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Integrated application of river water quality modelling and cost-benefit analysis to optimize the environmental economical value based on various aquatic waste load reduction strategies

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To assure the river water quality, the Taiwan government establishes many pollution control strategies and expends huge monetary investment. Despite all these efforts, many rivers still suffer from severe pollution because of massive discharges of domestic and industrial wastewater without proper treatment. A comprehensive evaluation tool seems required to assess the suitability of water pollution control strategies. Therefore, the purpose of this study is to quantify the potential strategic benefits by applying the water quality modelling integrated with cost-benefit analysis to simulating scenarios based on regional development planning. The Erhjen Creek is selected as the study example because it is a major river in southern Taiwan, and its riverine environment impacts a great deal to the neighboring people. For strategy assessment, we established QUAL2k model of Erhjen Creek and conducted the cost-benefit analyses according the proposed strategies. In the water quality simulation, HEC-RAS was employed to calculate the hydraulic parameters and dilution impact of tidal effect in the downstream section. Daily pollution loadings were obtained from the Water Pollution Control Information System maintained by Taiwan EPA, and the wastewater delivery ratios were calculated by comparing the occurrence of pollution loadings with the monitoring data. In the cost-benefit analysis, we adopted the market valuation method, setting a period of 65 years for analysis and discount rate at 2.59%. Capital investments were the costs of design, construction, operation and maintenance for each project in Erhjen Creek catchment.

In model calibration and model verification, the mean absolute percentage errors (MAPEs) were calculated to be 21.4% and 25.5%, respectively, which met the prescribed acceptable criteria of 50%. This model was applied to simulating water quality based on implementing various pollution control policies and engineering projects in the Erhjen Creek. The overall improvements in BOD, SS and NH3-N were estimated as 36.2%, 27.7% and 29.2%, respectively. The net present value (i.e. economical-based environmental impact) becomes positive in the sixtieth year following the original government planning. We designed two scenarios for further comparison: (i) treatment efficiency improvement of pollution control facilities, and (ii) biogas-based power generation using livestock manure.

If government budget is not a limiting factor, improving the efficiency of sewage treatment plants can make the occurrence of balance between payments and revenues (i.e. net present value in this study) three years earlier. For the biogas-based power generation scenario, if all pig farms with livestock number >2000 install the on-site power generation equipment, BOD will further improve by 9% and the time span of payback period will be shortened by 1 year. If all the manure waste from pig-farms is collected for subsequent electricity generation, the BOD river pollution index is estimated to improve to lightly-polluted category for more than half the length of Erhjen Creek.

In short, water quality modelling technique not only can assess the contributions of related projects, but establish a practical pollution reduction strategy using cost-benefit analysis, which allows decision-maker to find a suitable pollution reduction plan to exhibit most benefits in river water quality.