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Lifespan Assessment of the Fish Crossing System of Itaipu Power Plant (Brazil/Paraguay) Based on the Reaching of Its Sedimentological Equilibrium Computed by 3D Modeling and Churchill Trapping Efficiency

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Abstract : This study aimed to assess the lifespan of the fish transposition system of the Itaipu Power Plant (Brazil/Paraguay) by using 3D hydrodynamic modeling and Churchill trapping effiency in order to identify the sedimentological equilibrium configuration in the main pond of the Piracema Channel, which is part of a 10 km hydraulic circuit that enables fish migration from downstream to upstream (and vice-versa) the Itaipu Dam, overcoming a 120 m water drop. For that, bottom data from 2002 (its opening year) and 2015 were collected and analyzed, besides bed material at 12 stations to the purpose of identifying their granulometric profiles. The Shields and Yalin and Karahan diagrams for initiation of motion of bed material were used to determine the critical bed shear stress for the sedimentological equilibrium state based on the sort of sediment (grain size) to be found at the bottom once the balance is reached. Such granulometry was inferred by analyzing the grosser material (fine and medium sands) which inflows the pond and deposits in its backwater zone, being adopted a range of diameters within the upper and lower limits of that sand stratification. The software Delft 3D was used in an attempt to compute the bed shear stress at every station under analysis. By modifying the input bathymetry of the main pond of the Piracema Channel so as to the computed bed shear stress at each station fell within the intervals of acceptable critical stresses simultaneously, it was possible to foresee the bed configuration of the main pond when the sedimentological equilibrium is reached. Under such condition, 97% of the whole pond capacity will be silted, and a shallow water course with depths ranging from 0.2 m to 1.5 m will be formed; in 2002, depths ranged from 2 m to 10 m. Out of that water path, the new bottom will be practically flat and covered by a layer of water 0.05 m thick. Thus, in the future the main pond of the Piracema Channel will lack its purpose of providing a resting place for migrating fish species, added to the fact that it may become an insurmountable barrier for medium and large sized specimens. Everything considered, it was estimated that its lifespan, from the year of its opening to the moment of the sedimentological equilibrium configuration, will be approximately 95 years–almost half of the computed lifespan of Itaipu Power Plant itself. However, it is worth mentioning that drawbacks concerning the silting in the main pond will start being noticed much earlier than such time interval owing to the reasons previously mentioned.

Keywords : 3D hydrodynamic modeling, Churchill trapping efficiency, fish crossing system, Itaipu power plant, lifespan, sedimentological equilibrium
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