Water Quality Assessment at Perai Industrial Park

Khairul Rahmah Ayub[1], Faridah Abu Hassan Asaari[2], Rozi Abdullah[2], Lau Tze Liang[2], Nor Azazi Zakaria[1], Aminuddin Ab. Ghani[1], & Chang Chun Kiat[1]

[1]*River Engineering and Urban Drainage Research Centre (REDAC), University Science Malaysia, Engineering Campus, Seri Ampangan, 14300 Nibong Tebal, Penang, Malaysia*

[2]*School of Civil Engineering, University Science Malaysia, Engineering Campus, Seri Ampangan, 14300 Nibong Tebal, Penang, Malaysia*

ABSTRACT: Perai has experienced a high growth rate in population due to the rapid increase of commercial and industrial activities. Due to its attractive setting, the population of the study area increases year by year. Rising standards of living and increase of industries have caused and will continue to cause an increasing rate of consumption of water with the attendant increased burden of waste discharges to the natural waterways and sea. In 1978, wastewater discharge in Seberang Perai Tengah is estimated approximately 110,000 cu m/day. Public interest has become more concerned on the need for clean water bodies to satisfy the need for developed industrial area with better drainage and wastewater treatment system for living condition and to conserve the natural qualities of the environment.

Keywords: wastewater; water quality; heavy metals.

1 INTRODUCTION

The Study area, Perai Industrial Complex, is located on mainland of Penang State (Figure 1). The Study area with the total area of 731.14 hectares was developed by Penang Development Corporation (PDC) in 1971 into the biggest industrial park in Malaysia to date. It comprises Prai Industrial Park and Prai Free Industrial Zone (202.69 hectares).

Currently, most of the industrial wastes water in the study area are discharged directly to drains or other waterways. The discharge of most of the industrial wastes water without proper treatment is causing increased pollution in the existing drains, rivers and other downstream area. Wastewater flow through the nearest downstream and eventually polluting the beaches and offshore marine waters due to low flow in dry season. Finally, this condition has resulted in adverse biological effects, odours and nuisances. It is evident that the pollution causing by industrial wastewater will become more apparent in the future if no action is taken to improve or alleviate the drainage system in the study area.

Due to consciousness of Penang State Government, Majlis Perbandaran Seberang Perai (MPSP) is intended to upgrade the stormwater drainage facilities for quantity and quality control in the study and surrounding area. Hence, MPSP has requested the River Engineering and Urban Drainage Research Centre (REDAC), Universiti Sains Malaysia to study the drainage system and the water pollution problems in the Kawasan Perindustrian Perai.

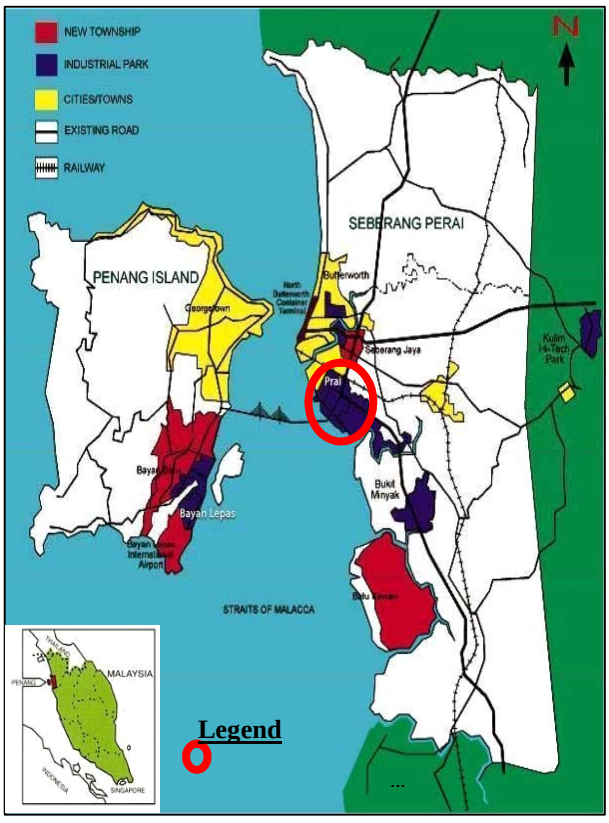


Figure 1. Map of Seberang Perai [1]

2 PROJECT BACKGROUND

Perai Industrial Complex is located in Seberang Perai Tengah, Penang (Figure 2). Perai Industrial Complex is divided into four zones, namely Kawasan Perusahaan Perai 1, 2, 3 and 4. This area have been fully developed into an industrialise region except some coastal area which still remain as mangroves area. The Study area covers part of Kawasan Perusahaan Perai 1, the whole Kawasan Perusahaan Perai 2 and 3, some villages and residential area adjacent to Kawasan Perusahaan Perai 3.

The study area is severely polluted by industrial and commercial effluent. The untreated effluent may contain toxic material and excess concentration of pollutant that are contaminating the waterway and the sea and disrupting the aquatic ecosystem consequently.

Due to flat and low-lying ground platform level, the drain water tends to stagnate and decompose, causing drain water black in colour, odours, in viscous liquid form, visible nuisance as well as hazards to public health.

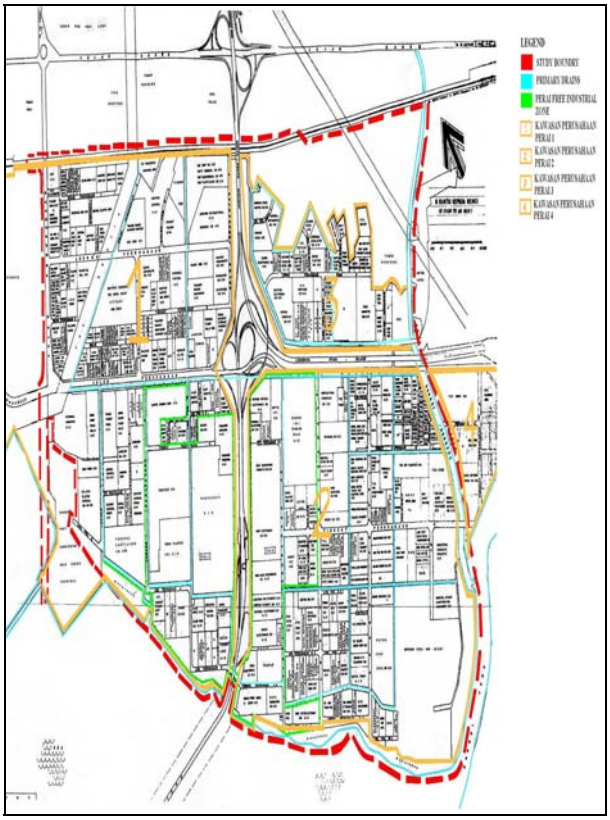


Figure 2. Location of Study Area [2]

3 WATER QUALITY PROBLEMS

The study area is severely polluted by industrial and commercial effluent which is discharge to the nearby waterway. Few site visits and industry survey were carried out in order to identify the sources and types of wastewater in the study area. Figure 3 shows the present wastewater condition of study area on 18th August 2003. The water quality in the existing drains may be affected by the frequency of pumping activities by the both pumping stations in the study area.

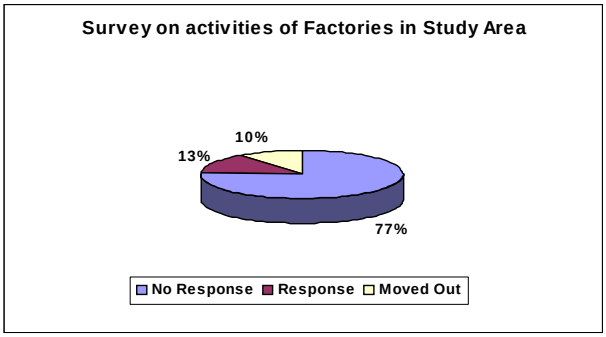
(a)

(b)

Figure 3(a)-(b). Wastewater conditions in study area [2]

289 questionnaires have been sent to the factories and only 38 (13%) factories have responded (Figure 4(a)). Out of the 13% who have responded, 58% (22) of these factories are equipped with the wastewater treatment plant (Figure 4(b)). These 22 factories are 17% chemical or fertilizer type, 14% plastic and plastic product followed by 13% of food processing type (Figure 4(c)). The other 42% of the factories also express their concern about the environment and agree to have a centralized treatment plant within the study area. The type of treatment plant which is equipped in these 22 factories for Septic Tank (45%) as wastewater treatment plant followed by Activated Sludge (19%), Trickling Filter (3%) and Oxidation/Stabilization (3%) (Figure 4(d)). From this questionnaire, the sources of wastewater

from the 22 factories come from sanitary waste (23%), manufacturing waste (21%), cooling discharge (15%), and kitchen waste (15%).



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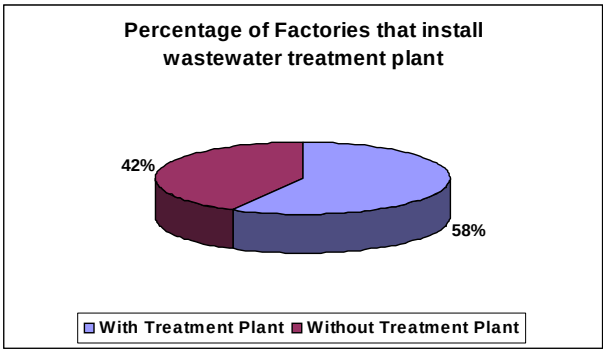

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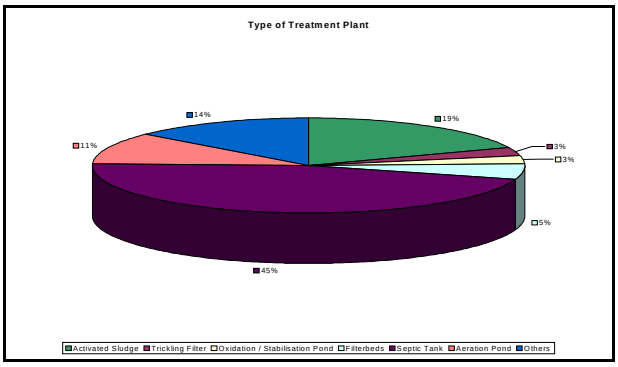

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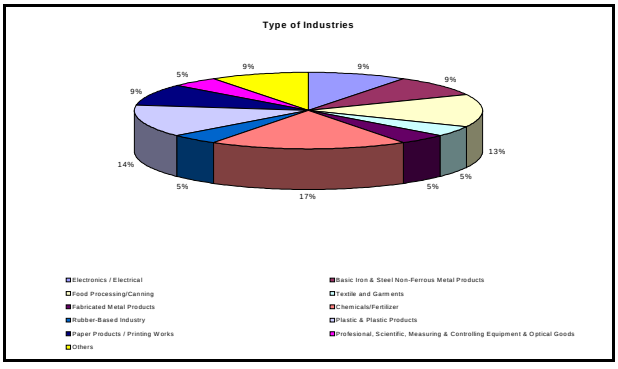


(d)

Figure 4 (a) – (d). Industry Survey [2]

4 MONITORING STATION

A total of eighteen sampling points were established in order to collect water samples for analysis (Figure 5). Six Monitoring Stations are chosen in Kawasan Perusahaan Perai 1, nine monitoring station in Kawasan Perusahaan Perai 2 and three monitoring stations at Kawasan Perusahaan Perai 3.

At each location, at least three samples (1.5L) shall be collected. Water samples of the selected location were analyzed and these monitoring stations are considered to represent the water quality in selected drains in the study area.

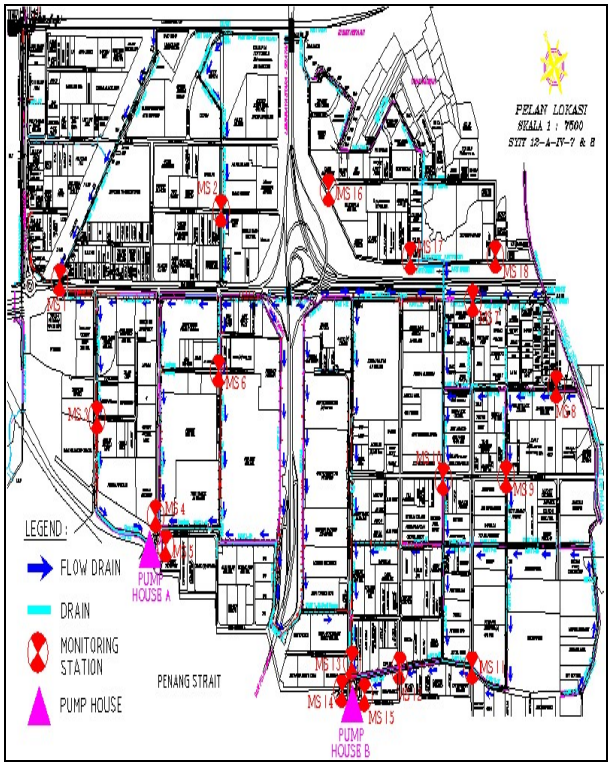


Figure 5. Location of Monitoring Stations [2]

5 PRELIMINARY RESULTS OF WASTEWATER ANALYSIS

Several water samples were analyzed and the results obtained are discussed in comparison with Environmental Quality (Sewage and Industrial Effluents) Regulations 1979.

5.1 pH

In general the pHs for most of the sampling stations were well within the compliance limit of Standard B, where the pH range is 5.5- 9.0 (Figure 6). If pH is less than 5.5 (indicating acidic condition) or greater than 9.0 (alkaline condition), this shows that the water will support very few, if none at all, aquatic microorganisms.

The lowest pH was sampled on 4th November 2003 at MS7 and 19th November 2003 at MS 17 having pH of 5.25 and 4.61 respectively and is slightly lower than the compliance value of 5.5.

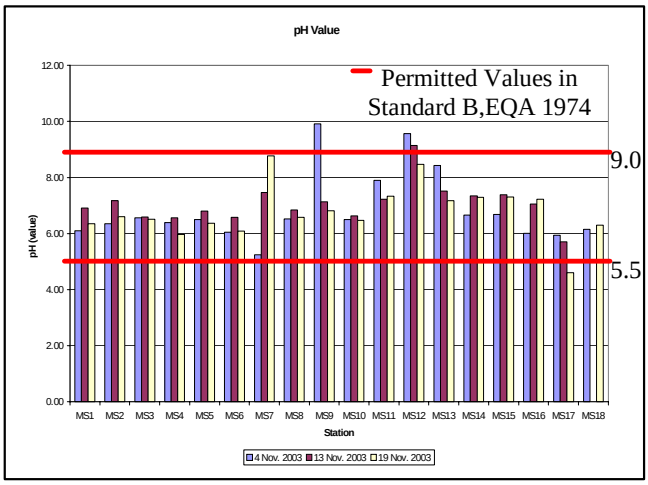


Figure 6. pH Value

5.2 *Suspended Solids (SS)*

The suspended solids determination is extremely valuable in the analysis of polluted waters. According to Standard B, EQA 1974, the permissible SS value is 100mg/L for industrial wastewater.

On 4th November 2003, MS7 (117 mg/L) and MS14 (124 mg/L) do not comply with the standard. On 13th November 2003, only MS7 (390 mg/L) does not comply with the standard. However, on 19th November 2003 all sampling stations comply with the standard. Figure 7(b) summarized the results of the analysis.

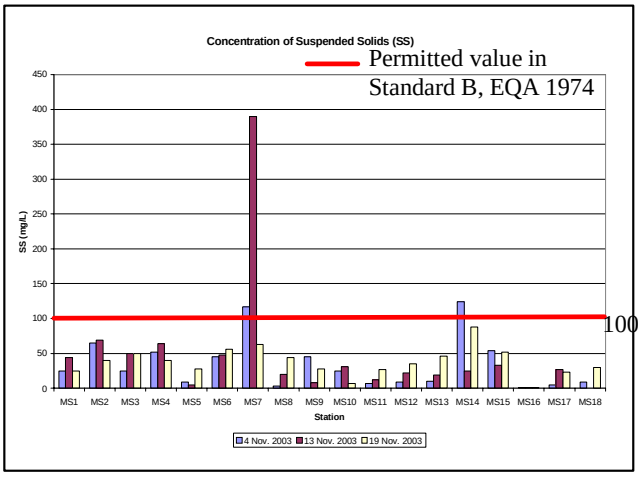


Figure 7. Concentration of SS

5.3 *BOD_5 (Biochemical Oxygen Demand)*

The BOD_5 test is very important to determine the resultant pollution strength of wastewaters if discharged into natural watercourses or drains. According to Standard B, EQA 1974, the BOD_5 of the effluent must be equal to or less than 50 mg/L. Sampling points of MS 2, MS 4, MS 7, MS 8, MS 10, MS 12, MS 14 and MS 18 show values more than 50mg/L for water sampled on 4th November 2003 (Figure 8. In general, samples which have high DO content will have low BOD_5 and vice- versa. MS7 (BOD_5=139 .5 mg/L) and MS2 (BOD_5=133.5 mg/L) were amongst the stations that have the highest BOD_5 values obtained. However, water samples 13th November 2003 show that only five stations that are not in compliance with the standard namely MS2 (BOD_5= 108 mg/L), MS3 (BOD_5 = 57 mg/L), MS4 (BOD_5 = 93 mg/L), MS6 (BOD_5= 51 mg/L) and MS7 (BOD_5 =159 mg/L). For water sampled on 19th November 2003, only 4 stations are not in compliance with the standard which are MS3 (BOD_5= 65 mg/L), MS4 (BOD_5 = 84 mg/L), MS6 (BOD_5 = 65 mg/L) and MS7 (BOD_5= 174 mg/L).

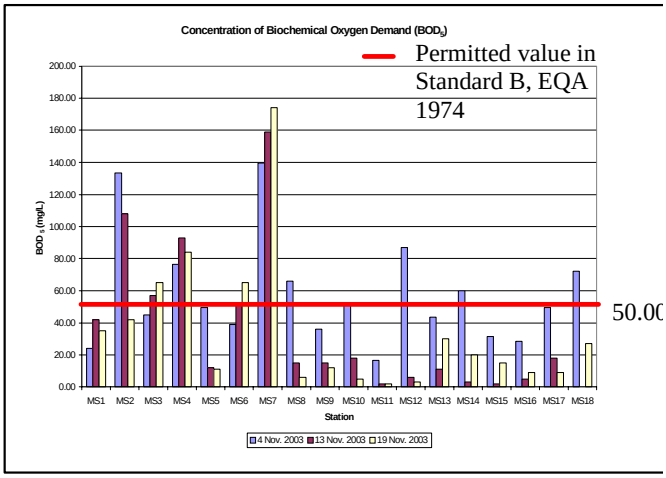


Figure 8. BOD_5

5.4 *COD (Chemical Oxygen Demand)*

COD test is used as a means of measuring the organic strength of wasteswaters. It is based upon the fact that all organic compounds, except for a few, can be oxidized by the action of strong oxidizing agents. According to Standard B, EQA 1974, the COD values must not exceed 100mg/L for industrial wastewater.

On 4th November 2003, water samples obtained from MS2, MS4, MS 7, MS13, MS14, and MS15 show values greater than the compliance concentration of 100 mg/L. This indicates that high organic pollution occurred in those areas. MS14 has the highest COD content followed by MS7. COD values on 13th November 2003 show seven stations fail to comply with the standard of 100 mg/L namely MS1, MS2, MS 4, MS 6, MS 7, MS8 and MS18. MS7 has the extremely highest COD content of 7000mg/L. Water sampled on 19th November 2003 still indicates that high organic pollutant occurred in those study area and MS7 still has the highest COD content of 1900mg/L. The result is shown in Figure 9.

5.5 *Oil and Grease*

Oil and grease is not soluble in water, is lighter than water and therefore floats. This layer of oil and grease may hinder the exchange of gases particularly oxygen and therefore may cause anaerobic condition to occur in the water body beneath this top layer. The EQA (1974), Standard B maximum permitted value for oil and grease concentration in wastewater is 10 mg/L. From the results, all the stations are in compliance with the standard as given in Figure 10.

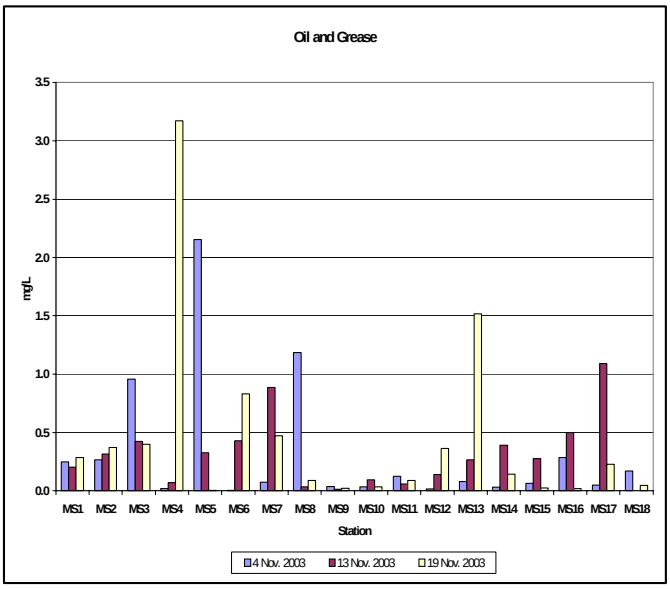
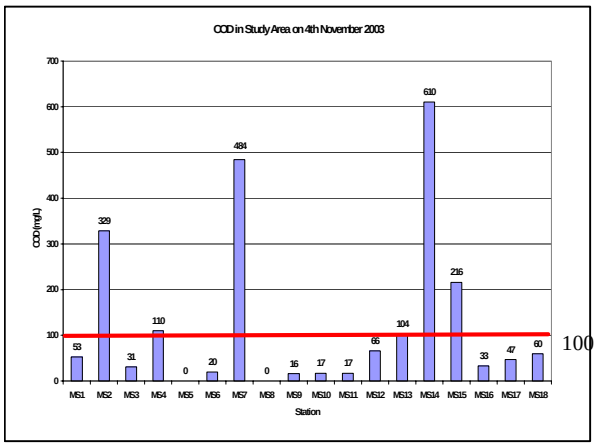


Figure 10. Oil and Grease



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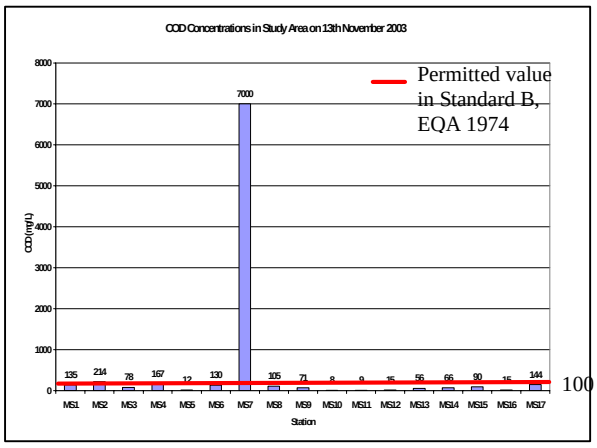

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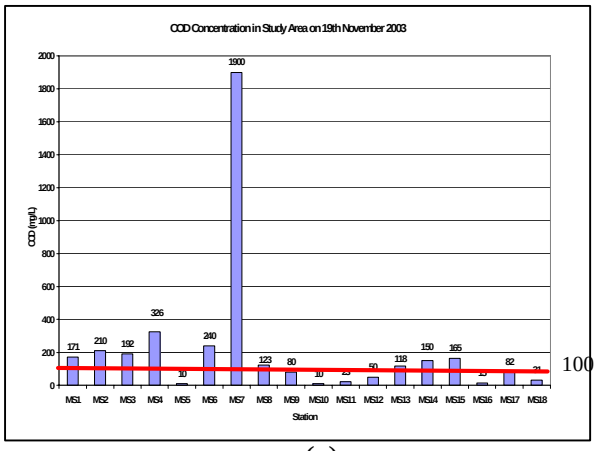


(c)

Figure 9. Concentration of COD on; (a) 4th November 2003, (b) 13th November 2003 and (c) 19th November 2003

5.6 *Sulphide, SO^{2-}*

Sulphide is formed during the reduction of sulphate and is associated with smell. If the pH of the wastewater is 8 or above the reduced sulphur is in the form of HS^- and S^{2-} and odour problem does not occur but at pH lower than 8 , it shifts to form unionized H_2S and cause serious odour problem. However, H_2S in the presence of oxygen and bacteria can convert sulphide to acid sulphuric and cause corrosion problem in concrete sewer systems. Therefore the EQA (1974) Standard B maximum permitted value for sulphide is 0.5 mg/L. Sulphide contents in all the water sampled were lower than 0.25mg/L on 4th November 2003 and on 19th November 2003 the range is 0.004-0.5mg/L. However, on 13th November 2003 the concentration of Sulphide for MS6 (3.85mg/L) and MS7 (0.59mg/L) exceeded the Standard B, EQA (1974).

5.7 *Boron, B*

Boron is normally found in low concentration in domestic and industrial wastewater owing to its perborate content during detergent preparations. Small concentrations are not harmful to man but are harmful to plants when present in contaminated irrigation water. The permissible value in Standard B, EQA (1974) for boron is 4.0 mg/L. From the results, all water samples from 18 sampling stations 13th November 2003 comply with the Standard B value except for MS7 (53mg/L). Water sampled on 19th November 2003 show MS7 (5.6mg/L) and MS6 (6.5mg/L) do not comply with the limit of Standard B.

5.8 Phenol

Phenols are aromatic hydrocarbons with hydroxy groups attached to the aromatic ring. Its concentration is usually higher in industrial wastewater than to natural waters. The permissible concentration of phenol in Standard B, EQA (1974) is 1.0 mg/L. Only the water sampled on 13th November 2003 from MS 7 contained the highest amount of phenol 101mg/L followed by MS8 (3.7mg/L). On 19th November 2003 the same stations (MS7=84mg/L, MS8=5.7mg/L) also have high concentration of phenols and followed by MS9 (2.6mg/l). Other water samples comply with the standard.

5.9 Free Chlorine

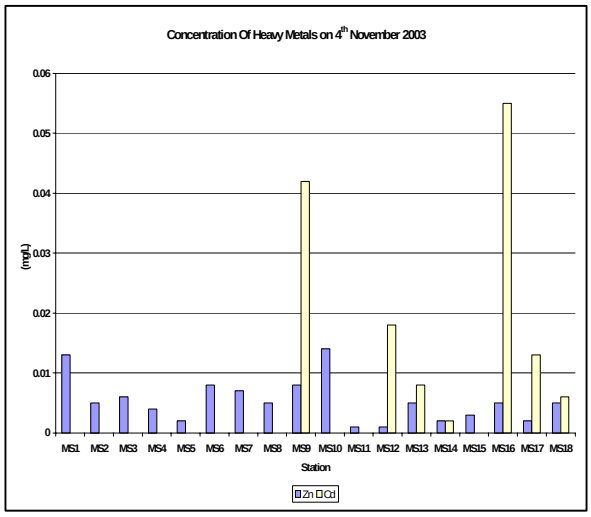
Free chlorine refers to chlorine, hypochlorous acid or hypochlorite ion found in water and they are also powerful oxidising agents. For Standard B EQA (1974) the permissible amount of free chlorine is 2.0mg/L. The free chlorine concentrations found in the monitoring stations comply with Standard B in the range of 0-0.34mg/L for November 2003.

5.10 Heavy Metals (Zn, Cu, Fe, Mn, Cd, Cr, Pb, Ni, Sn, Hg , As)

Heavy metals such as Zn, Cu, Fe, Mn, Cd, Cr, Pb, Ni, Sn, Hg and As are found in contaminated water systems and can be toxic towards aquatic microorganisms. Figure 11 show the variations of heavy metals concentrations in each monitoring station on 4th November 2003 respectively. For Zinc, (Zn) the allowed concentration in Standard B, EQA (1974) is 2.0mg/L. All water samples from all stations are in compliance with the standard. For Ferum, (Fe) the permissible value for Standard B in effluent is 5.0mg/L. All water samples from MS 1 until MS18 are in compliance with the standard. The permissible discharge concentration for cadmium, (Cd) is 0.02 mg/L as stated in Standard B, EQA (1974). All the sampling stations are in compliance with the limit except for MS9 (0.042mg/L) and MS16 (0.055mg/L). For manganese, (Mn) the allowable concentration for this metal in Standard B, EQA (1974) is 1.0 mg/L. All the sampling stations are in compliance with the limit.

The permissible discharged concentration for Cu in Standard B, EQA (1974) is 1.0mg/L. From the results, most of the stations have low Cu concentration which were in the ranges of 0.0 - 0.773. However, MS1 (0.773 mg/L) and MS17 (0.564 mg/L) are considered the stations with highest discharged concentration for Cu (Figure 12(a)). For nickel, (Ni) the permissible value in Standard B, EQA (1974) is 1.0 mg/L. Most of the water samples comply with the standard with the exceptions of MS 1 (2.085 mg/L), MS 6 (1.669 mg/L) and MS 8 (1.226 mg/L) (Figure 12(b)). The permissible value for tin (Sn), in Standard B, EQA (1974) is 1.0 mg/L. Most of the water samples do not comply with the standard and the values range between 1.015 – 9.8085 mg/L (Figure 12(b)).

The permissible discharge concentration for chromium (Cr), in Standard B, EQA (1974) is 0.05 mg/L. Most of the sampling stations are in compliance with the limit with the exceptions of seven stations which are: MS 1(0.2105 mg/L), MS 6 (0.5332), MS8 (0.1544 mg/L), MS 9 (0.16884.), MS 11(0.0982 mg/L), MS 15(0.1263) and MS 17 (0.1965 mg/L). For mercury (Hg), the Standard B, EQA (1974) allow 0.05 mg/L of this metal in effluent. Eleven sampling stations have very high Hg content ranging from 0.1397 – 1.5514 mg/L. This means that the effluent contains more than two times of the values recommended by Standard B, EQA (1974). Figure 13(a) show the summarized of Chromium and Mercury load in wastewater discharge.



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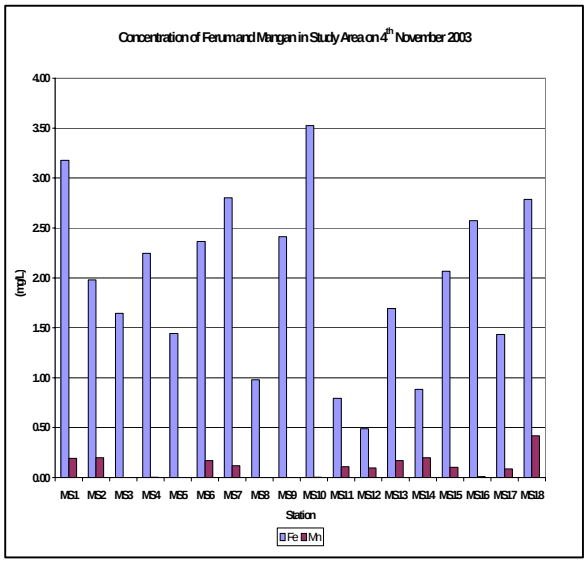
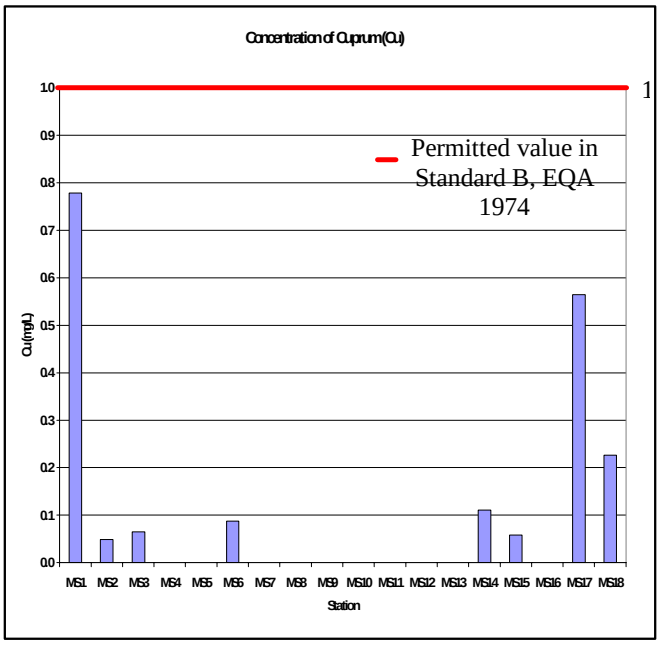


(b)

Figure 11(a)-(b). Concentration of Heavy metals (a) Zn and Cd; (b) Fe and Mn

For plumbum, (Pb) the allowable concentration in Standard B for this metal in effluent is 0.50 mg/L. Most of the sampling stations have very high Pb concentration ranging from 0.32 to 17.84 mg/L. Finally for arsenic (As), the permissible level in wastewater effluent according to Standard B, EQA (1974) is 0.10mg/L. All the sampling stations show high levels of 1.5762 mg/L to 5.3116 mg/L, which is more than ten times of the recommended value in Standard B, EQA (1974) (Figure 13(b)).



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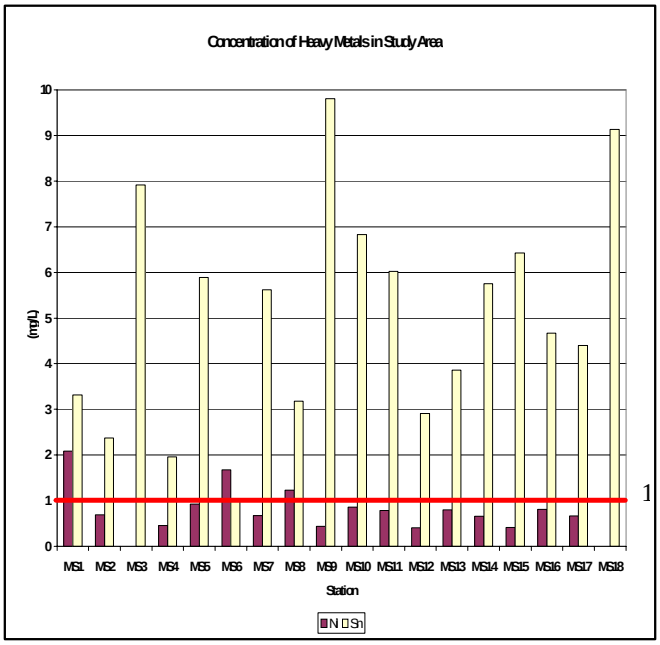

(b)

Figure 12. (a) Cuprum and (b) Nickel and Tin

6 CONCLUSIONS

From the discussions above, it can be concluded that the water samples collected in November 2003 in general are polluted, especially with BOD, COD, Phenol Boron, and heavy metals such as mercury, arsenic, plumbum and tin.

7 ACKNOWLEDGMENT

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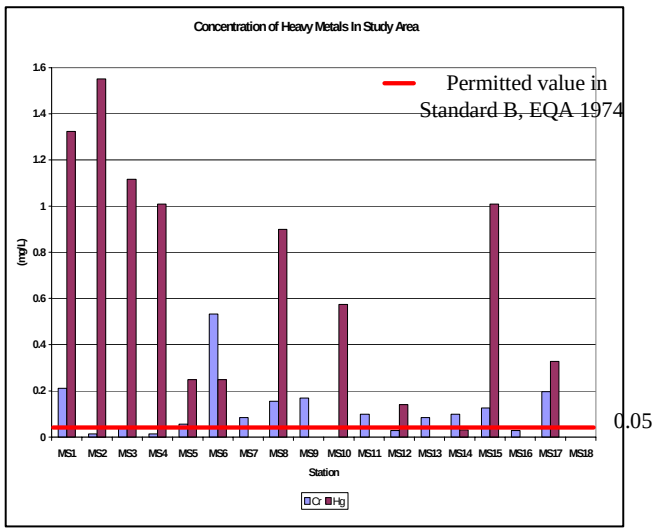

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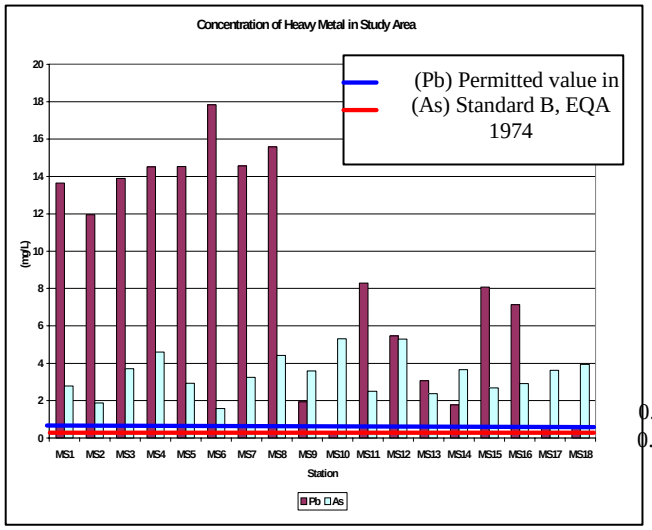

(b)

Figure 13 Variations of heavy metals concentration on 4th November 2003; (a) Chromium and Mercury, (b) Plumbum

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