Preliminary study of water quality surrounding the petrochemical plants at Teluk Kalong industrial area

Mohd H Ibrahim1*, Rabiatul M Mohamed1, Azharin S. Abdul Aziz1 and Sairam Chandran2

1 Faculty of Engineering Technology, University College TATI, 24000 Kemaman, Terengganu, Malaysia
2 Amspec Testing Services Pte Ltd.
E-mail: habir@tatiuc.edu.my

Abstract. Wastewater from industry could lead to water pollution if not properly treated. This research aims to analyze quality of effluent discharge surrounding the petrochemical plants at Teluk Kalong Industrial Area. The purpose is to identify of uncertain level of Biochemical Oxygen Demand (BOD), Total suspended Solids (TSS), heavy metal zinc and copper. These properties could affect water quality if the effluent is not properly treated prior to discharge on water surface. In order to obtain the aim of this research, the laboratory analysis has been carried out on the waste water discharged from the petrochemical industry area. An experiment was conducted and discovered that the minimum value for BOD, TSS, Zn and Cu was 35.55mg/l, 21.667mg/l, 0.006mg/l, and 0.001mg/l accordingly. The maximum value for BOD, TSS, Zn and Cu was 60.150mg/l, 742.667mg/l, 0.839mg/l and 0.044mg/l accordingly. As not all parameters obtained satisfactory to the local standard, it is recommended further research be performed to ensure appropriate result complying to the regulatory standards.

1. Teluk Kalong industrial area and water pollution – an overview
Nowadays, the pollution of the environment (air, water and land) occurs quickly and it should not be taken lightly. There are tendencies suggest that environmental pollution is a modern-day problem that has come to live with us and indirectly give some dangerous effect on human health. Even though the domestic or municipal activities that contributed to pollution seem to be controlled, other forms of pollution arising from activities in agricultural, industrial and hospitals (biomedical) are on the increase [1]. One of the environment pollutions is caused by the petrochemicals industries [2].

Telok Kalong Industrial Area is an industrial zone area initiated by the Terengganu state government mainly to support the petroleum industry which is abundant in the state of Terengganu. Most of the industries and services built are related to petroleum and gas. There are hundreds of small and medium industries operated in this area and including petrochemical plants. This area also considers as main hub of the pipeline’s gas connecting to other Malaysia regions [3]. Previously researches conducted indicate that the petrochemicals plant has contributed to the heavy metal waste that could cause danger to environment as well as human [4, 5].

The proximity of the chemical industries to the receiving water body is important when considering the toxicity, turbidity and pollution defect in biological and chemical oxygen demand of the water for
agricultural activities. Aquatic lives depend on the quantity of sediment in the stream the water temperature, the amount of oxygen taken out of the system by respiring and decaying organisms, and the amount of oxygen put back into the system by photosynthesizing plants, stream flow, and aeration [6]. Chemical plant effluent is highly variable in quality and composition. The pollution discharge from chemical plant effluent comes from the losses in the chemical production process and from the clean-in-place system. In the examination of wastewater, 75% of total dissolved solids are suspended solids and about 40% of the filterable solids [7]. The major toxic heavy metal in waste water are zinc, magnesium and phosphate.

The food source for water-borne bacteria generated from natural organic detritus and organic waste such as from waste water treatment plants, failure of septic systems and agricultural. Bacteria decompose these organic materials using dissolved oxygen (DO), thus reducing the DO present for fish. Biochemical oxygen demand (BOD) is a measure of oxygen that bacteria will consume while decomposing organic matter under aerobic conditions. It able to be determine by incubating a sealed sample of water (5 days) and measuring the loss of oxygen (start to end of the test). Chemical oxygen demand (COD) does not differentiate between biologically available and inert organic matter, and it is a measure of the total quantity of oxygen required to oxidize all organic material into carbon dioxide and water. COD values are always greater than BOD values, but COD measurements faster than BOD measurements [6]. These are further complemented if a waste water treatment plant is installed to treat chemical wastewater prior to discharge to water bodies either by conventional or advanced treatment method. Waste water if not properly treated is harmful for humans and environment. Diseases contracted by drinking contaminated water or eating contaminated food are often referred to as waterborne and foodborne diseases.

There are several actions can be taken to reduce the water pollution. Previous experiments have been conducted to identify the effect of pollutant to water including which surrounded by the chemical plant area by analyzing the waste water, which consist of several parameters in order to determine the quality of the water. The important of the water quality could be also observed by several research efforts being conducted; such as using artificial neural networks (ANNs) that could estimate the value of BOD much faster [8]; response surface methodology technique for the removal of divalent heavy metal ions from synthetic wastewater [9]. An advanced modelling research to identify patterns of water quality was also recently conducted [10]. Looking into this important scenario, the objective of this paper to analyze water pollutant of surrounding the petrochemical plants. The specific water quality parameters are BOD, TSS and heavy metal, mainly zinc and cooper.

2. Methodology

2.1 Introduction
In order to carry out this research, an experimental flow chart was developed (figure 1). In general, the experimental consist data collection and analysis on the main parameters of water quality included BOD, TSS and heavy metal (zinc and cooper). Data collection was performed at the receiving surface water for the duration of 7 weeks, 5 days per week. There was no data collection was taken during weekend.
The most widely used wastewater parameters are the BOD, COD, Volatile Organic Carbon (VOC), pH, Electrical Conductivity (EC) and Total Suspend Solid (TSS). Generally, BOD is a measure of the amount of dissolved oxygen used by the microorganism in the oxidation of organic matter. Meanwhile COD measures the total oxygen required for chemical oxidation of organic matter to carbon dioxide and water. The BOD parameters will be measured using dissolve oxygen meter. The device will as well be used to analyse COD parameter. The last two parameters which will be analyse were the TSS and heavy metal. 30 sample will be analysed for each parameter will be analysed for each as this is commonly considered statistically accepted.

2.1.1 BOD. Firstly, dilute the sample by distilled water until dissolve oxygen not more than 6 mg/l for each sample. Then, check pH of sample. It should be range 6.5 to 7.5. pH can adjust by sulphuric acid and sodium hydroxide 0.01M. After dilution place the sample to bottle of 300ml with label. Record the initial DO and pH for 5 time reading and keep with cover by aluminium foil incubated at 20°C for 5 days. After 5 days, record the final DO and pH. Then calculate the BOD of the sample. Repeat 3 duplication and record result for each sample.

To conduct this experiment, 9 pcs of incubation bottles 300ml, air incubation or water bath, thermometer, 1 pcs of beaker 400 ml, 500 ml 1000 ml, 1 pcs of measuring cylinder, 10 pcs of bottle sample 500ml, 1 pcs of pipette, glass rod, wastewater sample and distilled water required.

2.1.2 COD. In digestion method, blander the homogenize 100 ml of sample for 30 second. Turn on and preheat for 150°C cod reactor. Then, place the plastic shield in front of the reactor. Remove the cap of COD digestion reagent vial and hold the vial 45’ angle, pipet 2.0 ml of sample into vial. Tightly replace the vial cap. Use deionized water and wipe the vial clean with a paper towel. Hold the vial by the cap and over a sink. Gently invert in several times to mix the content. Then, preheated the vial in the cod reactor. Prepare a blank by repeating step above with substituting 2.0 mm/l of deionized water for
sample. Place the blank in the cod reactor. Then turn off cod reactor and wait for 2 min for vial to cool down. Invert each vial several time while still warm and place the vial into rack.

For calorimetric measurement of cod, press the soft key under Hach program. Select the stored program number for ultra-low range cod by pressing 2700 with numeric keys and press enter. Then insert the test 'N tube Adapter into the sample cell module by sliding it under the thumb screw and into the alignment grooves. Then fasten with the thumb screw. Clean the outside of the blank with towel. Then place the blank into adapter and close the light shield. After that press the soft key under zero. Clean the outside of the sample vial with towel and place the sample vial into adapter. Make sure close the light shield. The result in mg/l cod will be displayed.

To conduct this experiment, Hach UV apparatus, Wastewater sample, Towel, Deionized water are required.

2.1.3 TSS. In preparation of glass fibre disk, insert disk with wrinkle side up in filtration apparatus. Then apply vacuum and wash dish with 3 successive 20 ml portions of reagent-grade water. Continue suction to remove all trace of water and turn off vacuum and discard washing. Then remove filter from filtration apparatus and transfer to an inert aluminium weighing dish. If a grouch crucible is used, remove crucible and filter combination and dry in an oven at 103 to 105 for 1 hour. Cool in desiccator to balance temperature and weigh. Then, repeat cycle of drying, cooling, desiccating, and weighing until a constant weight is obtained or until weight change is less than 4% of previous weighing or 0.5mg, whichever is less. Then store in desiccator until needed. Repeat 5 times and record for each sample.

In selection of filter and sample sizes, choose sample volume to yield between 2.5 to 200 mg dried residue. Increase sample volume up to 1 l if volume filtered to meet minimum yield. Increase filter diameter or decrease sample volume if complete filtration takes more than 10 minutes.

For TSS sample analysis, assemble filtering apparatus and filter and begin suction. Wet filter with a small volume of reagent grade water to seat. Then stir the sample with magnetic stirrer or mixing impeller at a speed shear larger particle to obtain a more uniform. While stirring, pipet a measured volume onto the seat fiber glass for homogeneous sample from approximate midpoint but not in vortex. Choose a point both mid depth and midway between wall and vortex. Then wash filter with three successive 10 ml volume of reagent grade water, allowing complete drainage between washing and continue suction for 3 minutes after filtration is completed.

To conduct this experiment, 1 pcs of porcelain 90m diameter, 3 pcs of Erlenmeyer flask 250 ml, 1 pcs of beaker 400,500,1000 ml, 1 pcs of measuring cylinder 500 ml, 10 pcs of bottle sample 500 ml, 3 pcs of high silica glass, pipette 10 ml, drying oven, filter paper, vacuum pump, domestic wastewater sample, industrial wastewater sample and distilled water required. After the analysis, data obtained was compared accordingly to the local standard as on the following table 1.

| Parameter   | Standard A mg/l | Standard B mg/l |
|-------------|-----------------|-----------------|
| BOD         | 20              | 50              |
| Suspended Solid | 50              | 100             |
| Copper      | 0.2             | 0.1             |
| Zinc        | 2.0             | 2.0             |

Table 1. Standard guidelines of Malaysian discharged waste water [11].
3. Result and Discussion

3.1 Biological oxygen demand
The BOD was calculated from the results of DO obtained. The BOD was calculated by difference between initial and final DO. Figure 2 shows the relationship between the amount of DO and BOD. The amount of DO observed to be decreased constantly varies according to weeks. Changes of DO ordinarily varies according to water quality. It is noted that the highest and the lowest amount of BOD recorded is 60.15 and 35.55 mg/l respectively.

![DO & BOD Graph](image)

Figure 2. Biological oxygen demand value and changes of dissolve oxygen in waste water sample.

3.2 Total suspended solid
Figure 3 shows the trend of TSS in the wastewater during study period. The highest value of TSS was 742.67 mg/l while the lowest value was recorded at 22.33 mg/l. In general graph present shows TSS readings are initially higher comparing to the rest. From the observation, the value of TSS are fluctuated throughout the study period which directly related to the raining seasons. It was noticed on day 18th onward. The contribution of the raining water was observed starting from day 8th to day 18th in the irrigation within the industrial zone contributed to the lower value of TSS.
Figure 3. Amount of total suspended solid in waste water sample.

3.3 Heavy Metal

Figure 4 shows the trend of zinc and copper content. It was noted that the maximum and the minimum value of zinc was 0.839 mg/l and 0.006 mg/l respectively. For copper, the maximum and minimum value was recorded at 0.044 mg/l and 0.001 mg/l respectively. The average reading for both zinc and copper was calculated at 0.1239 mg/l and 0.0166 mg/l respectively. Figure 4 also indicates that the amount of zinc is higher than copper. From the analysis it is proven that zinc and copper exist in waste water which was disposed by industries within the Telok Kalong industrial area.

Figure 4. Composition of zinc and copper in waste water sample.
4. Conclusion
In general, and for a long-term run, the average result obtained from this research discovered that all parameters measured are within the regulatory requirement. This shows that the local industries have practiced their manufacturing activities according to the specified standard. Since there is an evidence of the heavy metal which is harmful to human, it is recommend that future researchers to implement the more advance technique in order to identify water quality.

Acknowledgment
The authors would like to thank University Collage TATI for providing financial support for this study. Any statement stated in this paper are those of the authors and do not reflect the view of the supporting organizations.

References
[1] Barnes K H, Meyer J L and Freeman B J 1998. Sedimentation and Georgia’s Fishes: An analysis of existing information and future research.
[2] Biswasa S, Sharmaa S, Mukherjeea S, Meikapab C and Senb T K 2020 J. Water Process Eng. 37 101-406
[3] Dogan E, Sengorur B L and Koklu R 2009 J. Env. Management 90 1229–1235
[4] Environmental Quality Act 1974 - Environmental Quality (Industrial Effluent) Regulations
[5] Guzman M L C, Arcegac K S G, Cabigao J M N R and Su G L S 2016 Adv. Env. Biology 10(1) 10-15
[6] Inez H V D S S, Mariangela S D A, Wanderley R B and Dario P D C 2016 Aus. J. Basic and App. Sci. 10(16) 211-218
[7] Lim Z W and Goh K L 2019 Energy Policy 128 197–211
[8] Metcalf and Eddy 2013 Wastewater Engineering: Treatment and Resource Recover McGraw-Hill Education 5th Edition
[9] Meshesha T W, Wang J and Melaku N D 2020 J. Hydrology 587 124952
[10] Mokarrama M, Saber A and Sheykhic V 2020 J. Cleaner Production 277 23-380
[11] Ronald W C and Tchobanoglous G 1998 McGraw-Hill series in water resources and environmental engineering
[12] Sun C, Zhangb Z, Caoola H, Xua M and Xu L 2019 Concentrations, speciation, and ecological risk of heavy metals in the sediment of the Songhua River in an urban area with petrochemical industries, Chemosphere 219 538-545
[13] Wang S, Kalkhajeh Y K, Qin Z and Jiao W 2020 South China Environmental Research 188 109-661