

more than 21 major tributaries. The water supply resources are demanded by approximately 60% of Seremban population. Major anthropogenic activities nearby this river include palm oil and rubber plantations, aquaculture, paddy cultivations, manufacturing industries and human settlement areas [12, 13].

The aim of this study was to apply the chemometric methods on water quality data set of Linggi River in order to identify sources of pollution and explicit latent factors responsible for temporal and spatial variations.

MATERIALS AND METHODS

Sampling and Laboratory Analysis

The data sets of 26 selected sampling stations, which consist of 11 water quality variables monitored monthly from January to December 2011. The map location and descriptive information of sampling stations are presented in Figure 1 and Table 1, respectively. All surface water samples were collected at a 0.5 m depth at each sampling station taken using 1 L pre-cleaned polyethylene and glass bottles. Samples were then placed in ice filled cool box prior transfer to ALIR, UKM laboratory. The monitored water quality variables namely pH, temperature, salinity, electrical conductivity, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, suspended solids, ammonia nitrogen, iron and manganese.

Temperature, pH, electrical conductivity, dissolved oxygen and salinity were measured *in situ* using a multiprobe sensor instrument (YSI 550, USA). Other parameters were analyzed in the laboratory using standard methods as following biochemical oxygen demand (5 days incubation), chemical oxygen demand (reactor digestion and colorimetric determination), suspended solids (gravimetric method), ammonia nitrogen (salicylate method), and iron and manganese (flame atomic absorption spectrometry). Metal ions were determined as total dissolved metal concentration after filtering using 0.45 μm . The quality control of water sample was ensured by careful standardization, procedural blank measurements and triplicate samples analyses. Water Quality Index (WQI) was determined by Malaysia Department of Environment formula based on six parameters as given by the following Equation 1 [14];

$$\text{WQI} = 0.22*S_1\text{DO} + 0.19*S_1\text{BOD} + 0.16*S_1\text{COD} + 0.15*S_1\text{AN} + 0.16*S_1\text{SS} + 0.12*S_1\text{pH} \quad (1)$$

where S_1 represents sub-index of each parameter, WQI was then used to classify river segment based on National Water Quality Standard Malaysia (NWQS) which categorized water quality into five classes namely class I (WQI > 92.7), class II (WQI 76.6 – 92.7), class III (WQI 51.9 – 76.5), class IV (WQI 31.0 – 51.9) and

class V (WQI < 31.0) based on beneficial use of the water [15].

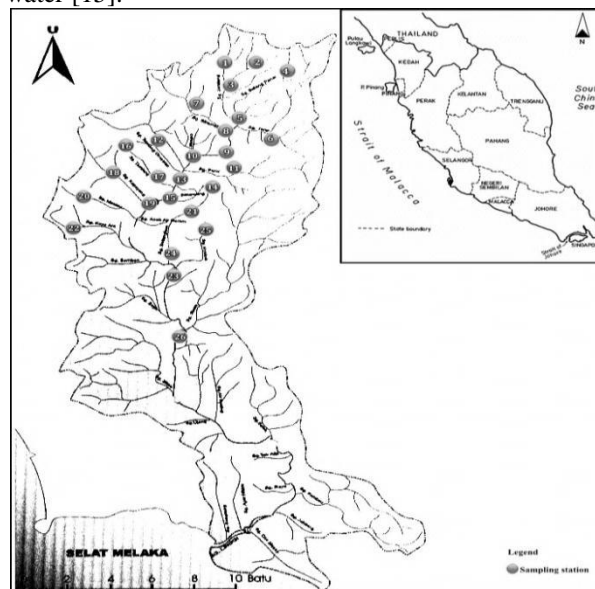


Figure 1. The map location of sampling stations (inside small map of Peninsular Malaysia)

TABLE 1. The descriptive information of sampling stations on the Linggi River

Code	Station	Type	WQI	Class
S1	Jerlang River	Tributary	80	II
S2	NgoiNgoi River	Tributary	77	II
S3	NgoiNgoi River Point 2	Tributary	80	II
S4	BatangPenar River	Tributary	86	II
S5	BatangPenar Point 2	Tributary	76	II
S6	Terip River	Tributary	74	III
S7	Sikamat River	Tributary	68	III
S8	Sikamat River Point 2	Tributary	69	III
S9	Shimpa River	Tributary	67	III
S10	Shimpa River Point 2	Tributary	67	III
S11	Paroi River	Tributary	74	III
S12	Temiang Division River	Tributary	75	III
S13	Linggi River Point 1	Main river	66	III
S14	Senawang River	Tributary	63	III
S15	Linggi River Point 2	Main river	62	III
S16	Temiang River	Tributary	61	III
S17	Linggi River Point 3	Main river	60	III
S18	Kepayang River	Tributary	74	III
S19	Linggi River Point 4	Main River	67	III
S20	Mantau River	Tributary	74	III
S21	Anak Air Garam River	Tributary	75	III
S22	KayuAra River	Tributary	66	III
S23	Linggi River Point 5	Main river	62	III
S24	Belangkan River	Tributary	82	II
S25	Nyatoh River	Tributary	69	III
S26	Linggi River Point 6	Main river	72	III

WQI – Water Quality Index

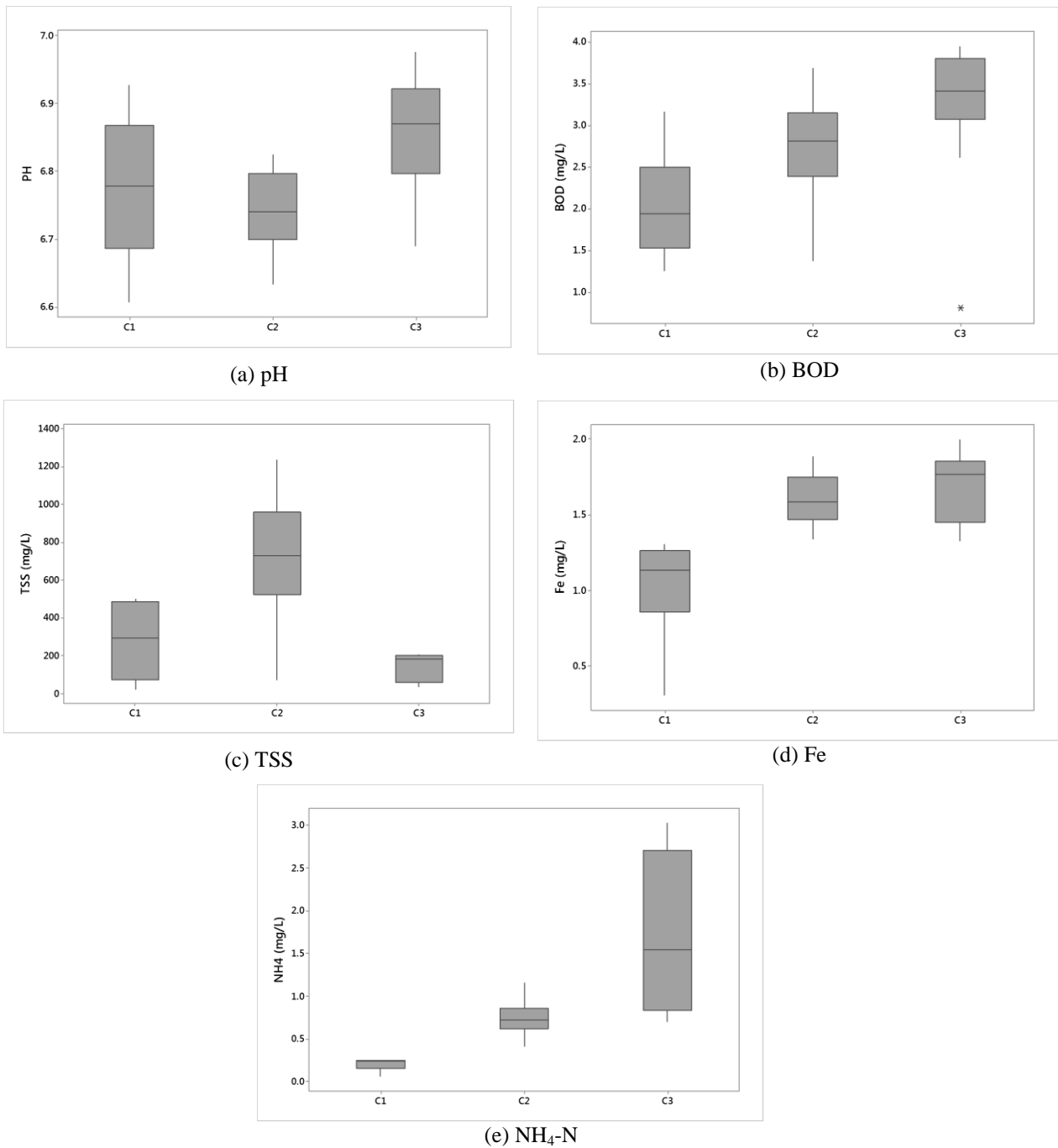


Figure 4. Box and whisker plots of 5 selected variables showing spatial variations

CONCLUSION

In this study, latent factors in Linggi River water quality in terms of temporal and spatial variations explained the structure of data sets. Cluster analyses successfully examined the existence of three zones (cluster) from 26 sampling stations separately for their differing water chemistry. According to principle component analysis with factor analysis loading results, the four

varifactorsextracted indicated that the anthropogenic activities mainly affecting Linggi River include aquaculture, agricultural run-off, industrial discharge, and municipal discharge, especially in clusters 2 and 3. Discriminant analysis confirmed the discriminant function weighed with 5 and 7 variables capable of distinguishing between spatial and temporal variation respectively. The multivariate analysis outcomes may be helpful for further monitoring programs by perhaps

