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Eutrophication in Water Bodies in the Semi-arid Region of Northeast Brazil

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ABSTRACT

This thesis analyses the drivers, dynamics, and impacts of eutrophication in freshwater reservoirs in the semi-arid region of Northeast Brazil (NEB), a water-stressed area where reservoirs are essential for public supply, agriculture, and economic activities. The study rationale is based on increasing climatic pressures in the region, characterized by prolonged droughts, irregular rainfall, and high evaporation, combined with nutrient inputs from agricultural runoff, domestic wastewater, and land-use change across the Caatinga biome. These combined factors intensify nutrient accumulation and algal proliferation, threatening water security and ecosystem health. A mixed methodological approach was applied. Reservoir data were obtained from the National Water and Sanitation Agency (ANA-SAR), state monitoring programs (COGERH), and peer-reviewed studies. Major reservoirs above 10 hm³ located within the official semi-arid boundary defined by SUDENE were selected. Geospatial processing was conducted in QGIS to map reservoir distribution and storage patterns. Temporal analysis evaluated long-term storage trajectories. Limnological data (total phosphorus, total nitrogen, chlorophyll-a, Secchi depth) were standardized and assessed using Principal Component Analysis (PCA) to identify dominant gradients in water quality. Seasonal conditions during rainy and dry periods were compared. Results show that more than half of the analysed reservoirs were below 50 percent capacity during the dry season, reflecting persistent hydrological stress. Storage records reveal sustained depletion following the severe 2012-2016 drought, with slow and incomplete recovery in subsequent years. Lower reservoir volume was strongly associated with higher nutrient concentrations, elevated chlorophyll-a, and reduced transparency. PCA indicated a clear contrast between larger, clearer, low-nutrient reservoirs and smaller, eutrophic systems with high nutrient loads and algal biomass. Seasonal clustering was weak, suggesting that prolonged drought conditions diminish typical seasonal

patterns and sustain eutrophic states even during wetter months. The study concludes that eutrophication in NEB reservoirs is driven by the combined effects of external nutrient inputs, internal sediment nutrient recycling, and chronic low water storage intensified by climate variability. Once established, eutrophication persists due to hydrological instability and limited dilution capacity. Effective management requires integrated watershed planning, expansion of sanitation and wastewater treatment, reduction of agricultural nutrient export, and adaptive governance suited to the socio-climatic context of semi-arid regions. Strengthening monitoring systems, improving regulatory enforcement, and adopting basin-scale, participatory water management approaches are essential to safeguard water quality and long-term water security in the NEB.

Key words: Eutrophication. Semi-arid reservoirs. Northeast Brazil. Nutrient loading. Drought and water scarcity.