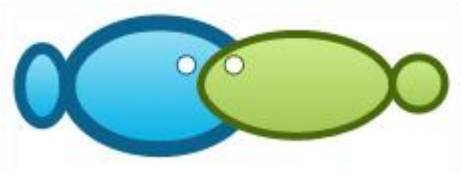

Impacts of sulfide exposure on juvenile *Tor tambroides*: behavioral responses and mortality

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Abstract. Construction of hydroelectric reservoirs had been reported to be the cause of increased sulfide levels resulting from the decomposition of organic matter. As more dams are being built, a better understanding of the impact of sulfide on indigenous species is required. In Sarawak, *Tor tambroides* is a highly valuable and sought after species which is facing declining population. This study aimed to determine the behavioral responses and mortality of juvenile *T. tambroides* exposed to sulfide. The three exposure experiments were gradual sulfide exposure, gradual sulfide exposure under lowering DO and gradual sulfide exposure under lowering pH. A modified flow-through design was used to expose the juveniles in containers to sulfide of different concentrations. Actual total sulfide in containers was determined according to standard method. During the duration of the experiment, behavioral responses, DO and pH were monitored. Experimental results show that negative controls recorded no behavioral response and no mortality was observed in all control experiments. However, under all sulfide exposure experiments, the juveniles displayed at least one behavioral response in the progression of huddling together, aquatic surface respiration, loss of equilibrium and turning upside down except for the gradual sulfide exposure experiment where no response was observed with the lowest total sulfide concentration tested (82 μg L^{-1}). For all three exposure experiments, faster responses and mortalities were observed when the concentration of sulfide increased. The LC_{50} at 6^{th} hour of exposure was estimated to be 306 μg/L total sulfides (138 μg L^{-1} H_2S) at 95% confidence level. Sulfide toxicity was found to be highly related to the decreasing DO and pH levels attributable to intensifying toxicity which led to mortality.
Key Words: tolerance, hydrogen sulfide, gradual sulfide exposure, negative controls, toxicity.

Introduction. Over the years, anthropogenic activities are said to be one of the major factors in the disruptions of aquatic habitat. Construction of reservoirs for example, fragmented rivers and become an obstacle for longitudinal exchanges such as recycling, water chemistry and migration (Brismar 2004; Mc Cartney 2009). In Sarawak, three major hydroelectric reservoirs had been built for the purpose of energy production over the past 30 years namely Batang Ai Hydroelectric Reservoir (1985), Bakun Hydroelectric Reservoir (2010) and Murum Hydroelectric Reservoir (2014). The alteration of lotic water bodies into lentic could lead to the increase of sulfide and lowering of dissolved oxygen (DO) and pH levels in the water bodies. The increase of sulfide in water bodies had been discussed by several papers such as in Bakun Hydroelectric Reservoir, Malaysia (Nyanti et al 2012), Batang Ai Hydroelectric Reservoir, Malaysia (Ling et al 2012), Danau Maninjau, Indonesia (Henny & Nomosatryo 2012), and the effect of hypoxic condition and low pH levels with sulfide in nature water bodies (Tobler et al 2006).

Hydrogen sulfide emits rotten egg smell and high levels are toxic to both environment and living organisms. It is introduced into aquatic habitat through runoff or the decaying process of organic matters (Guidotti 1996) and can also be found in aquatic environment associated with oil deposits and geothermal activity (Van Dover 2000; Tunnicliffe 1991). Hydrogen sulfide affects fishes by binding to haemoglobin and replacing oxygen (Tobler et al 2006), interacting with essential enzymes (Affonso et al 2002) and disrupting disulfide bonds in macromolecules (Guidotti 1996).