Geochemical and Environmental Investigation of Copper Deposit of North Muhammad Khel, Waziristan

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Copper, the third most consumed metal globally, has diverse applications, from phones to cars, owing to its alloys. Geochemically, copper-bearing materials fall into three categories: sulphur, oxide, and native copper metal ore, with sulphide being the most abundant. However, copper mining, smelting, and processing are associated with environmental issues like acid mine drainage and heavy metal contamination. The current study investigates the geochemical aspects of copper deposits in North Muhammad Khel, Waziristan, Pakistan, and their environmental impacts on agricultural soil, river sediments, and drinking water quality. Sophisticated instruments such as the Perkin Elmer Atomic Absorption Spectrometer (AAS-700) and the ICPMS (NeXion 350D), along with portable XRFs (Olympus DP-4050) and SEMs (JSM-IT100), were utilized for agricultural soil, river sediments, and drinking water analysis. Results showed elevated concentrations of heavy metals like Ni, Cr, Pb, Zn, and Cu in soil and sediment samples, with pollution indices indicating contamination. In drinking water, heavy metal concentrations were generally within WHO guidelines, except for Cd and Pb, posing risks, especially for children. SEM analysis revealed ore minerals such as Chalcopyrite and Pyrite for copper, and Pentlandite for nickel. Rock samples exhibited high concentrations of economically significant metals like Ni, Cr, Zn, Cu, Pb, and Mn, suggesting geogenic and anthropogenic influences. Economically significant mineral mining sites were identified, emphasizing the need for detailed geological surveys.