# Adverse Impacts of Poor Wastewater Management Practices on Water Quality in Gebeng Industrial Area, Pahang, Malaysia

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***Abstract*****—**This study was carried out to investigate the adverse effect of industrial wastewater on surface water quality in Gebeng industrial estate, Pahang, Malaysia. Surface water was collected from six sampling stations. Physicochemical parameters were characterized based on in-situ and ex-situ analysis according to standard methods by American Public Health Association (APHA). Selected heavy metals were determined by using Inductively Coupled Plasma Mass Spectrometry (ICP MS). The results revealed that the concentration of heavy metals such as Pb, Cu, Cd, Cr and Hg were high in samples. The results also showed that the value of Pb and Hg were higher in the wet season in comparison to dry season. According to Malaysia National Water Quality Standard (NWQS) and Water Quality Index (WQI) all the sampling station were categorized as class IV (highly polluted). The present study revealed that the adverse effects of careless disposal of wastes and directly discharge of effluents affected on surface water quality. Therefore, the authorities should implement the laws to ensure the proper practices of wastewater management for environmental sustainability around the study area.

***Keywords*****—**Gebeng, heavy metals, waste water, water quality index.

## I.Introduction

THE most stable and abundant complexes on the nature is water that can be polluted with natural and human activities. Fresh water is the essential part of environment and important for all living being. Contaminated water is harmful to human health and need to purify. Contaminated water from industrial sources plays a leading role to contain a range of pollutants including heavy metals and oil [1]. Rapid urbanization, growing population and speedy industrialization made tremendous pressure on the demand of fresh water in the last few decades and thus the fresh water availability through surface water sources is becoming critical day by day. Rapid development of industries are generating multifarious conventional and non-conventional pollutant and discharging into the river flow that causes the deterioration of water quality throughout the world [2].

Gebang industrial area is facing a series of wastewater and large-scale discharge of untreated wastewater from food and beverage, chemical, textiles, paper, palm oil and rubber processing plants that do not function or function only badly. Such industrial practices however have increased the pollution level in surrounding water catchment. Most of the wastewater released from the industries contains pollutant and directly is dumping in to the surface water, resulted more deterioration of water quality [3]. Therefore, this paper focuses on to detect the contamination level and pollution status of surface water in the eastern part of peninsular Malaysia.

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## II. Materials and Methods

### *A. Study Area and Selection of Sampling Stations*

Gebeng industrial estate is the main industrial town and rapid growing industrial area in Pahang, Malaysia. The study area lies between 3° 55' 0" to 4° 01' 0" N and 103° 22' 0" to 103° 27' 0"E (Fig. 1). A total of six sampling stations were selected for monthly sampling. Global positioning system (GPS) was used to locate the sampling stations. Water samples were collected in dry and wet seasons. Water samples were collected from pre-selected six stations during July to September 2013 (dry season) and November and December in 2013 and January in 2014 (wet season).

### *B. Sampling and Data Collection*

Water samples were collected from about 10 cm below the water surface using 500 ml HDPE bottles those were kept into icebox (<4$^{o}$C ) immediately after sampling and were preserved and transported to laboratory for analysis. The dark BOD bottles (300 ml) were used for BOD samples. In-situ parameters *viz.* temperature, dissolved oxygen (DO), electrical conductivity (EC), pH, salinity and turbidity were determined by using YSI 6600 (YSI Incorporate, USA) metre during the sampling time.

### *C. Laboratory Analysis*

*Ex-situ* parameters such as ammoniacal-nitrogen, nitrate, sulfate, phosphate and chemical oxygen demand (COD) were determined by spectrophotometer with standard procedure [4], [5], while heavy metals were determined by ICPMS. Biochemical oxygen demand (BOD) was determined by using DO meter. Furthermore, total suspended solids (TSS) and total dissolved solids (TDS) were analyzed gravimetrically after filtration with an adequate sample through a glass fiber filter and drying at 105°C.

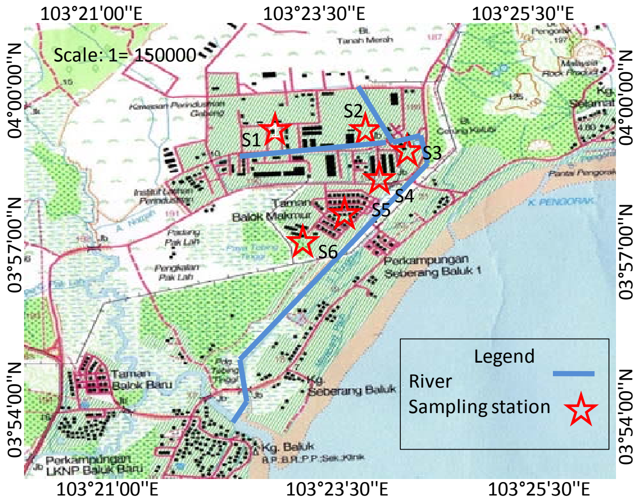


Fig. 1 Map of the study area and sampling stations

*D. Contamination Intensity (CI) Calculation*

Contamination intensity of the different parameters were calculated to compare with the standard values of different parameters recommended by [6] and [7]. The following equation was used to calculate CI given by [8]:

$$CI = C \text{ Standard value} / C \text{ Analysed value}$$

where, CI denotes contamination intensity and C means concentration.

*E. Water Quality Index Calculation*

The water quality indicator reflects the state of water quality, where water quality parameters are compared with the respective standard value. In the study, water quality index was calculated on the basis of the concentrations value of pH, DO, BOD, COD, ammonical nitrogen and TSS [9]. The following equation was used to calculate WQI:

$$WQI = 0.22 \times SIDO + 0.19 \times SIBOD + 0.16 \times SICOD + 0.15 \times SIAN + 0.16 \times SITSS + 0.12 \times SIpH \quad (1)$$

where, SI indicates the sub index function of the each given parameter and the coefficient as well as the weighting factors derived from the opinion poll. DO is in percentage saturation and concentration in mg/l for all parameters except pH.

## III. Results and Discussions

The highest temperature (36ºC) was found at station 5 in dry season owing to the discharge of hot water and effluents from scattered industries activities. The average temperatures were recorded above the recommended limits of Malaysian standard [10]. The pH value of the surface water ranged from 5.31 to 7.55 and 5.65 to 7.95 for dry and wet seasons, respectively. The pH was recorded mostly acidic because of high temperature. The similar results were stated by [11] in India. Electrical conductivity (EC) value ranged from 0.44 to 2.67 mS/cm in dry season, while 0.03 to 2.48 mS/cm in wet season. The EC value at stations 4, 5 and 6 in dry season and station 5 and 6 were measured above the WHO [6] recommended standards. The value of dissolved oxygen value varied from 0.93 to 3.35 mg/l. The DO concentration was very low at all stations, which falls into Class III. Yisa and Jimoh [12] recorded the similar results in their studies on water quality of the River Landzu in Nigeria.

The turbidity reading of samples varied from 8.16 to 63.33 NTU in dry and 11.67 to 69.26 NTU in wet season. The highest turbidity (66.81 NTU) was measured at station 2 in wet season, because of rainy season and probably related to the high flow and concentration of clay particles. The turbidity values at all stations were within the permissible limit. The salinity of all samples ranged from 0.09 to 0.99% in dry and 0.11 to 0.99% in wet seasons. Malaysian threshold level for surface water salinity is 0.50%. Total dissolved solids (TDS) concentration varied from 47.67 to 181.38 mg/l. The level of TDS was in permissible limits (500 mg/l). The value of total suspended solids at 6 stations during the different seasons varied from 23.78 to 226.17 mg/l. Results indicate that the trend of TSS in dry season was almost similar but significant variation was observed in wet season especially at industrial zone. The NWQS recommends maximum threshold levels of TSS for Malaysian surface water from 25 to 50 mg/l.

Biochemical oxygen demand is a parameter that measures the organic load as well as the pollution level of water bodies. The BOD of the water sample varied from 41.28 to 106.73 mg/l in dry and 41.68 to 97.03 mg/l in wet season. Comparatively, higher BOD value was observed in dry season than in wet season because of higher temperature and lower precipitation. The observed BOD values in the study exceeded the threshold level (extremely polluted). The previous study revealed that discharges from industries contributed to the BOD loadings in the river stream in Malaysia [7]. Chemical oxygen demand value of collected samples ranged from 63.60 to 117.72 mg/l and 46.07 to 102.43 mg/l in dry and wet seasons, respectively. The results showed that the average COD value exceeded the Malaysian threshold values. Higher values of COD indicated that the water contains higher wastes [13]. The result also indicates that the water of the river could not be used for any purposes before extensive treatment.

The value of ammoniacal-nitrogen ($NH_3$-N) ranged from 0.86 to 2.80 mg/l. The highest value (2.80 mg/l) was recorded at station 4 in wet season, while the lowest (0.86) was at station 6 in dry season. The highest value was most probably due to industrial activities and malfunctioning sanitation system in the study area. Varlo et al. [14] conducted a research on surface water quality in Turkey, and detected higher value of $NH_3$-N. The mean value of $NO_3^-$ ranged from 0.29 to 0.51 mg/l in dry and 0.29 to 0.48 mg/l in wet seasons. The content of $NO_3^-$ value was within safe level. Sulfate ($SO_4^{2-}$) values varied from 30.37 to 61.72 mg/l in dry and 23.37 to 51.84 mg/l in wet seasons. According to NWQS Malaysia, the threshold level of sulfate value for the support of aquatic life is 250 mg/L. The ranges of phosphate levels across the sampling times were: 0.32 to 1.17 mg/l and 0.66 to 0.57 mg/l in dry and wet seasons, respectively. The higher amount of $PO_4^{2-}$ was due to wastes of detergent and other industrial activities in the study area. The mean values of $PO_4^{3-}$ in the study area were recorded above the permissible level. Based on NWQS Malaysia, the threshold level of phosphate for the support of aquatic life is 0.10 mg/L. The concentration of total nitrogen and phosphate was below the value of the standard limit.

Concentration of Arsenic (As) in the studied samples ranged from 0.023 to 0.051 ppm in dry and 0.026 to 0.047 ppm in wet seasons. The highest concentration was recorded at station 5 in dry season, while the lowest was at station 3. According to NWQS, a major part of the study area was slightly affected by Arsenic pollution. Concentration of Barium (Ba) ranged between 0.033 and 0.057 ppm and 0.027 and 0.038 ppm in dry and wet seasons, respectively. The concentrations of Ba in the study area were found to be low level. Cadmium concentration ranged from 0.037 to 0.098 ppm and 0.036 to 0.073 ppm in dry and wet seasons, respectively. The studied results showed that the concentrations of Cd were recorded higher during the sampling time. The value of Cd exceeded the permissible limit and categorized as class V (extremely polluted). The low precipitation, dry season, industrial activities and especially the availability of effluents inflow caused the contamination level of heavy metals likes Cd, Cr, Pb, Zn, Ni, and Cu in Nigeria [15]. Cobalt (Co) values ranged from 0.034 to 0.098 ppm in dry season and 0.035 to 0.083 ppm in wet seasons. According to Ministry of Environment Protection USA [16], the permissible limit of Co value in surface water is 0.05 mg/l. Concentration of Chromium (Cr) ranged from 0.057 to 0.071 ppm and 0.046 to 0.056 ppm in dry and wet seasons, respectively. Cupper (Cu) concentration ranged from 0.064 to 0.093 ppm in dry and 0.045 to 0.065 ppm in wet seasons. Nickel (Ni) value varied from 0.025 to 0.057 ppm and 0.020 to 0.056 ppm in dry and wet seasons, respectively. The value of Cr, Cu and Ni also exceeded the permissible level (Class III) of Malaysia. Mercury (Hg) value varied from 0.037 to 0.075 ppm in dry and 0.046 to 0.081 ppm in wet seasons. The recommended toxic level of Hg for Malaysia surface water is 0.001 ppm. The highest concentrations of Hg were noticeable at all sampling stations, while the most polluted was station 1. Concentration of Pb varied from 0.044 to 0.072 ppm in dry and 0.051 to 0.081 ppm in wet seasons. According the Malaysian standard, the threshold limit of Pb for surface water is 0.05 ppm. The concentration of Pb exceeded the permissible level and categorized as Class III. Haque et al. [17] studied extremely higher value of Cr and Pb concentration in surface and ground water at Karachi industrial areas in Pakistan.

### *A. Contamination Intensity*

The study revealed that the contamination intensity value was comparatively higher in dry season than in wet season. The CI value for temperature, BOD, COD, TSS, DO, ammoniacal nitrogen and phosphate showed > 1.0, while TDS, sulfate, nitrate, TN and TP were found to be <1.0 in both seasons. The CI value for pH was recorded >6.0 in both seasons. Moreover, the contamination intensity values for EC calculated higher than 1.0 at station 4, 5 and 6 in dry and wet seasons, where as salinity was >1.0 at station 5 and 6, while the rest of the station showed <1.0 for both EC and salinity during the two seasons. Based on contamination intensity, water samples were categorized as Class IV (highly polluted) in both seasons.

Results of the study also showed that the CI of Ni was >1.0 at station 5 and at the rest were <1.0 in both seasons, while as, Ba, Co and Zn were found to be < 1.0 in both seasons. In addition, CI value for Cd, Cr, Cu, Hg and Pb were recorded >1.0 in both seasons. However, contamination intensity value for Hg and Cd were very high, that varied from 37.10 to 81.40 and 3.57 to 9.77 respectively.

### *B. Water Quality Index*

The WQI values were calculated based on pH, DO, BOD, COD, $NH_3$-N and TSS concentration to status of the water quality. The calculated DOE-WQI score are shown in Tables I and II. Based on the DOE-WQI, the water quality of the study area was highly polluted and classified as class IV.

TABLE I
CLASSIFICATION OF WATER BASED ON WQI* IN A DRY SEASON

| Stations | DO (%) | BOD (mg/l) | COD (mg/l) | $NH_3$-N (mg/l) | TSS (mg/l) | pH | WQI Value | Water Class |
|---|---|---|---|---|---|---|---|---|
| 1 | 13.84 | 106.73 | 117.60 | 1.01 | 157.4 | 6.85 | 37.75 | IV |
| 2 | 28.69 | 82.58 | 79.21 | 1.24 | 190.56 | 6.25 | 40.51 | IV |
| 3 | 23.92 | 55.18 | 63.60 | 1.06 | 26.08 | 7.42 | 49.72 | IV |
| 4 | 18.74 | 71.18 | 117.72 | 1.16 | 50.61 | 6.51 | 43.70 | IV |
| 5 | 34.28 | 71.62 | 88.21 | 1.12 | 55.67 | 7.08 | 48.61 | IV |
| 6 | 27.39 | 41.28 | 66.59 | 0.96 | 40.76 | 6.78 | 51.10 | IV |

* WQI = Water quality index, Class I= >91.76; Class II= 75.36 - 91.75; Class III= 51.68 - 75.35; Class IV= 29.61 - 51.67; Class V= <29.60

TABLE II
CLASSIFICATION OF WATER BASED ON WQI* IN A WET SEASON

| Stations | DO (%) | BOD (mg/l) | COD (mg/l) | $NH_3$-N (mg/l) | TSS (mg/l) | pH | WQI Value | Water Class |
|---|---|---|---|---|---|---|---|---|
| 1 | 15.10 | 97.03 | 76.07 | 1.11 | 174.74 | 6.85 | 38.54 | IV |
| 2 | 43.51 | 73.45 | 52.17 | 1.41 | 215.67 | 6.59 | 45.52 | IV |
| 3 | 27.91 | 41.68 | 46.07 | 1.19 | 32.01 | 7.97 | 51.21 | IV |
| 4 | 24.34 | 68.50 | 102.43 | 1.73 | 67.33 | 6.67 | 42.95 | IV |
| 5 | 38.83 | 76.29 | 78.24 | 1.22 | 67.08 | 7.28 | 49.06 | IV |
| 6 | 35.84 | 66.37 | 55.50 | 1.14 | 41.62 | 7.19 | 51.17 | IV |

* WQI = Water quality index, Class I= >91.76; Class II= 75.36 - 91.75; Class III= 51.68 - 75.35; Class IV= 29.61 - 51.67; Class V= <29.60.

## IV. CONCLUSION

The CI value, pollution level and classification of water quality indicated that the studied water having higher contaminants level especially, BOD, COD, $NH_3$-N, phosphate, Pb, Cd, Cr, Cu, and Hg and lower values of DO. The present deteriorated situation has reached a critical point. The current waste management practices are not satisfactory and causing serious negative environmental impacts in the study area. Therefore, it is recommended that the careless disposal of wastes and directly and indirectly discharges of effluents should be discouraged, and comprehensive solid waste management system should be adopted in order to ensure the protection of water resources in the study area. To protect the natural resources, sustainable industrialization approaches have to be initiated in the Gebeng industrial area.

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## REFERENCES


[1] V. O. Abramov, A. V. Abramova, P. P. Keremetin, M. S. Mullakaev, G. B. Vexler, J. Timothy, and T. J. Mason, "Ultrasonically improved galvanochemical technology for the remediation of industrial wastewater. *Ultrasonics Sonochemistry*, vol. .21, pp. 812–818, 2014.

[2] M. A. Hossain, I. M. Sujaul, and M. A. Nasly, "Water Quality Index: an Indicator of Surface Water Pollution in Eastern part of Peninsular Malaysia", *Research Journal of Recent Sciences*, Vol. 2, no. 10, pp. 10-17, 2013.

[3] I. M. Sujaul, M. A. Hossain, M. A. Nasly, and M. A. Sobahan, "Effect of industrial pollution on the spatial variation of surface water quality," *Am. J. Environ. Sci.,* vol. 9, pp. 120–129, 2013.

[4] HACH, *The Handbook of DR/2500 Laboratory Spectrophotometer*. Loveland, CO: HACH Company, 2003.

[5] APHA, *Standard methods of water and wastewater analysis.* 22nd ed. Washington D.C., American Public Health Association, 2013.

[6] WHO, *GEMS/Water operation guide.* 3rd ed. M. Allerd, ed., World Health Organisation, Geneva, 1992.

[7] Department of Environment Interim National Water Quality Standard (INWQS), for Malaysia, Kuala Lumpur, Malaysia, 2000.

[8] Rao'S (ed.) PIG-a numerical index for dissemination of groundwater contamination zones. Hydrological Processes, John Wiley & Sons, 2012.

[9] M. A. Haque, Y. E. Huang, and T.S. Lee, "Seberang Perai rice scheme irrigation water quality assessment," *J. Institution of Engineers Malaysia,* vol. 71, no. 4, pp. 42-49, 2010.

[10] DOE, Interim National Water Quality Standard for Malaysia, Department of Environment, Kuala Lumpur, Malaysia, 2008.

[11] R. Reza, and G. Singh, "Heavy metal contamination and its indexing approach for river water," *Int. J. Environ. Sci. Technol*. Vol. 7, no. 4, pp. 785-792, 2010.

[12] J. Yisa, and T. Jimoh, "Analytical studies on water quality index of river Landzu," *Am. J. Applied Sci*. vol. 7, pp. 453-458, 2010.

[13] K. Varunprasath, and N. A. Daniel, "Comparison studies of three fresh water rivers (Cauvery, Bhavani and Noyyal) in Tamilnadu, India." *Iranica J. Ener. Environ*., vol. 1, pp. 315-320, 2010.

[14] M. Varol, B. Gokot, A. Bekleyen, and B. Şen, "Spatial and temporal variations in surface water quality of the dam reservoirs in the Tigris River basin, Turkey," *Catena*, vol. 92, pp. 11–21, 2012.

[15] M. D. Wogu, and C. E. Okaka, "Pollution studies on Nigerian rivers: heavy metals in surface water of Warri River, Delta State," *J. Biodiver. Environ.* Sci. vol. 1, no. 3, pp. 7-12, 2011.

[16] Ministry of Environment protection. *Permissible concentration of Cobalt in surface water*, *USA*. 1991.

[17] U. N. Haque, M. A. Arain, Z. Haque, N. Badar, and N. Mughal, "Drinking water contamination by Chromium and lead in industrial lands of Karachi," *J. Pak. Med. Assoc.* vol. 59, no. 5, pp. 270-274, 2009.