COMPLETION REPORT

**The application of Japanese concept in developing an integrated water resource management and restoration in highland area for Malaysia**

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**Introduction:** This research assessed the effects of extensive agriculture activities in the upstream area of Bertam river, in Cameron Highlands, Malaysia. The major concern arises and widely discussed is the risk of drinking water contamination in the area from the rampant agriculture and tourism activities. **Method:** Sampling activities were done twice during wet (September 2017) and dry season (March 2018). Water and sediment samples taken were evaluated for physicochemical parameters and heavy metals concentration. Heavy metals were tested using ICPMS. The health risk assessment was calculated to identify the potential risk of metal toward human health through river water ingestion. The contamination factor (CF), index of geo-accumulation ($I_{geo}$) and pollution load index (PLI) of studied metals on the river sediment were calculated for ecological risk assessment. **Results:** In general, the water quality was found to be poorer during wet season compared to dry season and obvious movement of pollutant from the upstream was obtained and prominent at the downstream area of the river. The pH value of the river water ranged from neutral to slightly acidic (5.81-7.01) and the overall mean of turbidity (109.94 NTU ± 160.73) and *E. coli* (5191.00 CFU ± 14937.42), were exceeded the Malaysian Drinking Water Quality Standard. The $NH_3$-N content also exceeds the standard by fourfold (0.85 mg/L ± 0.54). The river water also content high total suspended solid (TSS) value of 82.01 mg/L ± 104.49. All of this possibly was caused by extreme precipitation that increase the river bank and steep hill slopes erosion. Consequently, it has caused large amount of sediment to be transported which deteriorated the river water quality, nutrient loss and also influence the elevation of major metal transport within water column. The assessment of water samples during wet season has obtained the concentration of heavy metals have exceeded the standard value. The heavy metals concentration were in the following order of; Iron (Fe) >Aluminium (Al) >Copper (Cu) > Zinc (Zn) > Lead (Pb) > Cadmium (Cd). The non-carcinogenic health risk for adult and children from daily consumption of water within the study area was within an acceptable risk. However, significant potential cancer risk from Cd exposure in the study area, which higher among male ($3.06 \times 10^{-3}$) compared to female ($2.98 \times 10^{-3}$) and children ($4.92 \times 10^{-3}$). The ecological risk indication through CF, $I_{geo}$, and PLI were <1 which indicating that there were low contamination risk of sediment by studied metals in the study area. This possibly was influenced by the sediment characteristic where the percentage of sand is 93.89%. **Conclusion:** Overall, results have shown extensive agriculture activities in the upstream area of Bertam river has caused significant impact to the water quality of this area and significant health risk. **Study recommendations:** Ongoing efforts and strategies to mitigate the problem is needed for example through efficient and strict law enforcement, frequent and continuous monitoring for illegal land clearing for agriculture activities, continuous monitoring of sustainable and good agriculture practices, and civic awareness among local communities especially farmers to dispose organic agricultural wastes and pesticide bottles to proper places and not into the river.

Publication of the Results of Research Project:

Verbal Presentation (Date, Venue, Name of Conference, Title of Presentation, Presenter, etc.)

Date: March 2019
Venue: Malaysia
Name of conference: International conference of Public Health
Title presentation: The effects of agriculture activity in Cameron Highland towards human health
Presenter: Sharifah Norkhadijah Syed Ismail

Date: Sept 2019
Venue: Australia
Name of conference: Ecological risk
Title presentation: Ecological risk effects from rampant agriculture activity in Cameron Highland
Presenter: Sharifah Norkhadijah Syed Ismail

Date: Dec 2019
Venue: Malaysia
Name of conference: Environmental health summit
Title presentation: The effects of extensive agriculture activity in Cameron Highland towards water quality of Bertam river
Presenter: Sharifah Norkhadijah Syed Ismail

Thesis (Name of Journal and its Date, Title and Author of Thesis, etc.)

1) Name of Journal: **Ecological Processes**
   Date: May 2018
   Title: Land use change in highland area and its impact on river water quality: a review of case studies in Malaysia
   Authors: Azlini Razali, Sharifah Norkhadijah Syed Ismail, Suriyani Awang, Sarva Mangala Praveena, and Emilia Zainal Abidin
2) Name of Journal: **Malaysian Journal of Medicine & Health Science**
   Date: July 2018
   Title: Heavy metals contamination and potential health risk in highland river watershed (Malaysia)
   Authors: Azlini Razali, Sharifah Norkhadijah Syed Ismail, Suriyani Awang, Sarva Mangala Praveena, and Emilia Zainal Abidin
3) Name of Journal: **Chemosphere**
   Date: Submitted
   Title: Assessment of spatial and seasonal water quality variation of Bertam River using multivariate statistical techniques and its association with health risk
   Authors: Azlini Razali, Sharifah Norkhadijah Syed Ismail, Suriyani Awang, Sarva Mangala Praveena, and Emilia Zainal Abidin

Book (Publisher and Date of the Book, Title and Author of the Book, etc.)
Publisher: UPM Press
Date of the book: submitted (Dec 2018)
Title: The effect of rampant agriculture activity to Cameron Highland
Author: Sharifah Norkhadijah Syed Ismail and Azlini Razali