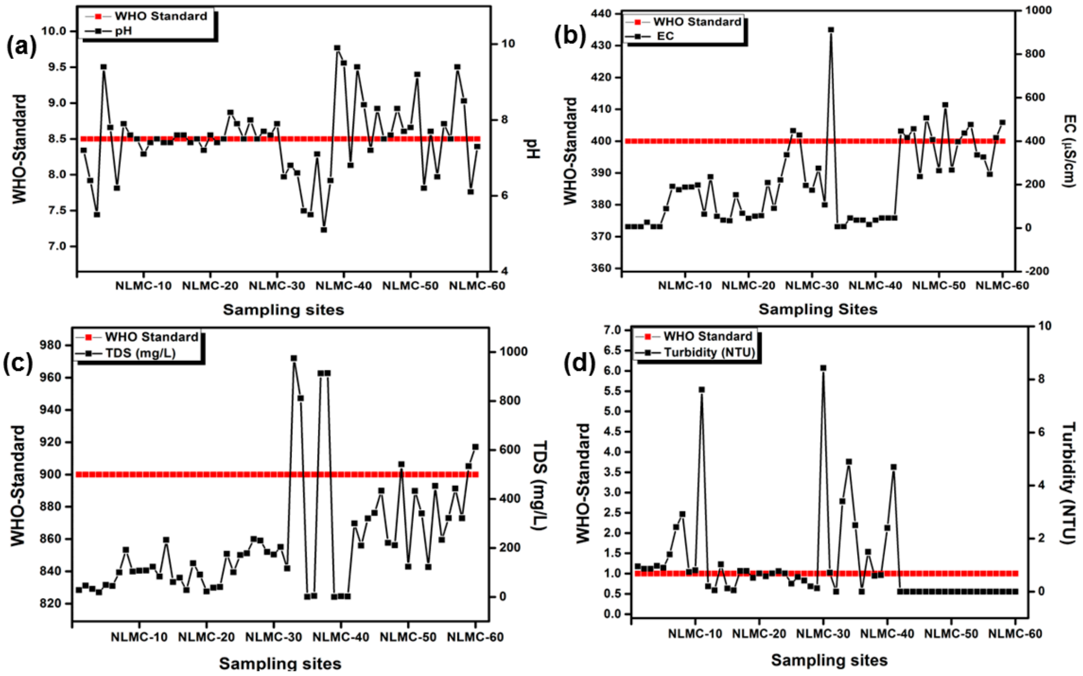

Figure S1. Plots show the concentrations of the physical parameters vs standard WHO values (a) pH, surpassing the standard values, (b) EC, with higher values than WHO-STD (c) TDS values with increments at some sites, (d) Turbidity increase vs WHO standard limit.

ANIONS

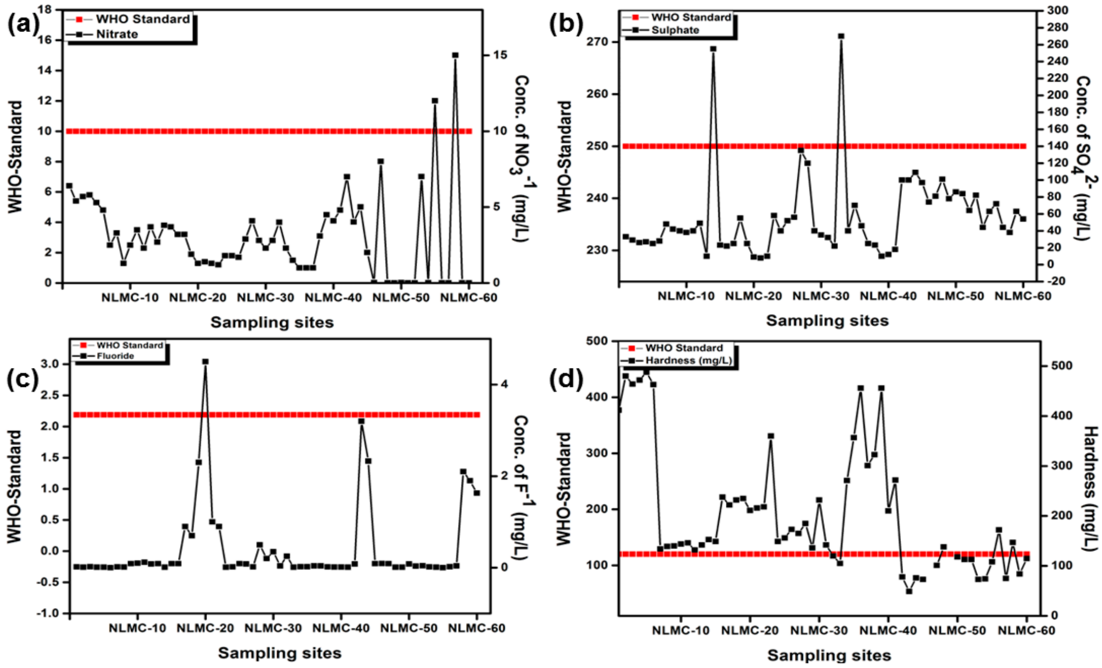

Figure S2. Plots show the concentrations of the anions vs standard WHO values (a) NO_3^{-1}, surpassing the standard values at two sites, (b) SO_4^{2-}, with higher values than WHO-STD (c) F^{-1} values with increments at one site, (d) hardness increase vs WHO standard limit crossing almost at all sites.

Discussion

Physical Parameters

Amongst different polluting point sources, the physical parameters such as temperature, TDS, EC etc., are the first-hand indicator to tell whether the given usable water source is clean or not. Usually, air and water temperatures show a very characteristic annual cycle, with higher values during the day and lower in the dry seasons and at night.

The water temperature led to a yearly variation band of about an average of 17 °C with as minimum as 9 °C during the sampling expedition. So, we can conclude that due to extensive natural vegetation is the reason for lower values of the water temperatures, even in summer, when related to other collection areas of AJK in the same season. The importance of pH is vital for the aquatic systems and communities; the mean pH values during the cycle showed variation at the different collection points. Still, they were within the range of WHO-allowed levels. The values were generally between 5.0 to 9.0 during the downstream study of District Neelam, AJK. EC parameter during the annual cycle has shown significant changes; the averages were 6.00 to 912.10 μS/cm (at DNLMP-37 and DNLMP-3, respectively). The study is also related to the physicochemical parameters of the Paraná River (the second largest hydrographical system in south América, after the Amazon River-Brazil) [86]. They concluded the same kind of variations in conductivity which were higher in the rainy season and as lower as 11.40 to 82.71 μS/cm in the dry season representing the waters with high electrolyte concentration. The turbidity was generally lower (4.20 NTU) during wet months and higher (67.05 NTU) in drier periods. In another study in the Vigário River (Rio de Janeiro-Brazil), the significant human impacts found on this hydrological system were: urbanization, cattle and horse ranching, and sand extraction from stream bottom sediments [87]. This river receives treated sewage from the city of Rio de Janeiro. TDS and hardness were also important parameters to consider in the present study in DNLM. The hardness hasn't had a significant impact on the water quality of DNLM, but the turbidity parameter strongly impacts the region. Turbidity values were as high as 974.60 mg/L, which indicated the high amount of suspended agglomeration in the water resources. The extensive tourism in the region and non-management of the littering problem has created this spoilage of the drinking water sources. High turbidity in DNLM was also relative to a study in which this parameter varied from 0.0 to 8.3 NTU, and it was concluded that the higher turbidity in the water resources is mainly due to the muddy rocks and human influence in the region.

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