Comment on "Anthropogenic-drive alterations in black carbon sequestration and the structure in a deep plateau lake": proper sediment dating is not neglectful

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Huang et al.[1] reported changes in the incorporation of black carbon (BC) in the sediments from a deep lake on the Yunggui Plateau in China. Burial processes and the relations with anthropogenic drivers were considered using four ^{210}Pb dated sediment cores. The article focus is BC burial history in the lake sediments and possible human impacts. For this, secure sediment dating is an essential part of the study as the history was set up on the sediment's chronologies, and therefore, sediment chronologies should be as accurate as possible. Otherwise, the foundation of the research may be compromised. In the article of Huang et al.[1], some points related to sediment dating need clarification.

1. Methods for geochronology and accumulation rate

The equation used for the constant rate of ^{210}Pb supply (CRS) model in the Supporting Information (SI; *Eq*. 1) is wrong, it should be[2]

$$t = \frac{1}{\lambda}\ln(\frac{A(0)}{A}) \quad (1)$$

Where $A(0)$ is the residual of unsupported ^{210}Pb in the entire record (from the sediment surface to the equilibrium depth of total ^{210}Pb with supported ^{210}Pb), or the ^{210}Pb inventory, A is the residual of unsupported ^{210}Pb in the sediments of age t or greater, and λ is the ^{210}Pb decay constant. As all the cores do not reach their equilibrium depths, the $A(0)$ should not be only "the total content of ^{210}Pb in the sediment core[1]". If a core does not reach the equilibrium depth, our practice in the UCL Environmental Radiometric Facility is to estimate the equilibrium depth in the sediments by following the ^{210}Pb exponential decay trend in the bottom of the core, and then derive the missed unsupported ^{210}Pb beyond the core base for the residual calculations.

In the article of Huang et al.[1], *Eq*. 2 in the SI for calculating accumulation rate of BC and polycyclic aromatic hydrocarbons (PAHs) gives BC and PAHs units in g cm^{-2} yr^{-2}. This is incorrect. Sediment accumulation rate can be calculated using[2]

$$r = \lambda(\frac{A}{C}) \quad (2)$$

where C is the unsupported ^{210}Pb activity in the sediments at time t. Therefore, the accumulation rate of BC and PAHs (AR) can be calculated as

$$AR = r\delta \quad (3)$$

Where δ is the concentration of BC and PAHs in the sediments.

2. Chronologies of the cores

Unsupported ^{210}Pb activities decline rapidly from around 400 Bq Kg^{-1} in the surface sediments to much lower activities (10 – 80 Bq Kg^{-1}), and the low activity section occupies the greater part of each individual core, especially in cores 1, 2 and 3. These large sections with low ^{210}Pb activities can lead to substantial chronological errors due to gamma counting errors associated with the low isotope concentrations. Error bars should be added to unsupported ^{210}Pb activities and the chronologies to show their uncertainties. In this study, the four cores have not reached the equilibrium depth of total ^{210}Pb with supported ^{210}Pb at their bases, and only the residuals of unsupported ^{210}Pb in the measured cores were used as total unsupported ^{210}Pb inventory $A(0)$ for the chronology calculations, this may be the reason why the bases of all the cores were dated to a similar age around the 1880s. Hence, the chronologies are questionable.

In core 2, unsupported ^{210}Pb activities decline with depth from the core surface to 10 cm, showing unsupported ^{210}Pb decays with time. However, from 10 to c. 38 cm, unsupported ^{210}Pb activities are fairly constant. This relatively thick section with low and constant unsupported ^{210}Pb activities compared with the rapid decay section with much higher activities in the surface sediments is unusual. Based on the chronologies of the core in the SI, it is suggested that from the 1890s to the 1990s, sediment accumulation rates are likely to have gradually increased for c. 16-fold. There should be similar increases in cores 1 and 3. As these increases could have considerable impacts on the BC and PAHs burial rates, an interpretation for the increases is needed. Given a thick section with low and constant unsupported ^{210}Pb activities from 10 to c. 38 cm in core 2 and that all the cores have not reached the equilibrium depth at the bases, it is possible that the gamma spectrometer was not properly calibrated for the relevant radionuclides. To find out if there was problem in the spectrometer's measurements, counting a longer core that reaches the equilibrium depth and re-calibrating the gamma spectrometer may give clues. The samples were counted in gamma spectrometer for "under 40,000 s^{1}". Such short time for ^{210}Pb gamma counting may not be enough, especially for some low activity sediment samples, even using low background HPGe well-type gamma spectrometer.

The sediments were analyzed by a gamma spectrometer for ^{210}Pb and should also provide ^{137}Cs and ^{241}Am data. If possible, independent assessments of a 1963 date determined from the peak activities of ^{137}Cs and ^{241}Am in the sediment records can be used to validate the ^{210}Pb chronologies. Although the use of ^{137}Cs and ^{241}Am in some China lakes needs caution[3].

Based on the discussion above, the reported chronologies of these cores and the calculated fluxes of BC and PAHs to the sediments in the article of Huang et al.[1] need to be re-examined.

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