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## URBANIZATION VS. ENVIRONMENTAL QUALITY: SOME OBSERVATION IN TELIPOK, SABAH, MALAYSIA

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### ARTICLE DETAILS

### ABSTRACT

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The study area is underlined by Crocker Formation of Eocene to late Early Miocene age and Quaternary deposit. Rapid urbanization activities have caused changes in land use. These activities accelerate higher rate of weathering, surface runoff, soil erosion and siltation. Urbanization processes may contribute to exposure of impervious surface, loss of vegetation cover, modification of slope gradient and drainage system. This study provides strong evidence that urbanization at the study area negatively affects the natural environment. Soil erosion, siltation, poor water quality and flash floods are common within the study area in the event of heavy rainstorm. The main factors causing environmental problem in the study area are natural (geology, meteorology, geography, topography and drainage system) and human (lack of proper planning, human activities and community's attitude). Therefore, any activity which potentially causing environmental problem must be implemented efficiently. Strict enforcement of environmental (soil erosion, siltation, water quality and flash flood) regulation and sustainable land use planning and management is crucial. Serious efforts to increase the community's awareness to environmental problem and reconstruction of natural ecosystem must be taken. This is to ensure that future activities in the study area will not cause further damage to natural environmental condition or ecosystem.

#### KEYWORDS

Crocker Formation, surface runoff, drainage system, Early Miocene, siltation.

### 1. INTRODUCTION

The study area is bounded by longitude 6°5.4'N to 6°7.2'N and latitude 116°10.2'E to 116°12.5'E, about a kilometre to the north of Telipok town and occupies an area of 20 km<sup>2</sup> (Figure 1). Generally, study area is under lying by the Crocker Formation of Late Eocene-late Early Miocene ages and quaternary alluvium (Figure 2). The Crocker Formation is a deep marine environment deposit and denoted as a flysch type. Flysch is characterized by rhythmic alteration of sandstone and fine-grained (pelitic) or shale layers. The fine-grained layers from centimeter to meters. The Crocker Formation is also divided into sandstone facies, sandstone-shale interbedded facies and shale facies.

The study area has undergone rapid urbanization that caused extensive change in land use. In the recent past, this area was mainly under agricultural and forest land cover. Converting these lands for residential and commercial needs without appropriate land use planning, development and management of the area changes the present situation [1].

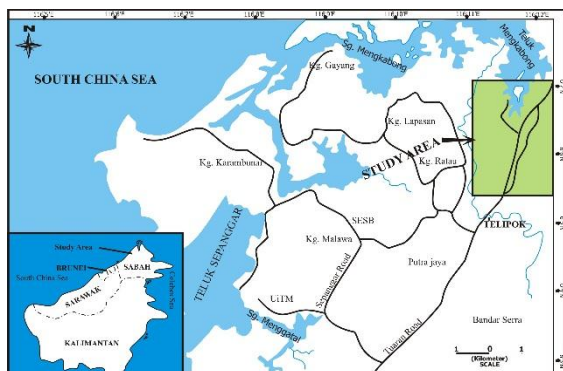


Figure 1: Location of the study area

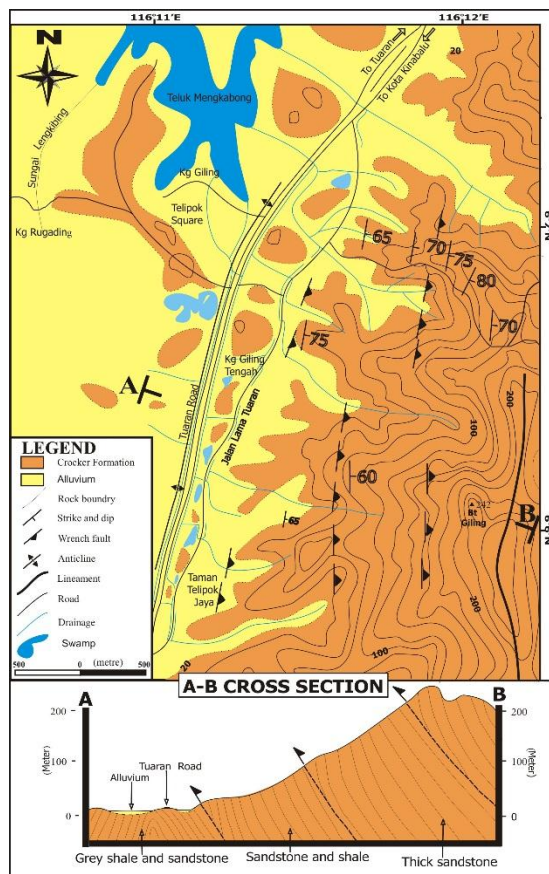


Figure 2: Geological map of the study area [2]

The major development of the study area and its surrounding include industrial area, quarry, business centre, residential area, farming, cemetery and Tuaran road (Kota Kinabalu-Tuaran Highway and Jalan Lama Tuaran) (Figure 3). This in turn has contributed to the degradation of environmental quality and environmental problem such as soil erosion, siltation, water quality, existence of fresh water fish community and flash flood problems in the study area [1].

The occurrences of urbanization related environmental degradation has been reported and published in many publications for the last five decades [3]. Urbanization processes has contributed to the exposure of impervious surface, loss of vegetation cover, modification of slope gradient and drainage system which then accelerate the rate of weathering, surface runoff, soil erosion and siltation and flash flood intensity and magnitude [4-10].

Siltation and occurrences of impervious surface in an urbanized area are also reported to degrade the quality of water and habitat, hydrology and biodiversity of stream ecosystem by affecting stream fish production [11-15].

The natural and human factors have been identified in controlling environmental quality and problem in this area. The natural factors include geology, meteorology, geography, topography and drainage system and human factors are lack of proper planning, human activities and community's attitude.

The solution for environmental problem and to avoid further damage to natural environmental condition or ecosystem in the study area are strict enforcement of environmental (soil erosion, siltation, water quality and flash flood) regulation and sustainable land use planning and management (including formulation of 'geoindicator' database for sustainable development), serious efforts to increase the community's awareness to environmental problem and reconstruction of natural ecosystem.

The aim of this study is to observed urbanization activities and environmental quality or problem in the study area and to propose some mitigation measure for sustainable land use planning and management.

## 2. METHODOLOGY

This study was conducted due to environmental problem after the past ten years of urbanization activities in the study area. Effect of urbanization became worst after the Kota Kinabalu Industrial Park (KKIP) project has been started to increase in the development of Kota Kinabalu area together with entitlement as a City of Kota Kinabalu on 2<sup>nd</sup> February 2000. The methodologies used in this study include:

1. Observation series, flood measurement and hydrological changes for thirty (30) years.
2. Soil profile studies and hand augering to monitor changes in water table.
3. Monitoring of siltation problem in selected areas using topographic map, aerial photograph studies and field observation.
4. Recording of drainage changes and biological fresh water life for thirty years.
5. Mapping of changes in physical morphology and land use.
6. Estimation of the rate of soil loss by Universal Soil Loss Equation (USLE) method.

## 3. URBANIZATION

Urbanization refers to a process in which an increasing proportion of an entire population lives in cities and the suburbs of cities. Historically, it has been closely connected with industrialization. When more and more inanimate sources of energy were used to enhance human productivity (industrialization), surpluses increased in both agriculture and industry. Larger and larger proportions of a population could live in cities. Economic forces were such that cities became the ideal places to locate factories and their workers.

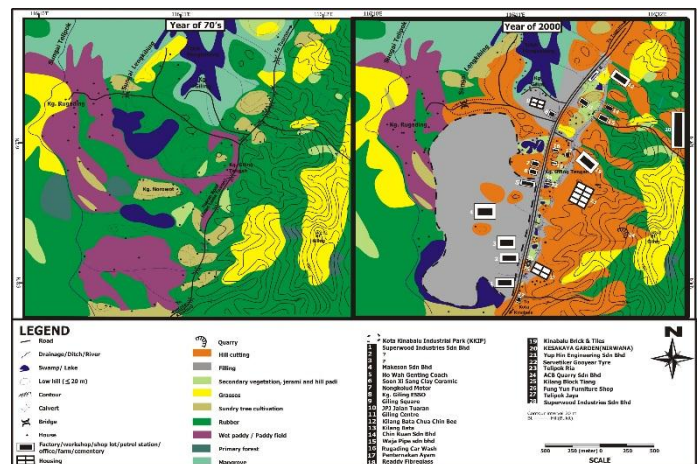
Land use is the way in which land is used, especially in farming and city planning. The term landuse is used to describe the function or use of an area of land. Large urban areas tend to have a number of landuse zones ranging from high density residential areas to industrial zones.

Urbanization has causing extensive change in land use in the study area since the early 90's (Figure 3). Before 1990, the study area is occupied as residential area or villages such as kampung Rugading, kampung Giling, kampung Giling Tengah, kampung Bukit Giling and kampung Norowot.

Most of the local people are farmer, rubber taper and fisherman as well as few serving local government and private sectors in town.

About 60% of the area was planted by rubber tree or estate and most of the low land (alluvial plain) is paddy field. Mangrove along the Teluk Mengkabong, primary forest, secondary tree cultivation, secondary vegetation, jerami, hill paddy in Bukit Giling and Tuaran road (Jalan Lama Tuaran) are also found in this area. For the fisherman, they are enjoying fishing in their surrounding wetland. They can easily have found biological marine life in Teluk Mengkabong and South China Sea as well as biological fresh water life in the terrestrial river and lake (Figure 1 and 3).

After 1990, the study area and its surrounding has undergone rapid urbanization which include industrial area (north eastern part of Kota Kinabalu Industrial Park, KKIP), quarry (ACB Quarry Sdn Bhd), business centre (Giling Centre), residential area (Telipok Jaya, Telipok Ria and Giling Square), farming (Chicken Farm), cemetery (Nirvana Memorial Park) and Tuaran road (Kota Kinabalu-Tuaran Highway) (Figure 3).



**Figure 3:** Land use map before (year of 70's) and after (year of 2000) urbanization in the study area.

## 4. ENVIRONMENTAL QUALITY

The environment is our physical surroundings. This includes human (man-made), social and physical (natural) features. Natural features include soil, atmosphere, water, vegetation and wildlife. Human features include housing, transport and industry. Social features include things such as culture, language and political systems.

This study provides strong evidence that urbanization at the study area negatively affects the natural environment. Urbanization has been causing damaging in natural environment by cutting and filling hence decreasing environmental quality of the area and generating environmental problem such as soil erosion, siltation, water quality and flash flood.

### 4.1 Soil Erosion

Soil erosion is a main problem in an urbanized area and caused by rain drop and runoff which act onto exposed soil material [16]. The energy of rainfall will be separating, dispersing and transporting soil particles to the lower slope. Major soil erosion characters are drop mass and size, size distribution, direction, intensity and rain velocity [17]. Rill and gully are main erosional features can be seen in the study area as well as disappearance of drainage.

Soil compaction and impervious surface is a product of soil erosion which was produced by infilling of fine soil aggregate into soil pores [18]. Impervious layer will be covering soil surface from infiltrating water and lets the water flowing on surface as a runoff then causing accelerated soil erosion.

The soil erosion in the study area or tropical climate in general are affected by the climate (rain erosivity), rock type (soil erodibility), topography, slope, vegetation cover and conservation practice [18]. The wet condition of tropical climate with 3470.9mm average annual rainfall has also causing active chemical weathering and increasing soil erosion.

Universal Soil Loss Equation (USLE), Modified (Revised) Soil Loss Equation (MUSLE), Water Erosion Prediction Project (WEPP) Model by Agriculture Department of United States is suggested for soil erosion estimation by the Department of Environment of Malaysia [19-22].

USLE has been used in this study because soil erosion caused by disturbance of physical terrain and slope stability to estimate the erosion in two difference situation i.e fresh and weathered rock. The north eastern part of the study area has been selected for this estimation due to slope and cutting activities in this area (Figure 4)

The basic of USLE are [19];

$$E = R \times K \times L \times S \times C \times P$$

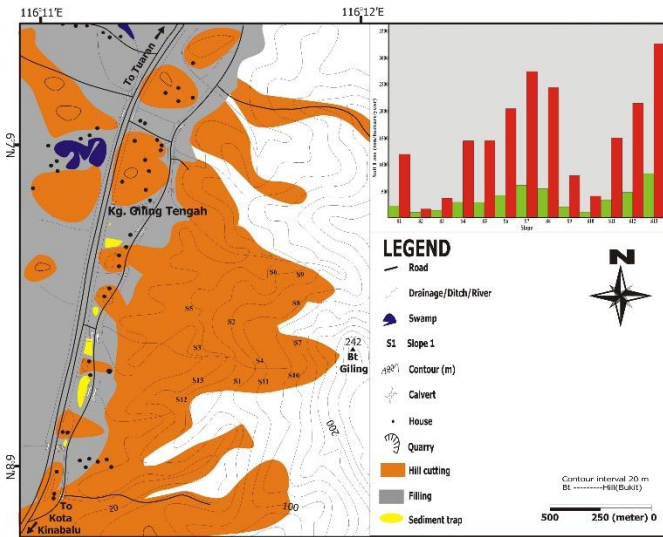
Where;

- E** = Average of Annual Soil Loss (tan/hectare/years)
- R** = Rainfall Erosivity Factor (MJ.mm/hacter.hour.years)  
= Pa (average of annual precipitation = 3470.9 mm/years) x 0.5  
= 1735.45 MJ.mm/hacter.hour.years
- K** = Soil Erodibility factor (tan.hacter.years/hectar.MJ.mm)  
= 0.5 (minimum) and 0.02 (maximum) (weathered Crocker Formation)
- L** = Slope Length Factor (m)
- S** = Slope Gradient (Steepness) Factor (%)
- LS** =  $(L/22)^{1/2} \times (0.065 + 0.045 + 0.0065S^2)$
- C** = Cropping Management (Vegetation Cover) Factor  
= 1 (no vegetation after operation)
- P** = Conservation Practice Factor  
= 0.5 (contouring and terrace on hill slope)

With the assumptions;

1. The rainfall data has been observed and collected from nearest station to the study area i.e. Meteorology Station of Lawa Mandau, Telipok.
2. Average of annual rainfall data (Pa = 3470.9 mm/years) for not less than 10 years was used in this analysis.
3. K = 0.02 (minimum) and K = 0.05 (maximum) is used according to the sandy loam and sandy clay loam soil texture (Table 1) in the study area which has derived from weathered Crocker Formation [23].
4. K value on every slope has been assumed as similar and slope surface are flat.

Result of this soil loss estimation in the study area are shown in Table 2 and shows that the rate of soil loss is high and critical i.e. 379.33 tan/hectare/year (K=0.2) and 1517.32 tan/hectare/year (K=0.05) which above the limit of Department of Agriculture (Table 3) [22].



**Figure 4:** Map of the cutting and filling area, slope location, new 'natural sediment trap' and histogram of the soil loss estimation.

**Table 1:** Grain size distribution and soil texture

Sample	Sand					Silt (Z)	Clay (C)	Percentage (%)			Soil Texture
	1 mm	500 μm	250 μm	125 μm	63 μm			Sand	Silt	Clay	
DJ1	0.14	0.83	2.77	3.92	3.21	4.00	3.50	59.17	21.77	19.06	Sandy loam
DJ2	0.10	0.19	1.52	3.93	4.07	2.50	4.50	58.36	14.87	26.77	Sandy clay loam
DJ3	0.12	0.14	0.98	3.90	5.11	3.00	3.50	61.19	19.91	20.90	Sandy clay loam
DJ4	0.15	1.45	2.44	3.69	4.18	3.00	1.50	72.58	18.28	9.14	Sandy loam
DJ5	0.42	0.58	0.80	1.24	2.38	3.00	1.50	54.64	30.24	15.12	Sandy clay loam

**Table 2:** Soil loss estimation

Slope	Length, L (meter)	Steepness, S (%)	LS	E (ton/hectare/year)	
				K <sub>min</sub> = 0.05	K <sub>max</sub> = 0.2
S1	50	24.2	6.96	301.97	1207.87
S2	38	9.1	1.27	55.10	220.40
S3	58	12.8	2.63	114.11	456.42
S4	42	27.2	7.91	343.19	1372.74
S5	35	28.8	8.00	347.09	1388.36
S6	60	30.0	11.24	487.66	1950.65
S7	103	31.2	15.79	685.07	2740.28
S8	183	24.2	13.44	583.11	2332.44
S9	23	24.2	4.76	206.52	826.07
S10	68	12.0	2.59	112.37	449.48
S11	30	30.0	7.97	345.79	1383.15
S12	42	35.5	12.41	538.42	2153.69
S13	211	28.0	18.69	810.89	3243.56
Average soil loss				379.33	1517.32

K<sub>min</sub> = minimum; K<sub>max</sub> = maximum

**Table 3:** Soil loss rate by DOA [22]

Soil Loss Rate (ton/hectare/year)	Category
0-500	Accepted
501-1000	Moderate
1001-3000	High
3001-6000	Very High
>6000	Worst

**4.2 Siltation**

Siltation is the second environmental degradation observed in the study area (Figure 5). Siltation is the deposition or accumulation of silt. The water flow or runoff has been eroding the exposed surface and transporting soil particles to foothill and alluvial plain which then into drainage system and finally deposited in river mouth or swampy delta of Teluk Mengkabong (Figure 2).



**Figure 5:** Factor causing environmental problem in the study area. A. Clog along the drain. Small and shallow ditch and siltation in the upper part of the culvert. B. Small culvert and partition of debris. C. Demolish house in the swampy area and grass field in the new natural sediment trap originated from paddy field. D. Congestion at the channel flow. The '90° corner' drainage channel (arrow I flowing to north and arrow II to the west) and small culvert (arrow II). E. Improper monitoring and maintenance of drainage channel to the solid waste and wild grass. F. Lack of enforcement of the environmental regulation (partition of debris and siltation).

Nevertheless, sediment transport in the study area has been blocked or trapped in certain point due to the changes in natural drainage system or basin. The drainage pattern were reconstructed into 'L corner' or '90° corner' (Figure 2 & 5D), the drainage basin become 'shoes-shape' (Figure 6) and the new 'natural sediment trap' has produced (Figure 4 & 5C). The bottom of the drainage channel is also not at the same level or sloping into the sea (Teluk Mengkabong) smoothly.

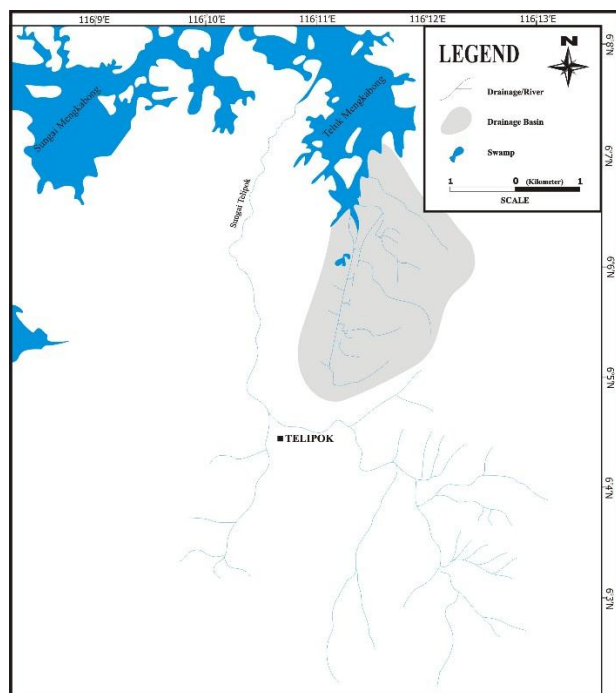


Figure 6: The 'shoes-shape' drainage basin

Sediment accumulation and rising in surface level has been observed in '90° corner' drainage channel, front of culvert and the new 'natural sediment trap' reducing the drainage channel and culvert load capacity (Figure 5A and 5B) and submerging settlement house (Figure 5C), respectively.

Hill cutting pressures, faster runoffs from exposed surface, fine sediment loads on some streams smother the bed killing off invertebrates and fish eggs resulting in fish not using them or in reduced spawning success. The fine sediment loading has severely affected streams egg survival and has been reduced to 0% [24].

Silt will affect aquatic life by retarding hatching rates of fish eggs, compacting the spawning gravels and reducing the invertebrate colonies. In the study area, siltation is also decreasing the water quality of the drainage system into IIA class as shown in Table 4 and reducing the community of stream fish life (Table 5).

Table 4: The water quality and class.

Sample	Turbidity (NTU)	Suspended Solid (mg/L)	Class
W1	48	45	IIA
W2	56	44	
W3	9	7	
M4	-	34	IIA
RG1	9	18	IIA
RG2	18	19	
RG3	7	22	
RG4	9	34	
S2	11	-	IIA

W1, W2, W3-Sinoh Environment, 1996; M4-Perunding Sekitar, 1993; G1, RG2, RG3, RG4- Perunding sekitar, 1992; S2-Eddy Affandy, 1999

Table 5: Recoded and observed biological fresh water community

Family	Species	Local Name	Record
Anabantidae	<i>Anabas testudineus</i>	Karuk (Climbing perch)	R
	<i>Trichogaster pectoralis</i>	Sepat siam	R
	<i>Trichogaster trichopterus</i>	Sepat padi	R
Channidae	<i>Channa striatus</i>	Haruan	R
Cichlidae	<i>Tilapia batrachus</i>	Tilapia	R
Clariidae	<i>Clarias batrachus</i>	Keli	R
Cypindae	<i>Lobocheilus bo</i>	Belanak sungai	R
	<i>Nematobramis alestes</i>	Gepeng	R
	<i>Nematobramis everetti</i>	Gepeng	K
	<i>Rasbora rutteni</i>	Seluang	S
	<i>Rasbora hubbsi</i>	Seluang	K
	<i>Puntinus sealei</i>	Lampam, Turonggou	S
Gastromyzontidae	<i>Puntinus schwanefeldii</i>	Lampam sungai	R
	<i>Gastromyzon borneensis</i>	Rokot, Rogut	R
	<i>Gastromyzon fasciatus</i>	Rokot, rogut	R
	<i>Oxyleotris marmoratus</i>	Kekutu	R

Record: S-Seen; R-Reported by local civilian; K-Known as exist in the similar habitat (Source from Perunding sekitar, 1992)

### 4.3 Flash Flood

Environmental degradation is also contributed to the flash flood problem in the study area. The flash flood occurs when the drainage system has lost the ability to handle discharge capacity, influenced by natural phenomenon like valley floor and environmental degradation due to human disturbance and characterized by varies in depth and limited in area [1].

The occurrence of flash flood usually after about 30 minutes of heavy rainstorm event but ended too shortly (i.e. life range is half an hour to a day). In the study area, flash flood usually last for three hours or more in a single heavy rainstorm or successive day of moderate rain during the rainy session (Figure 7). In general, flash flood usually coincides with the south-western monsoon session (May to September) such as on May 1995 (Figure 7B and 7C), 16 August 1998 and 13 August 2005 (Figure 7G and 7H) which is the same period of flash flood cycle in the east coast of the Peninsular Malaysia [10, 25].

The major effects of flash flood in the study area are submergence of the flood plain area. This led to traffic congestion at Tuaran road and Jalan Lama Tuaran, as well as submerging some settlement houses (Figure 7C) and to create unique phenomena i.e. 'stair without pole' (Figure 7D) and neglected houses (Figure 7C, 7D, 7E and 7F).

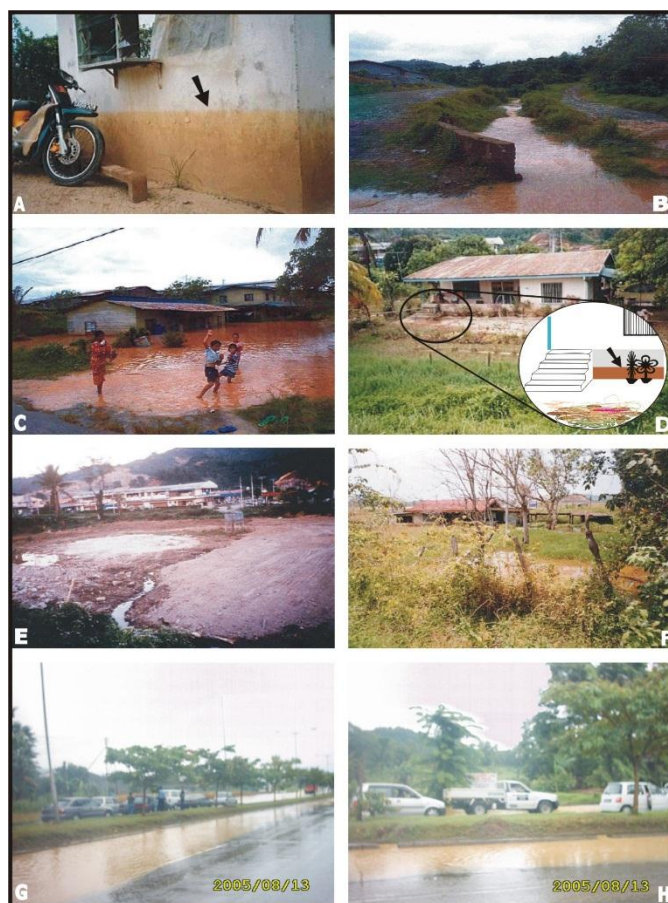


Figure 7: Flash flood in the study area. A. Trace of water level (arrow) or flash flood in Ho Wah Genting Coach's guard post at km 26 of Tuaran road. B. Raising of drainage water level during a single heavy rainstorm event on May 1995 (source from Wailey, Dept. of Irrigation and Drainage, Tuaran). C. The flash flood on May 1995. Original condition of 'stair without pole' house, view to the south eastern (Source from Wailey, Dept. of Irrigation and Drainage, Tuaran). D. The 'Stair without pole' house on Oct 2000 showing the trace of water level (arrow). View to the east. E. Site of demolished 'stair without pole' house on 22 February 2001, views to the east. F. Demolished house in the swampy area and grass field in the new natural sediment trap originated from paddy field. G & H. Flash flood on 13 August 2005 at km 26.5 of Tuaran road.

### 5. OCCURRENCE OF ENVIRONMENTAL PROBLEM

The main influential factors for the environmental problem in the study area are natural and human.

#### 5.1 Natural Factor

### 5.1.1 Geology

The study area is underlined by relatively soft interbedded sandstone and shale of Crocker Formation and alluvial deposit (Figure 2). The Crocker Formation also capped by thick zone of highly weathered and loosely consolidated material. This in turn has contributed to the increase of the rate of weathering, soil erosion (Table 2), soil degradation and deposition of tons of clay and silt material or siltation onto low land area and into drainage channel. The Crocker Formation has also undergone diagenetic processes characterized by poor porosity and permeability [26]. This resulted in the higher rate of surface runoff and decrease in infiltration.

### 5.1.2 Climate

Wet condition of tropical climate in the study area contributes up to 3470.9 mm/year of annual rainfall in average with longer and continues heavy rainstorm session. This heavy precipitation increases in the rate of weathering, soil erosion (Table 2), water resources supply and drainage water level in a shorter time (Figure 7).

### 5.1.3 Geography

The study area is boarded by coastal area on the west and dominated by flood plain in the middle toward the western parts (Figure 1 and 2). Tidal influence and high underground water table i.e. about 2.67 metres from surface are important factor in the rising of water level especially during high tide [27].

### 5.1.4 Topography

The hilly (20m to 300m) and steep slope ( $\geq 30^\circ$ ) in the eastern part and become gently towards low land or flood plain area (0 to 20m above sea level) in the middle and western part has led to immediate decreases in the velocity of runoff in the study area (Figure 2).

### 5.1.5 Drainage

Drainage characteristic factor is represented by shorter drainage channel i.e. less than 4 km in average and wide resources area such as western part of Bt. Gilling ridge in the eastern and western parts (KKIP area) of the study area may contribute in the narrowing channel outlet of discharge load but large in water resources supplies (Figure 2 and 6).

## 5.2 Human Factor

### 5.2.1 Lake of proper planning

Preliminary planning and management of any urbanization activities should consider the relationship between infrastructure development and drainage system such as construction of road, factory, quarry, etc. in relation to the culvert and drainage (ditch) design. In the study area, the road was constructed about 0 to 12 m above sea level and exposed to the submergence especially in the low laying area. Natural drainage channel and new ditch are located at the foot hill of Bt. Gilling ridge and in the middle and western part of the study area, respectively. The drainage system is also connected to the culvert (Figure 3 & 5), across the road and finally discharges into Teluk Mengkabong.

Construction of a small and shallow drainage (ditch) channel with 1 m depth from road's surface decreases the channel capacity (Figure 5B) and may caused immediate changes in vertical pattern of channel bed level. This in turn has change the paddy field and flood plain in the middle of the study area to become a new natural sediment trap and swampy area (Figure 5C). Smaller culvert is also contributing to increase in the siltation and lost of the smoothness of the drainage flow (Figure 5A, 5B, 5D & 5E).

This improper planning has led to the congestion of the drainage flow that cause runoff overflow or flash flood problem to submerge the settlement houses (Figure 7C), lower part of the road (Figure 7G & 7H) and paddy field area (Figure 7F).

### 5.2.2 Human activities

The most influential factor to environmental problem in the study area is human activities such as hill slope cutting and land filling (Figure 3) which has increased in the rate of weathering, soil erosion, siltation, loss of vegetation cover, exposure of surface area decreasing water quality (Table 4) and biological fresh water community (Table 5).

Land filling for the preparation of urbanization sites involved wide area of natural swamp and mangrove swamp in Teluk Mengkabong and natural

drainage system in the middle and western part of the study area. This degradation has caused major lost in the natural hydrological cycle in the wetland area such as lost of sungai Lengking and natural retention pond (Figure 3).

Major construction has created impervious surface such as bitumen road, parking lot, government, factory and business building and centre, housing, cemetery and farming area, asphalt and exposed surface in the study area (Figure 3). These contributes to the increase in the rate of surface runoff and to decrease in the infiltration and lag time of rain drop to reach the drainage system as well as affecting stream fresh water fish community.

Human activities also have caused modification of drainage pattern and channel flow's direction to form the '90° corner' of drainage channel, 'shoes-shape' of the drainage basin and the new 'natural sediment trap'. This in turn has led the change in drainage velocity and congestion of the channel's flow and deposition of silt and clay material in settlement house floor and paddy field.

### 5.2.3 Community attitude

Attitude of the surrounding public community also contribute to flash flood problem in the study area. Solid waste management of industrial, residential and settlement area is not handled in proper way but left, dump, assemble and thrown into drainage channel (Figure 5E & 5F).

## 6. DISCUSSION

The solution of the environmental problem in the study area could be achieved with the efficient enforcement of the environmental (soil erosion, siltation, water quality and flash flood) regulation, sustainable land use planning and management, to increase in the community awareness in environmental problem, reconstruction and conservation of natural environmental condition or ecosystem.

### 4.2 Enforcement of the environmental regulation

Any urbanization activities which potentially modified drainage system and flow must be supported by a completed EIA report. The existing regulation must be implemented and enforced to monitor and maintain drainage channel from the debris (Figure 5B), solid waste (Figure 5E & 5F), wild grasses (Figure 5F) and siltation in the upper part and outlet part of culvert (Figure 5A & 5B).

### 4.3 Sustainable land use planning and management

The study area has been gazetted for part of the north eastern part of the Kota Kinabalu Industrial Park (KKIP) and housing schemes by the Department of Town and Regional Planning of Sabah [2]. Implementation of the *Ecocity* concept is recommended in order to reach an integration or balance of sociological, environmental and economical factors in sustainable development of Kota Kinabalu.

Drainage modification and road construction should be reconsidered about the ability in handling high drainage load during heavy rainstorm event and flooding risk assessment (Figure 5). So, the culvert and drainage must design in optimum size, flowing smoothly and discharge to the open sea. The road surface should be higher or not less than 3m above sea level in the flood plain area or nearer to the coastal line area [26].

The areas of hill slope cutting ( $\geq 25\%$  slope steepness) and exposed surface must be provided with the sediment trap in strategic area, implementation of the *Envirofelt Method* (polypropylene fabric), the terrace or stages terraces, the plastic sheet cover and creative planting of the vegetation (cutting, hydro seeding or disperse seeding methods, scrub and suitable tress) to control the rate of weathering on soft Crocker Formation, erosion and siltation [28].

The opening of new area is also vital to conducts in stages but not once in order to control environmental degradation as well as implementation of the manual of *environmental friendly drainage methods* to maintain natural hydrological cycle of wetland area like study area [29].

Formulation and designation of 'geoindicator' to measure high resolution short term change in geological environment (urbanization related environmental changes) which is significant for environmental monitoring and for carrying out assessment related for sustainable development etc. [30]. This geoindicator will be used as a database for further sustainable development in the area. Attribute for tropical urban geoindicator are described in a study [31].

#### 4.4 Community awareness

Community's attitude in the awareness in natural environmental quality (soil erosion, siltation, water quality and flash flood problem) could be increased through extensive practical campaigns in mass media such as internet, newspaper, radio, television, magazine and entertainment posters [32-35]. Objectives of the campaign must be focused on solid waste management and flash flood problem.

#### 4.5 Reconstruction of natural ecosystem

Another aspect should be considered in the solution of environmental problem is to reconstruct the environment to its original condition by maintaining and monitoring of hydrological system in the study area (Figure 3).

### 5. CONCLUSION

Results of this study can be concluded as follows:

1. Environmental degradation is a serious environmental problem and has been induced by modification of land used in the urbanization activities.
2. Environmental quality in the study area has been influenced by natural and human factors.
3. Environmental problem in the study area could be avoided and mitigated by efficient enforcement of environmental (soil erosion, siltation, water quality and flash flood) regulation, sustainable land use planning and management, increase in community's awareness in environmental problem and reconstruction of natural ecosystem.

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