Distributions of Heavy Metals Contamination in Upstream River of Timah Tasoh Lake

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***Abstract*—Distribution of heavy metals namely lead, copper, chromium, arsenic, manganese and aluminium were determined for surface water samples during Southwest Monsoon and Northeast Monsoon 2012. The level of heavy metals was determined using Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and the spatial distribution of heavy metals contamination was visualized using MapInfo Software. The highest contamination was found is manganese, copper and aluminium which is exceeding the permissible limit set by Department of Environmental, Malaysia. These might due to the increase of agricultural, industrial and domestic wastes located near the river.**

***Index Terms*—contamination, heavy metals, surface water, inductively coupled plasma mass spectrometry, agricultural, wastes**

I. Introduction

Timah Tasoh Lake, Perlis (6^o 36^oN and 100^o 14'E) located approximately 13 km north of the Kangar town near the Thailand boarder having average surface area about 13.33 km^2. The storage capacity up tp 40 million meter cube and mainly used for drinking, agricultural and industrial purposed. However, due to discharged of anthropogenic activities wastes into water bodies in upstream rivers, the quality of water in the Lake have been depleted [1]. Most of the industries disobey the law by dumping their wastewater without being treated partially into surface water bodies. Moreover, the improper sanitation service especially in rural area makes nearby stream either canal or drains are the perfect places to dispose their sewage. The excessive use of fertilizer and pesticides are also can be a major source of water pollution. This situation has greatly introduced pollutants such as heavy metals in water bodies. Hence, a continuous monitoring and evaluation of water quality is very essential [2].

As the status of water quality varies spatially as a result from the distribution of human activities, mapping the chemical parameters using MapInfo Geograhical Information System (GIS) software is very useful [3]. GIS can be used as a tool for evaluating spatial or geographical data and has the advantages of handling attributed data in conjunction with the spatial features.

The objective of this research is to determine spatial distribution of heavy metals contamination by determining the concentration of heavy metals reading at the selected points. Then, this information will be visualized by using MapInfo to draw thematic maps of distribution heavy metals at each point.

II. Methodology

A. Study Area

Study area was divided into two main part which is Zone A and Zone B. Zone A contrain stations 1 until 4 which is located at Padang Besar menanwhile Zone B contaion station 5 until 10 located at Wang Kelian (figure 1). Based on the observation, the agricultural area in upstream catchments such as rubber, paddy, sugar, cane, timber plantation and livestock surrounding Lake [4] were identified as non-source pollution. Meanwhile, domestic and industrial zone were categorized as point source pollution to the Timah Tasoh Lake [4]. Both source of pollution may contribute to the depletion of water quality. The Fig. 1 below illustrates the location of sampling site.

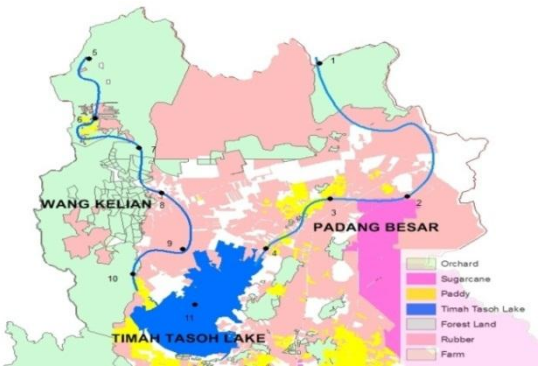

Figure 1. Location map for sampling points

B. Water Analysis

Surface samples were collected using Niskin water sampler from 11 sampling points (Fig. 1) on Southwest

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Monsoon (SW) and Northeast Monsoon (NE) 2012. Water sample was kept in polyethylene bottle sample and was acidified with concentrated HNO_3 to pH < 2. All preserved water samples were filtered through pre-washed 0.45 µm Milipore nitrocellulose filters for further elemental analysis. The elements such as lead (Pb), copper (Cu), chromium (Cr), arsenic (As), aluminium (Al) and manganese (Mn) were analyzed using Inductively Coupled Plasma Mass Spectrometry (ICP-MS).

Mili-Q water system and reagents with analytical grade were used throughout the work. Standard Reference Material (SRM) for fresh water and reagent blank were used for quality control sample during analysis. The percent recovery of metals is quite acceptable which is within 85-120%. The standard solution used for calibration was prepared by diluting stock solution of 1000 mg/L of multi element standards.

C. Mapping Procedure

The GIS analysis was carried out using MapINFO Professional Software in order to create the thematic map for spatial distributions of heavy metal concentration in surface water. The boundary of the study area was digitized using polygon tabfile. The basic geographic location such as longitude and latitude of study area were inserted as a basic layer and a database table containing the chemical data. For each element, the spatial analysis thematic map for each measured water parameter was extracted.

III. Results and Discussion

A. Mean Heavy Metal Concentration

The heavy metals concentration of water samples is summarized in Table I. Based on the mean value, heavy metal concentration sequence for SW monsoon was Pb<Cu<Cr<As<Al<Mn meanwhile for NE monsoon Pb<Cr<Cu<As<Mn<Al.

TABLE I. HEAVY METALS CONCENTRATION AND NATIONAL WATER QUALITY STANDARD IN MALAYSIA. ALL CONCENTRATION ARE IN PPB UNIT

SOUTHWEST MONSOON						
Stations	**Pb**	**Cu**	**Cr**	**As**	**Mn**	**Al**
1	0.60	0.30	6.87	0.30	31.83	9.17
2	0.37	1.07	4.67	4.40	78.24	10.30
3	0.72	1.28	5.16	2.30	146.47	34.94
4	1.77	1.40	2.17	3.83	217.43	97.34
5	0.53	0.27	0.80	5.97	11.37	21.65
6	0.17	0.23	0.57	6.63	121.90	24.12
7	0.73	1.50	1.27	5.03	94.97	26.37
8	0.57	0.50	3.93	10.10	39.83	27.10
9	0.73	0.93	3.30	12.60	66.80	32.89
10	2.00	2.07	1.37	11.20	105.50	60.15
11	1.30	2.07	0.97	9.57	128.43	28.12
Ave	**0.86**	**1.06**	**2.82**	**6.54**	**94.80**	**33.83**
Std Dev	**0.58**	**0.68**	**2.10**	**3.89**	**58.90**	**25.03**
NWQS	**-**	**20**	**2500**	**400**	**200**	**100**

Results were then analyzed for significant difference between both monsoon using t-test for paired observations [5] as shown in Table II. The test specifies that Cu, Mn and Al having a significant difference among them with the P values are < 0.05. Meanwhile, others have no significant different among them. This may indicate that only Cu, Mn and Al were affected with the monsoon changes.

NORTHEST MONSOON						
Stations	**Pb**	**Cu**	**Cr**	**As**	**Mn**	**Al**
1	1.50	1.65	7.63	0.00	30.04	51.37
2	2.67	20.92	4.91	3.07	69.33	153.01
3	2.33	6.44	5.24	0.88	96.04	178.51
4	5.29	3.10	5.11	1.15	130.68	463.48
5	2.17	1.35	1.89	2.75	21.93	117.24
6	3.01	1.41	3.57	6.13	133.28	92.70
7	2.53	1.57	3.22	3.38	87.83	100.95
8	2.67	2.63	3.32	7.61	85.76	77.59
9	3.67	1.99	2.91	10.27	93.91	87.67
10	6.48	1.60	2.37	6.86	114.07	129.34
11	3.72	2.04	2.55	5.94	112.87	113.07
Ave	**3.28**	**4.06**	**3.88**	**4.37**	**88.70**	**142.27**
Std Dev	**1.46**	**5.78**	**1.68**	**3.22**	**36.53**	**112.18**
NWQS	**-**	**20**	**2500**	**400**	**200**	**100**

TABLE II. HEAVY METALS T-TEST

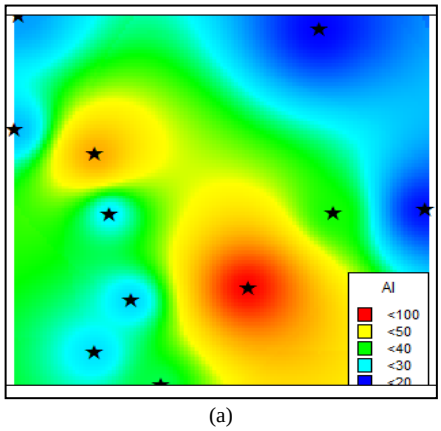
Elements	P values
Pb^a / Pb^b	0.0000
Cu^a / Cu^b	0.0163
Cr^a / Cr^b	0.1155
As^a / As^b	0.0000
Mn^a / Mn^b	0.0401
Al^a / Al^b	0.0030

*a SW monsoon
*b NE monsoon

Analyzed water samples were compared with the National Water Quality Standard (NWQS) derived from Department of Environmental in Malaysia standards for drinking water purposed. Among six elements, during SW monsoon only Mn was exceed the limit meanwhile Cu and Al during NE monsoon at the certain location were found exceeding the standard limit. These metals fall into Class III that is set by DOE which means an extensive treatment is required for the drinking water purposed as well as for fishery and livestock drinking.

B. Spatial Distributions of Heavy Metals in Surface Water of Upstream River

The spatial distribution patterns of heavy metals in surface water sample are showed in Fig. 2 using thematic contour maps. These map illustrated the distinct zones of lower or higher concentration by a graded color tone legend. The red color was used to the zone of higher concentration meanwhile dark blue color is for lower concentration.



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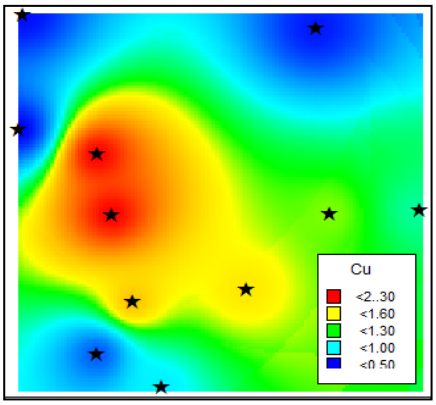

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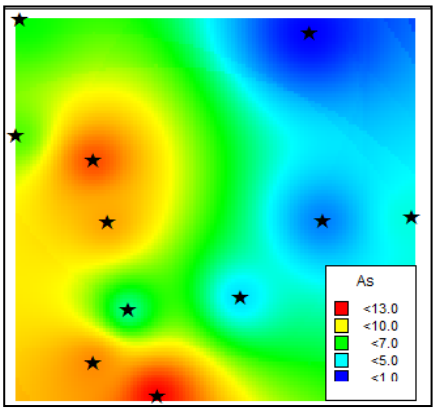

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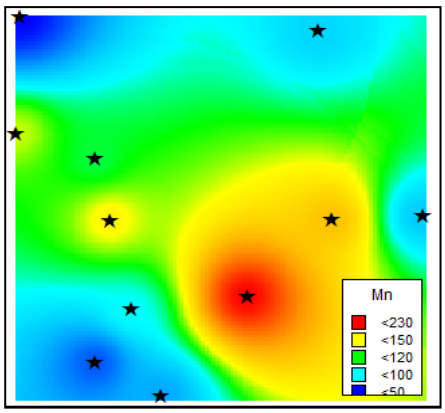

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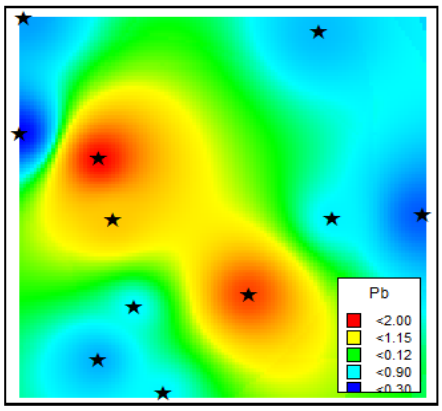

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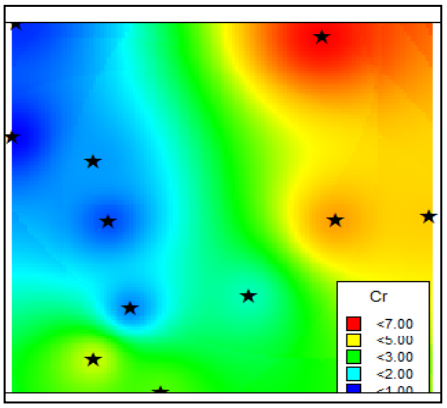

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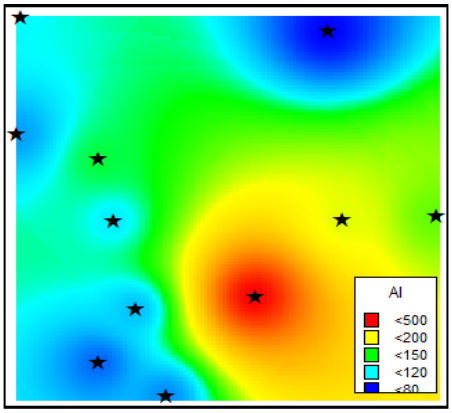
Figure 2 (i). Spatial distribution of heavy metals in Southwest Monsoon



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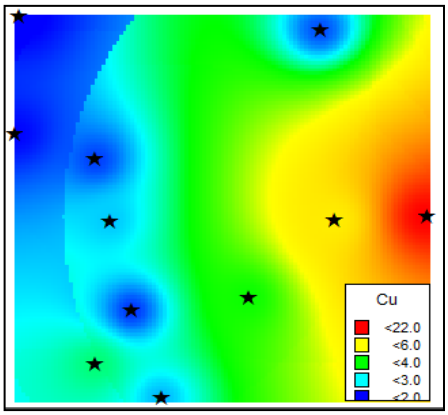

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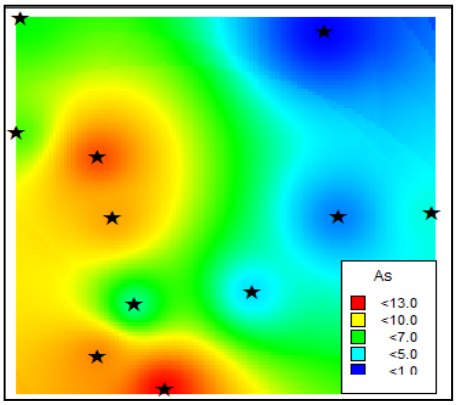

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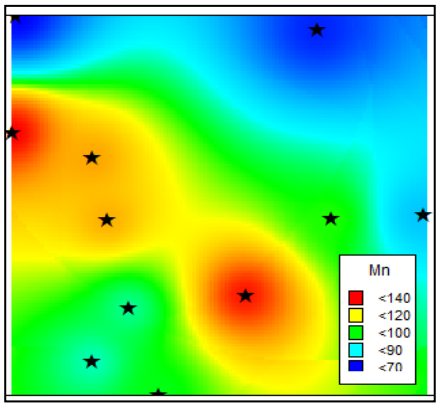

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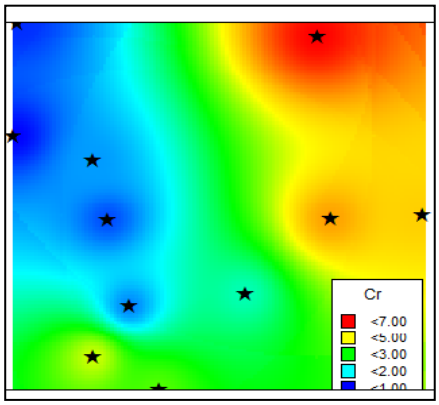

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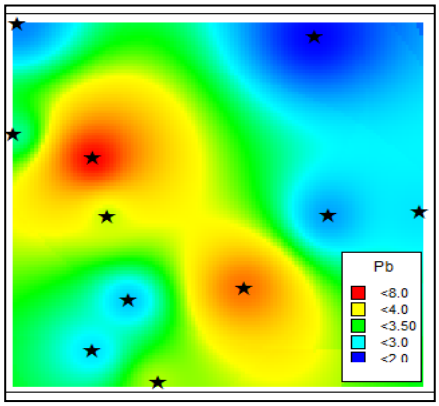

(f)

Figure 2 (ii). Spatial distribution of heavy metals in Northeast Monsoon

Mn was recorded high concentrations during SW monsoon at stations 4, meanwhile Al recorded high concentration at stations 2,3,4,5,7,10 and 11 during NE monsoon. These stations was found to exceed the permissible limit based on NWQS with the concentration of Mn < 200 and Al < 100 ppm respectively. The possible sources of these metals is primarily contribute to agricultural and industrial practice such as textile, fiberglass, chemical, food and rubber made industry located at Padang Besar near the river [6], [7]. Besides that, the occurrence of trace metals in river may naturally derived from soil and mineral weathering [8].

The highest concentration of Cu in station 10 and 11 during SW located at Timah Tasoh Lake is may come from the used Cu salts are in water supply system to controlled biological growth in reservoir and distribution pipe since this river is an important source of freshwater in Tasoh Dam [9]. Meanwhile during NE, highest Cu was recorded and exceed the permissible limit based on NWQS at station 2 located at Padang Besar area. This may due to the effect of high wind flow and received metals in the form of particulate matter such as the usage of copper in brake particles transportation in industrial and residential area since the river is near the main road [10]. Besides that, corrosion of copper that contain alloys in pipe fitting may leached measureable amounts of Cu into water in pipe systems.

The highest concentration Pb in station 10 for both monsoons may come from the dissolution of plumbing. The improper installation of pipe for tap that are not suitability treated may contain lead resulting from an attack on Pb service pipes. Moreover, an illegal dumping waste directly into the river was found at this station.

Cr and As give a maximum concentration at station 1 and 8 for both monsoon respectively The possible reason for high concentration of these metals may come from all anthropogenic sources such wastewater discharged from industries, residential area and application of pesticide since there was agricultural land, factory producing mineral water and domestic wastes at the upstream of this river. However, these metals might occur naturally from the extensive evaporation of water due to high temperature and low rate of rain falls [11].

IV. Conclusion

The upstream rivers of Timah Tasoh Lake are exposed to the pollution from natural and anthropogenic sources.The distribution pattern of metals was varied through the Upstreams River of Timah Tasoh Lake. This indicates that there is unregulated discharge of contaminated effluent into water bodies without earlier treatment by responsible industries and communities within the study area. Among six element, Al, Cu and Mn was found exceeding the standard limit derived from Department of Environmental (DOE) Malaysia. Both metals fall into Class III that is set by DOE which means an extensive treatment is required for the drinking water purposed as well as for fishery and livestock drinking

Results of this study provide baseline data which can be used for expanding this research by using other statistical analysis as well as further application for GIS analysis.

Acknowledgements

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