Electronic Annex I – Copper analyses and distributions in soils

EA-I.1 Copper analyses

Bulk concentrations of copper (Cu) in soils and sediments from the study area were measured by ICP-OES at Boston University on samples prepared by Li-metaborate flux fusion and dissolution in nitric acid. Reported Cu concentrations are based on sample weight after combustion for 2 hours at 550 ^{o}C, and thus reflect the concentration of Cu in the mineral fraction of each sample, undiluted by organics or other volatiles. Because of the mobilization of copper-enriched sediment during operations at the Ok Tedi mine, elevated Cu concentrations have been used as a tracer of mine-derived material in the Fly River system (Day et al., 2009).

EA-I.2 Distribution of copper in soils along Fly River

Disposal of mine-tailing waste since start of operations of the Ok Tedi mine in 1985 has resulted in the introduction of copper-rich sediments into the Fly River system. Monitoring of Cu concentrations in suspended, river bed and floodplain sediments reveals the dispersal of these mine-related materials and their impact on sediment accumulation throughout the system (e.g., Day et al., 2008; Hettler et al., 1997 and references therein). Absolute Cu concentrations in mine-impacted soils can vary as a function of grain size (finer particles have greater Cu loadings), timing of deposition since start of mine operations and mixing with non-mine materials. Elevated Cu concentrations have been used as a chronostratigraphic marker of post-1985 deposition in mine impacted deposits (Day et al., 2009). However, for the purpose of this study, we simply consider Cu concentrations of less than100 μg/g indicative of natural (non-mine) conditions, whereas concentrations greater than 400 μg/g are generally indicative of materials directly impacted by the input of mine-related materials.

Copper concentrations were measured in most all soil samples collected (Electronic Annex II) and averages for different regions of the Fly River system are summarized in Table 2. As can be seen from these data, most highland soils were characterized by natural, background Cu concentrations consistent with the lack of direct input from mine waste. The major exceptions (Electronic Annex II) were the surface soils in FRS01, a site directly adjacent to the Ok Tedi mine, and in FRS06, which is located along the gravel road connecting Kiunga and Tabubil. It is likely that inputs (e.g., dust) from mine operations were responsible for deposition of Cu-enriched materials at these sites. Elevated Cu concentrations (400 to over 1300 μg/g; Electronic Annex II) were measured in alluvium from the Ok Tedi River (FRS08a) and in the top 1 meter of soils of active flood plains along the upper- Middle Fly (FRS19) and lower-Middle Fly (FRS10 and FRS12). In the case of FRS19, soil horizons deeper than 1m displayed background levels of Cu consistent with deposition of natural materials under pre-mine conditions. An organic-rich horizon between 315 and 355 cm below the surface displayed moderately elevated (~200 μg/g), which could be indicative of reducing depositional conditions conducive to metal immobilization. Notably, active floodplain sediments from both the Upper Fly and the Lower Strickland, areas not impacted by input of mine-waste sediments, displayed natural Cu backgrounds. The major exception was the deepest horizon at the Upper Fly site (FRS20), which was characterized by somewhat elevated Cu concentrations (160 μg/g).

Moderately elevated Cu concentrations were measured in floodplain soils from the Lower Fly, below its confluence with the Strickland River (Electronic Annex II). In some sites, such as FRS16 and FRS17, the Cu-enrichments were restricted to the surface horizons, whereas in FRS15 the enrichments were measured throughout the whole 150 cm profile. The magnitude of the Cu enrichment at these sites (100 to 300 μg/g) was 5 to 10 times lower than the

concentrations measured in the mine-impacted samples from the floodplain along the upper- and lower-Middle Fly and indicate considerable dilution by non-mine sediments from the Strickland. Based on these results, we present the averages of mine-affected horizons and sites separately from those which did not display Cu contents above 400 μg/g and were not directly impacted by mine inputs (Table 2).