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RISK MAPPING ON HEAVY METAL AND NUTRIENTS AFTER FLOOD EVENT ON PAHANG RIVER USING INTERPOLATION DISTANCE WEIGHTED (IDW) APPROACH

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ABSTRACT

In December 2014, Kuala Krau which is located inthe state of Pahang, Malaysia has been hit by severe floods which caused a lot of destruction of property and damage to the project catfish in cages along Sungai Pahang. This study focused on the Kuala Krau area because this area is among the worst-hit areas in Pahang. The study aims to quantify nutrients concentrations such as nitrate (NO_3) and nitrite (NO_2), and other parameters that are necessary to know because it could affect the health of local residents such as iron (Fe), magnesium (Mg) and Zinc (Zn) as well as to investigate their potential environmental risk. GIS software is used to map the environmental risk assessment at each of the sampling location. The results of the study found that most of the parameter concentration is below the limit set out in the Malaysian Water Quality Standard and the trend of transport for most parameters showed a linear correlation when the river flows downstream, the concentration of the parameter also increases.

Keywords: risk mapping, heavy metal, nutrients, flood, Pahang river, interpolation distance weighted, Malaysia.

INTRODUCTION

Increasing of populations and rapid industrialization among the developing countries have cause the water quality deterioration due to the anthropogenic activities including industrial discharge, sewage system, domestic waste and agricultural waste [1-3]. Anthropogenic activities have caused excessive input of nutrients such as nitrate and other form of nitrogen that originate from the river into the coastal water. This phenomenon will lead biotic activities in estuaries and coastal seas influence nutrients carried by rivers and it will change conditions in their watersheds [4-5]. The presence of nitrate indicates an important macronutrient in the aquatic environment. It will affect human life because nutrient can break down into nitrite that will cause failure of red blood cells to carry oxygen [6]. Large quantities of hazardous chemical especially heavy metal have been released into rivers worldwide due to global rapid population growth and intensive domestic activities as well as agricultural production [7-8]. Their release in aquatic ecosystem is triggered by both natural and anthropogenic process [9-10]. When it released into the rivers, it may get either dissolved to form ion or complexes, suspended as particulate matter or settled down as bed sediments [11] and will may cause serious ecological threat through bioaccumulation if get a chance to enter food chain [12]. Nevertheless, in [13] stated that heavy metal are identified to be an essential environment factor that can lead to severe human health hazards including neoplasm via mainly three pathways, oral intake, inhalation and dermal absorption. In [14] reported that water quality was mainly influenced by seasonal processes such as flood and evaporation. Although sediment-associated metals accumulate in the river during periods of low discharge, they are suspended and transported downstream during flood events [15] especially during higher magnitude flood where the risks of metal mobilisation increase. Great attention should therefore be paid to the hydrological process and the transport of sediment associated metal and nutrients during flood events. These high magnitude floods are caused by heavy rain episodes which can episodically flush large amounts of sediments into the river, particularly when there is important runoff [16-17]. In [18] revealed that the rural pollution deteriorated by the increasing tendencies of total nitrate (TN) and total phosphorus (TP) and was linked to the abuse of fertilizer and pesticides. These problems can be solve by applying retention of the reservoir by decreasing concentration of the heavy metal from upstream to downstream. Concern has increased that climate change also contribute to the impact of hydrologic extreme such as floods event. [19].

DESCRIPTION OF STUDY AREA: KUALA KRAU, PAHANG

Kuala Krau is located in Temerloh, Pahang, Malaysia. In the area of the Kuala Krau, Pahang River there is a path which is a source of income for local residents who carry out activities for catfish in cages. However in 2014, the heavy rains have caused severe flooding area of Kuala Krau. Much of the losses recorded during the floods. During the first weeks of flooding that occurred in that area, which forced the local people moved to temporary flooding transfer center and most major routes into the Kuala Krau flooded and has been closed. For the study, three different sampling stations were selected along Pahang River. The sampling campaigns have been conducted twice after the flood event. Figure-1 indicated the locations of river water have been taken and Table-2 summarized details for each of sampling point.

There are only three sampling locations that can be made because the situation after the floods is difficult to access. Most of the location filling with mud and house damaged. This three sampling location also have been chosen because there is no major tributaries in between of each sampling location that can affect the water quality condition.

Figure-1. Location of sampling location along Pahang River.

Table-1. Coordinate and detail description on three sampling location.

Sampling point	Sampling station	Description
1	Kampung Cengkenik 3° 39' 6" N 102° 24' 43" E	The most upstream station for Kuala Krau area on the mainstream of Pahang river.
2	Kampung Kerai 3° 35' 27" N 102° 24' 56" E	Near to the residential area and catfish cages.
3	Kampung Teluk Sentang 3° 32' 24" N 102° 26' 10" E	Near to the residential, school and commercial area.

EXPERIMENTAL

Laboratory test

The parameters of water quality determined under laboratory test are Nitrate (NO_3), Nitrite (NO_2), Magnesium (Mg), Zinc (Zn) and Iron (Fe) analysis. Tests were conducted according to the Standard Methods for the Examination of Water and Wastewater [20].

Risk mapping using GIS

Data processing includes several works such as data preparation, data management, topological mapping and quality control. Spatial characteristics such as land use include residential, commercial, industrial and forestry were stored as spatial data. Then, the average data for the concentration of Nitrate (NO_3), Nitrite (NO_2), Magnesium (Mg), Zinc (Zn) and Iron (Fe) were added into the attribute table. Interpolation Distance Weighted (IDW) tool have been use in order to identify the risk potential based to the studied parameter in the affected area by flood.

RESULTS AND DISCUSSIONS

Laboratory test result

Laboratory analysis was done in the environmental laboratory, Faculty of Civil Engineering. The results of heavy metal and nutrients concentrations for three sampling points are present in the table below. The results are compared to the threshold limit by Malaysia National Water Quality Standards 2006 [21] as shown in Table-2, meanwhile result obtained from laboratory test represent in Table-3. The values in the data present the average value for each parameter.

Table-2. Threshold limit by Malaysia National Water Quality Standards 2006 for Class III (marine and river) condition.

Nitrate	Nitrite	Zinc	Magnesium	Iron
0.4	-	0.4	-	1.0

*unit of concentration is mg/L
*Class III categorized as water supply III-extensive treatment required and fishery III-common, economic value and tolerant species; livestock drinking

Table-3. Average value of result obtained from laboratory test.

Sampling point	1	2	3
Nirate	0.400	0.157	0.685
Nitrite	0.097	0.143	0.289
Magnesium	2.703	0.757	2.963
Zinc	0.193	0.413	0.852
Iron	1.173	1.337	1.891

*unit of concentration is mg/L

IDW output of iron (Fe)

The map of iron distribution showed above is based on the average concentration values recorded in Table-3. From the map, the colour region is based on the average concentration of iron recorded at each sampling locations. The permissible limit set by NWQS for iron is 1.0 mg/L. The third sampling location shows bright red colour since the iron concentration recorded at the point is slightly higher than other sampling locations. The value of iron concentration at all sampling point was recorded above the permissible limit of class III NWQS with the value of 1.173 mg/L, 1.337 mg/L and 1.891 mg/L from first sampling point until third sampling point. The slightly high iron concentrations were recorded at sampling point located within overcrowded residential areas. Besides, the concentration of iron increase at third sampling point

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because the flow of river which carry the pollutant from upstream to the downstream.

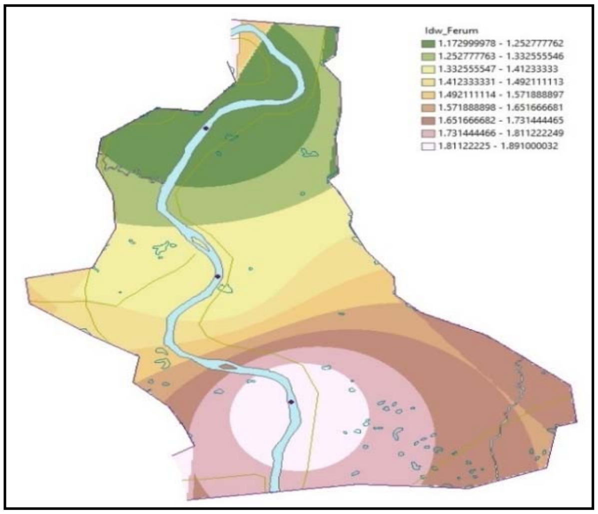

Figure-2. Risk mapping of iron distribution.

IDW output of nitrite (NO_2)

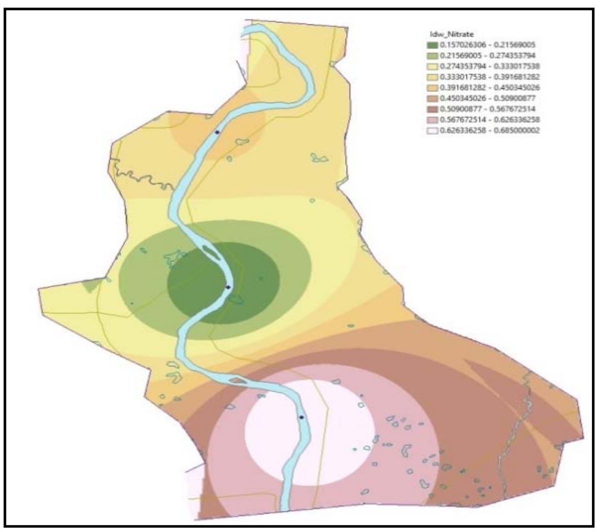

Figure-3. Risk mapping of nitrite distribution.

The nitrite dispersion map in Figure-3 is based on the average concentration values recorded in Table-3. As shown in the map above, third sampling point gave the highest amount of nitrite concentration with value of 0.289. Meanwhile, second sampling point showed higher value of nitrite concentration compare to first sampling point (upstream). This is because based to the observation on site, in the area of second sampling point has a higher population than the first sampling point. According to [22], nitrite pollution was caused from human waste from wastewater and septic tank runoffs. Also, study from [23] indicated that NO_2 in water bodies are mostly comes from industrial and domestic wastes.

IDW output of nitrate (NO_3)

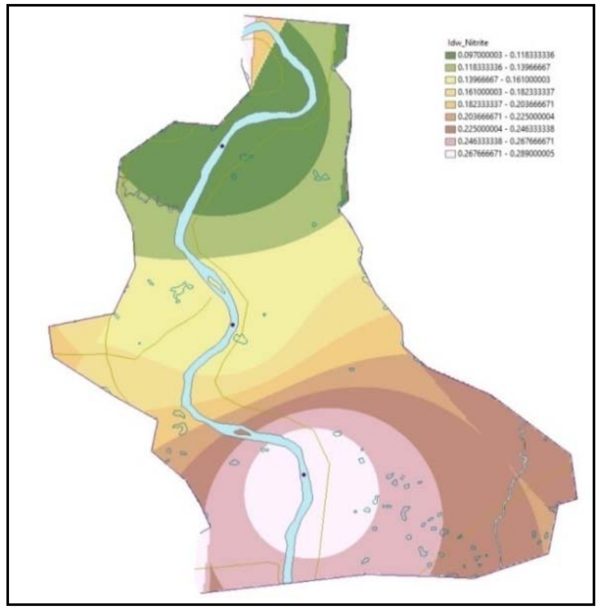

Figure-4. Risk mapping of nitrate distribution.

The nitrate distribution map is based on the average concentration values as stated in Table-3. From the map, the colour region is based on the average concentration of nitrate recorded at each sampling locations. Concentration recorded at first and second sampling point gave the value below the permissible limit of NWQS (0.4 mg/L) which are 0.4 and 0.157 mg/L respectively. Third sampling point gave the highest value of nitrate concentration at 0.685 mg/L. According to [24], low concentration of NO_3 in river is mainly because of NO_3 is naturally form from nitrogen and has high dispersion rate in water. Other than that, in [25] stated that NO_3 pollution are closely related with the low human activities nearby. The NO_3 is mostly found in agricultural activity where nitrogen fertilizers were used [22]. The area around first sampling point is low with agricultural activity according to land use classification.

IDW output of magnesium (Mg)

The map of magnesium distribution showed above is based on the average concentration values recorded in Table-3. From the map, the colour region is based on the average concentration of magnesium recorded at each sampling locations. The third sampling location shows bright red colour since the magnesium concentration recorded at this point is slightly higher than other sampling locations. The value of magnesium concentration at all sampling point was recorded with the value of 2.703 mg/L, 0.757 mg/L and 2.963 mg/L from first sampling point until third sampling point. The slightly high magnesium concentrations were recorded at third sampling point.

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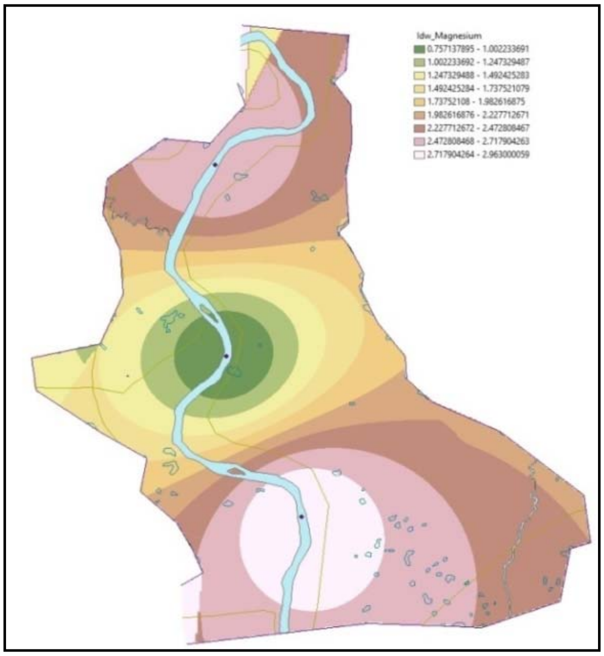

Figure-5. Risk mapping of magnesium distribution.

The concentration of magnesium seems gave higher value than other parameters studied this thing have to be prioritized because high magnesium content in the water can disrupt the health of local residents. High concentration of magnesium in human body can occur as a result of vomiting, diarrhea, use of certain diuretics, alcoholism and protein malnutrition [26]. Magnesium may also contribute undesirable tastes to drinking water [27].

IDW output of zinc (Zn)

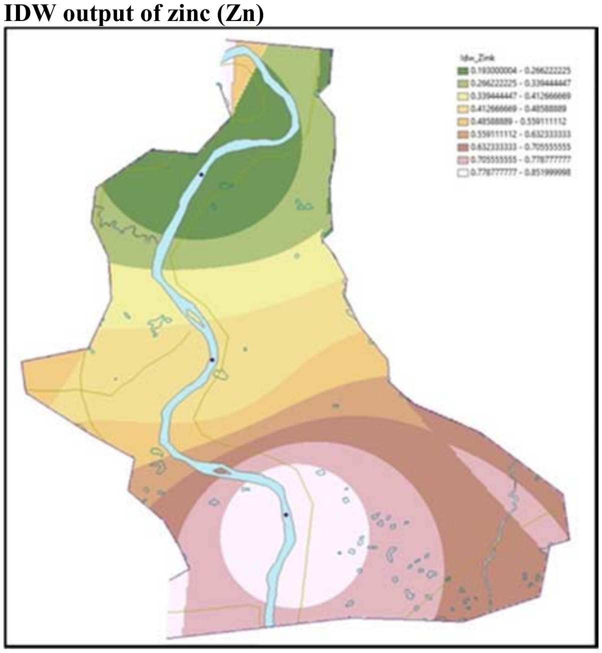

Figure-6. Risk mapping of zinc distribution.

From the map, the colour region is based on the average concentration of zinc recorded at each sampling locations. The map of zinc distribution showed above is based on the average concentration values recorded in Table-3. The permissible limit set by NWQS for zinc is 0.4 mg/L. The third sampling location shows bright red colour since the zinc concentration recorded at the point is slightly higher than other sampling locations. The value of zinc concentration at two sampling point was recorded above the permissible limit of class III NWQS (0.4 mg/L) which is second and third sampling points with the value of 0.413 mg/L, and 0.852 mg/L respectively. The concentration of iron increase at third sampling point because the flow of river which carry the pollutant from upstream to the downstream.

CONCLUSIONS

The results of the study found that most of the parameter concentration is below the limit set out in the Malaysian Water Quality Standard categorized under standard for class III (Marine and River) and the trend of transport for most parameters showed a linear correlation when the river flows downstream, the concentration of the parameter also increases. The linear correlation occurred due to the contribution factor on land use activity near to the river such as existing of commercial area at sampling location 2 and residential area at sampling location 1, this statement supported study done by[23] indicated that NO_2 and NO_3 in water bodies are mostly comes from industrial and domestic wastes.

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