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# Effluent Quality Testing from Wastewater Treatment Plant in Universiti Teknologi Malaysia

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**GRAPHICAL ABSTRACT**

(a) Primary treatment and (b) aeration and sedimentation tank of STP 3 in Universiti Teknologi Malaysia

**ABSTRACT**

The effect of population equivalent on the water quality parameters was successfully carried out. The effluent discharge from sewage treatment plant and oxidation pond in Universiti Teknologi Malaysia, Johor Bahru was monitored by running test on biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solid (TSS), oil and grease, ammoniacal nitrogen, nitrate nitrogen and phosphorus. The maximum limit must comply to Standard B of the Environmental Quality (Sewage) Regulations 2009 Second Schedule, Department of Environment (DOE) because it was discharged downstream of the raw water intake of Syarikat Air Johor (SAJ) water treatment plant. First stage sampling was done weekly for three weeks during the semester break where fewer students were staying on campus and thus lower population equivalent load. Second sampling was done monthly starting from first week of the semester and the month after. The samples collected were preserved immediately while the BOD determination was carried out immediately after sampling without preservation. The method used for determination of BOD and TSS were according to standard method, APHA method 5210B and 2540D, respectively. HACH method was used to determine COD, ammoniacal nitrogen, nitrate nitrogen, and phosphorus since it is more rapid. Oil and grease analysis followed the method of Wilks InfaCal TOG/TPH Analyzer which used less solvent and faster analysis. A total of 5 weeks sampling data was obtained from this study. BOD and COD values obtained for STP K10 increased drastically from 3.65 mg/L in week 3 and 21 mg/L in week 5 for BOD while 22 mg/L in week 3 and 61 mg/L in week 5 for COD. Ammoniacal Nitrogen values for STP V01, STP 3, STP K10 and STP K17 exceeded the maximum with reading of 6.85 mg/L,9.2 mg/L, 15 mg/L and 5.35 mg/L, respectively. Other parameters showed minor differences between weeks with concentration below the maximum limit. The sewage treatment plants in UTM should be maintained regularly to ensure effluent discharge complies with the Standard B.

*Keywords: sewage treatment plant, biological oxygen demand, standard B, effluent discharge, Environmental Act Regulation*



## 1. INTRODUCTION

Wastewater is any water that has been affected by human activity or can also be defined as the water that has been affected by anthropogenic influence. There are many sources of wastewater such as domestic, industrial, and agricultural. Municipal wastewater or also called sewage is the wastewater originated from domestic sources thus contaminated with faeces or urine from toilets. Municipal wastewater usually will be conveyed through sewer into a wastewater treatment plant before discharged into water bodies such as river and ocean.

Wastewater treatment plant in Universiti Teknologi Malaysia (UTM) currently runs without proper monitoring and reporting to Department of Environment (DOE). UTM was recently notified by DOE to regulate their wastewater treatment plant and effluent discharge to comply with the Environmental Quality Act. There are two standards that can be followed depending on the discharge point. If the effluent is discharged upstream of a raw water intake of SAJ water treatment plant, then Standard A must be followed. If the effluent is discharged downstream, then Standard B must be followed. Since our wastewater treatment plant discharged effluent downstream, then UTM must comply with Standard B.

The objective of this study is to monitor of the effluent discharged from wastewater treatment plant in UTM by running tests for the seven basic parameters for domestic effluent that needs to be regulated. UTM currently have six wastewater treatment plants which two of them are the classic oxidation pond (OP) type and the other four are sewage treatment plant (STP) type. The data collected will be used to determine the effectiveness of these two types of wastewater treatment plant and whether it still can be used or needs to be upgraded. By monitoring the effluent discharge for a month, a set of data is obtained and the trend on effluent quality against the population equivalent is observed.

Continuous monitoring on discharged effluent is important for the environment and the treatment system as well. Continuous monitoring on the discharged effluent will ensure pollutants are not released in harmful amounts and that the treatment plant is well maintained. Any change in the effluent composition will indicate the failure of the system or it is already overloading so the consecutive action can be taken to overcome that problem. This regulation will ensure that the water discharged into the water body is clean and safe for the environment.

## 2. EXPERIMENTAL

The samples are collected in two 1L clean plastic and a glass bottle at the same place and time for every sampling done. The samples are preserved immediately in the icebox at temperature of 4ºC or below. Tests were run as soon as possible after sampling. The first sampling was done during the semester break where number of students is low, and population equivalent load is also low. First sampling is taken weekly for 3 weeks. Second sampling was taken one week after semester open and one month after semester open where the number of students is high, and population equivalent load is also high.

BOD analysis is done by following the standard method from APHA 5210B. Samples that require dilution was diluted using dilution water prepared beforehand by adding BOD nutrient pillow into distilled water. 300 mL final sample volume was used, and the initial DO reading was taken, incubated at 20˚C for five days and final DO reading was taken.

TSS was determined by following standard method from APHA 2540D where the sample was filtered through 0.45 μm glass fibre filter paper, dried for 1 hour at 105˚C, desiccated and difference in weight of the filter paper was recorded. Ammoniacal nitrogen, nitrate nitrogen and phosphorus were determined using the HACH DR500 Spectrophotometer following its instruction and using their chemicals. Oil and grease were determined using the instrument Wilks InfraCal TOG/TPH Analyzer. A 100 mL of sample was poured into the glass sample bottle, followed by 10 mL of n-hexane, capped and shaken for 2 minutes. The sample was left to sit until the two liquid separates and 50 µL of the solvent was deposited onto the instrument interface that has been calibrated by using a micropipette.

**Table 1** Acceptable Conditions of Sewage Discharge of Standards A and B

| Parameter | Unit | Standard A | Standard B |
|---|---|---|---|
| Temperature | °C | 40 | 40 |
| pH value | - | 6.0-9.0 | 5.5-9.0 |
| BOD5 at 20 °C | mg/L | 20 | 50 |
| COD | mg/L | 120 | 200 |
| Suspended Solids | mg/L | 50 | 100 |
| Oil and Grease | mg/L | 5.0 | 10.0 |
| Ammoniacal Nitrogen (enclosed water body) | mg/L | 5.0 | 5.0 |
| Ammoniacal Nitrogen (river) | mg/L | 10.0 | 20.0 |
| Nitrate-Nitrogen (river) | mg/L | 20.0 | 50.0 |
| Nitrate-Nitrogen (enclosed water body) | mg/L | 10.0 | 10.0 |
| Phosphorus (enclosed water body) | mg/L | 5.0 | 10.0 |

## 3. RESULTS AND DISCUSSION

### 3.1 Results

Result from first week sampling (Table 2) shows lower value for each parameter. This can be related to the number of student present on campus and population equivalent. First week sampling was done during UTM semester break where less student present on campus thus making the population equivalent load is low. The treatment process was optimized, and the results obtained were within the Standard B requirement. During this week of sampling, STP K10 and STP K17 were under maintenance and sampling cannot be done.

**Table 2** Results for Week 1

| Parameter | STP V01 | STP 3 | OP 2 |
|---|---|---|---|
| pH | 5.1 | 7.1 | 6.9 |
| BOD5 (mg/L) | 5.94 | 1.38 | 12.51 |
| COD (mg/L) | 13 | 11 | 43 |
| TSS (mg/L) | 5.6 | 2.1 | 29.5 |
| Oil and Grease (mg/L) | 5 | 4 | 4 |
| Ammonia Nitrogen (mg/L) | 1.32 | 5.48 | 1.47 |
| Nitrate Nitrogen (mg/L) | 4.1 | 1.0 | 0.04 |
| Phosphorus (mg/L) | 1.22 | 0.18 | 0.35 |

Table 3 shows the result from second week sampling. The difference from week 1 was not significance with addition of one sample from STP K10. Second week sampling was also done during semester break where less students were present on campus thus making the population equivalent load is still low. The treatment process was optimized, and the results obtained were mostly within the Standard B requirement. However, ammoniacal nitrogen concentration from STP K10 and STP 3 is high and exceeds the Standard B requirement.

**Table 3** Results for Week 2

| Parameter | STP V01 | STP 3 | STP K10 | OP 2 |
|---|---|---|---|---|
| pH | 6.1 | 7.2 | 6.9 | 6.8 |
| BOD5 (mg/L) | 4.44 | 3.07 | 4.11 | 10.14 |
| COD (mg/L) | 13 | 7 | 21 | 42 |
| TSS (mg/L) | 4.6 | 4.4 | 5.1 | 21 |
| Oil and Grease (mg/L) | 5 | 6 | 4 | 5 |
| Ammonia Nitrogen (mg/L) | 1.26 | 5.62 | 7.05 | 1.13 |
| Nitrate Nitrogen (mg/L) | 3.44 | 0.87 | 1.76 | 0.10 |
| Phosphorus (mg/L) | 1.14 | 0.29 | 0.58 | 0.30 |

From Table 4, the results from third week sampling still show no significance difference from previous weeks. However, this week sampling shows high reading of ammoniacal nitrogen concentration from STP K10 and STP 3 and exceeds the Standard B requirement.

**Table 4** Results for Week 3

| Parameter | STP V01 | STP 3 | STP K10 | OP 2 |
|---|---|---|---|---|
| pH | 6.5 | 6.7 | 6.7 | 6.4 |
| BOD5 (mg/L) | 1.71 | 4.31 | 3.65 | 10.68 |
| COD (mg/L) | 10 | 13 | 22 | 44 |
| TSS (mg/L) | 5.4 | 7.7 | 3.9 | 30 |
| Oil and Grease (mg/L) | 6 | 5 | 6 | 5 |
| Ammonia Nitrogen (mg/L) | 2.09 | 7.90 | 7.75 | 1.04 |
| Nitrate Nitrogen (mg/L) | 3.80 | 1.20 | 1.20 | 0.10 |
| Phosphorus (mg/L) | 1.17 | 0.37 | 0.76 | 0.30 |

Result from the fourth week sampling (Table 5) shows almost similar value for each parameter. Fourth week sampling was done one week after semester opened where number of student present on campus started to increase thus making the population equivalent load is normal. The treatment process was optimum and most of the results obtained were within the Standard B requirement. However, ammoniacal nitrogen concentration from STP K17 and STP 3 were high and exceeds the Standard B requirement. Sampling was not done for STP K10 since it was under maintenance during sampling week and replaced by STP K17 that was just started to operate after maintenance.

**Table 5** Results for Week 4

| Parameter | STP V01 | STP 3 | STP K17 | OP 2 |
|---|---|---|---|---|
| pH | 6.9 | 7.1 | 7.2 | 7.4 |
| BOD5 (mg/L) | 1.40 | 2.91 | 8.61 | 13.98 |
| COD (mg/L) | 20 | 16 | 27 | 51 |
| TSS (mg/L) | 5.25 | 3.5 | 2.6 | 29 |
| Oil and Grease (mg/L) | 6 | 8 | 7 | 8 |
| Ammonia Nitrogen (mg/L) | 2.45 | 7.10 | 6.30 | 1.68 |
| Nitrate Nitrogen (mg/L) | 4.80 | 1.20 | 0.40 | 0.06 |
| Phosphorus (mg/L) | 1.25 | 0.29 | 0.83 | 0.38 |

Table 6 shows the result from final week sampling and indicate an increased value for almost each parameter of the test. The number of student present in campus and population equivalent load is the major reason here. Final week sampling was done during one month after semester open where most of the students already present in campus thus making the population equivalent load high. The treatment process was not optimized but the results obtained were still within the Standard B requirement for all parameters except for ammoniacal nitrogen that shows high reading in all STPs and exceeding the maximum limit.

**Table 6** Results for Week 5

| Parameter | STP V01 | STP 3 | STP K17 | OP 2 | STP K10 |
|---|---|---|---|---|---|
| pH | 6.4 | 6.6 | 7.2 | 6.1 | 7.1 |
| BOD5 (mg/L) | 5.46 | 3.94 | 8.58 | 22.56 | 21.18 |
| COD (mg/L) | 13 | 15 | 25 | 84 | 61 |
| TSS (mg/L) | 5.25 | 3.5 | 2.6 | 29 | 11.6 |
| Oil and Grease (mg/L) | 6 | 8 | 7 | 8 | |
| Ammonia Nitrogen (mg/L) | 6.85 | 9.20 | 5.35 | 3.43 | 15.0 |
| Nitrate Nitrogen (mg/L) | 7.80 | 4.20 | 0.90 | 0.06 | 1.60 |
| Phosphorus (mg/L) | 1.87 | 0.52 | 0.69 | 0.52 | 2.05 |

3.2 Comparison between Oxidation Pond and Sewage Treatment Plant

The BOD and COD reading for oxidation pond are slightly higher than the reading from the STP (Table 4.1). This is because oxidation pond let bacteria decompose the pollutant naturally while sewage treatment plant uses mechanical process to further increase the effectiveness of the treatment. The aeration process in STP ensures that dissolved oxygen in the system is kept at maximum thus giving the bacteria an optimum condition for decomposition.

TSS reading for oxidation pond also higher than the reading for sewage treatment plant (Figure 4.1). This is because of algae that presents in the oxidation pond. Algae grow rapidly in the oxidation pond because there is no aeration system presence. Nutrients (nitrate, phosphate) that are accumulated at the surface promote the growth of algae in oxidation pond. Algae in the effluent contribute to the high TSS reading and possibly harmful towards the environment. However, high number of algae helps is reducing the other parameters including nitrate, phosphorus and ammonia since it grows by feeding on these nutrients. All of the results have been submitted to Department of Environment for evaluation.

3.3 Trend of the Result

The results obtained were used to construct graphs to see the effects of high population equivalent load on the sewage treatment plants and the trend of the parameters. Figure 1-5 shows the trend of each parameter over the weeks and Figure 1 below shows that there are no major differences of pH reading between weeks. pH is not directly affected by the population equivalent load on the sewage treatment plants.

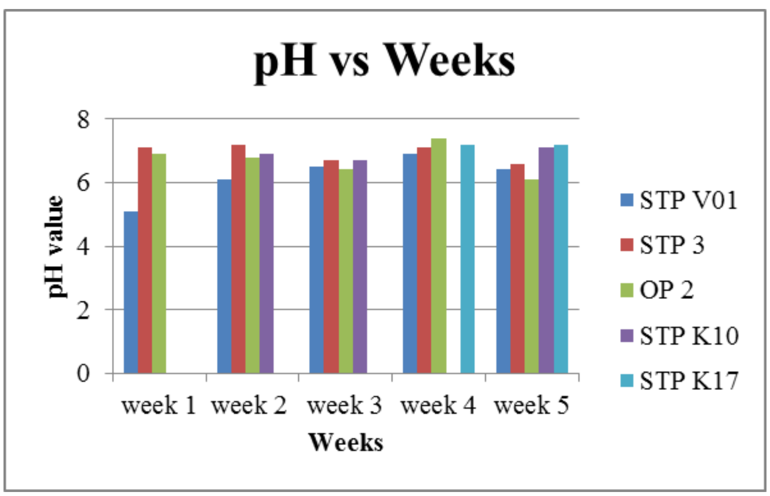


**Figure 1** Graph of pH Value vs Week.

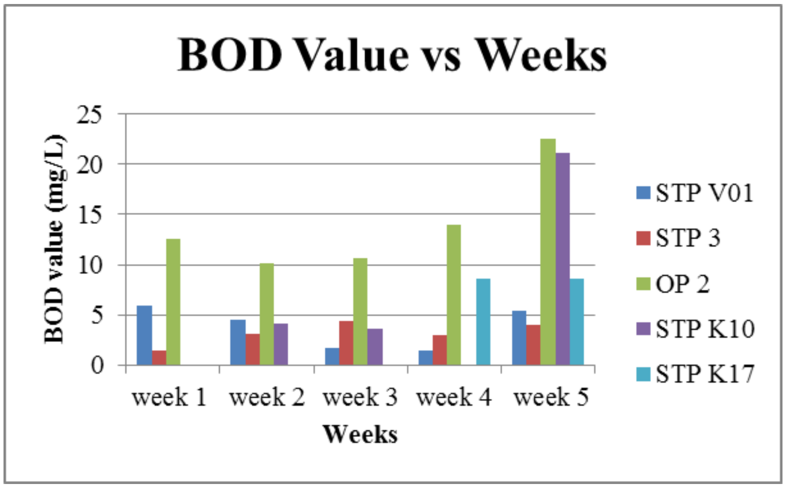


**Figure 2** Graph of BOD Value vs Week.

As shown in Figure 2, the BOD values were mostly steady with little changes throughout week 1 until week 3. Week 4 shows slight increase on the BOD values of oxidation pond but remains steady for other sewage treatment plants. However, in week 4, BOD values for STP V01 and STP K10 increases drastically, slight increase in OP 2 and STP 3, by 290%, 480%, 61% and 35% respectively compared to their last sampling week values. However, the highest recorded BOD reading from all samples still did not exceed the maximum limit of Standard B. From this graph, BOD was directly affected by population equivalent load.

Figure 3 shows the trend of COD value over the weeks. Small differences were shown from week 1 until week 3. COD value increased slightly during week 4 for all STPs and OP. During week 5, the COD values for STP K10 and OP 2 shows significant increase by 177% and 64% respectively while slightly decrease in other STPs. The maximum limit of COD values according to Standard B is 200 mg/L. All of the sewage treatment plants still operating well despite the increase of the value in the final week where most students were present on campus.

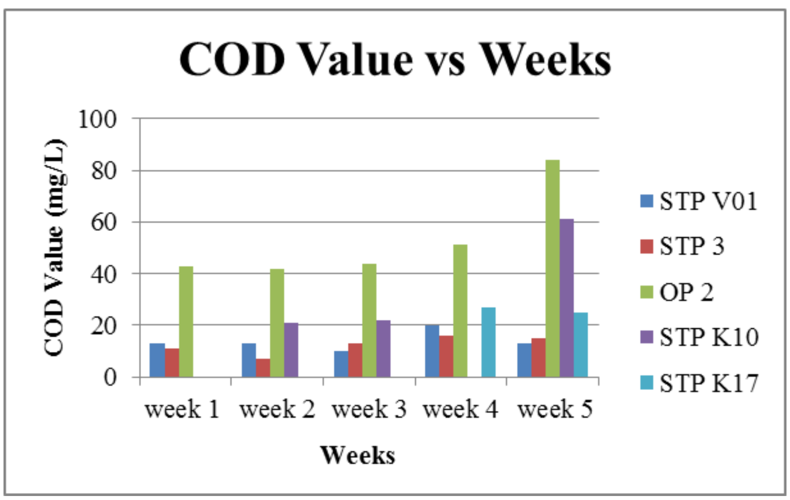


**Figure 3** Graph of COD Value vs Week.

Trend of TSS values over the weeks are as in Figure 4. No significant difference was shown throughout the weeks. Highest reading of TSS from week 5 was from the OP 2 only increase 51% from previous week and still lower than the maximum limit which is 100 mg/L.

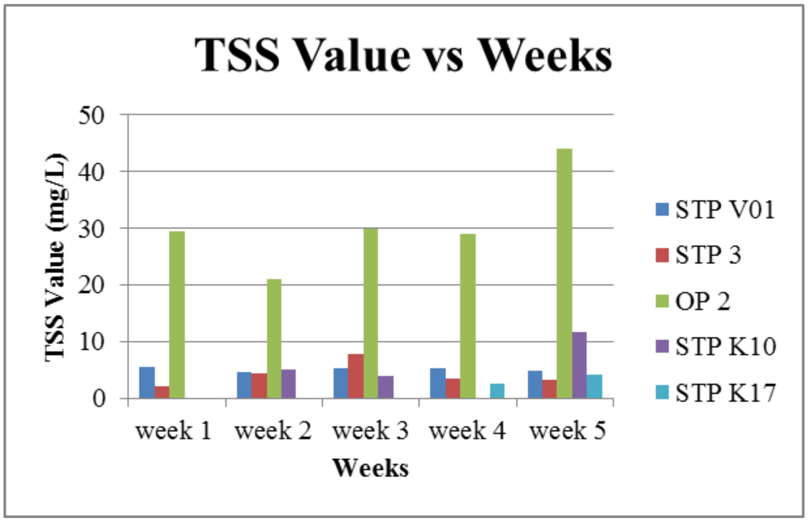


**Figure 4** Graph of TSS Value vs Week.

Results obtained for oil and grease shows uniform values with slight increase and decrease (Figure 5). Results from week 5 show slight increase but not significance. All oil and grease values obtained does not exceed the maximum limit from Standard B.

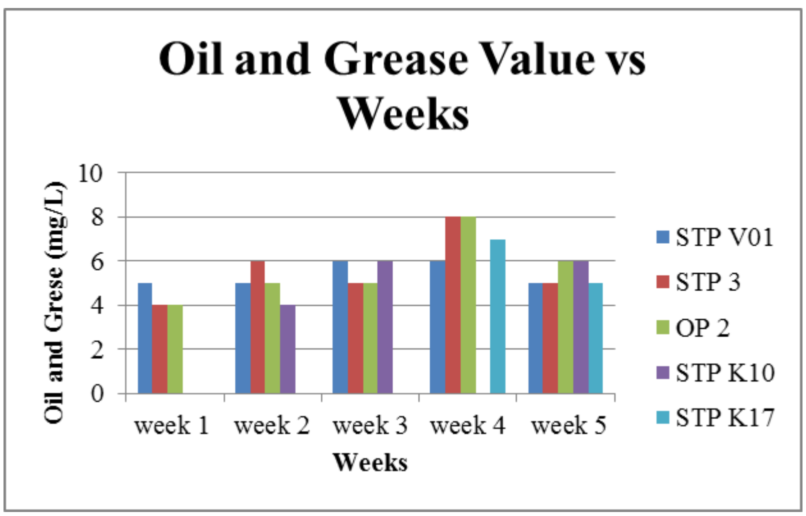


**Figure 5** Graph of Oil and Grease Value vs Week.

Figure 6 shows the trend of ammoniacal nitrogen values obtained from week 1 until week 5. Only slight difference was shown up to week 4.STP V01, STP K10 and OP 2 show the significant increase in values by 179%, 93% and 104% respectively. However, the main concern is that most of the STPs constantly exceeding the maximum limit of ammoniacal nitrogen concentration in effluent discharge which is 5 mg/L. Only STP 3 and OP 2 managed to maintain below the limit but only until week 4. All STPs and OP discharged effluent that exceed maximum limit on week 5. Maybe maintenance should be done regularly to ensure the STPs operate in best condition

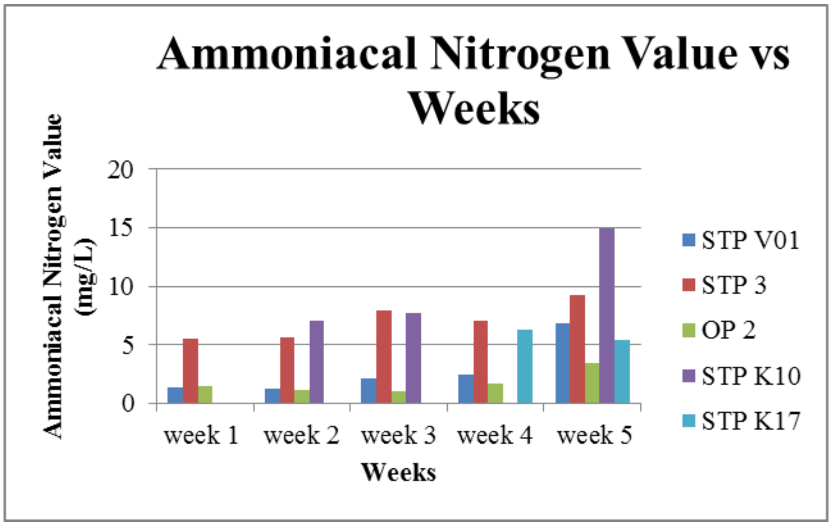


**Figure 6** Graph of Ammoniacal Nitrogen Value vs Week.

The results and trends of nitrate nitrogen in Figure 7 shows major increase on week 5 but still does not exceed the maximum limit as in Standard B which is 10 mg/L

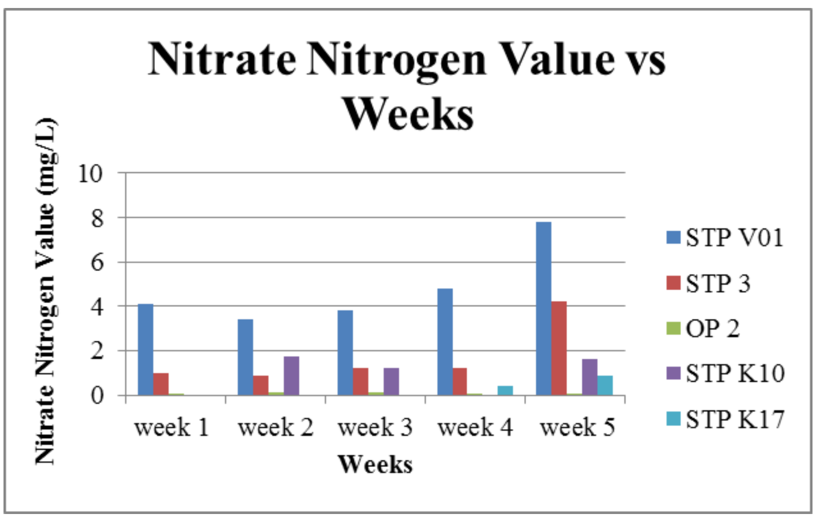


**Figure 7** Graph of Nitrate Nitrogen Value vs Week.

The results obtained for phosphorus value were far from the maximum limit of Standard B which is 10 mg/L. The highest result obtained as shown in Figure 8 is just slightly above 2 mg/L. Week 5 shows major increase in nitrate value but overall not so significant.

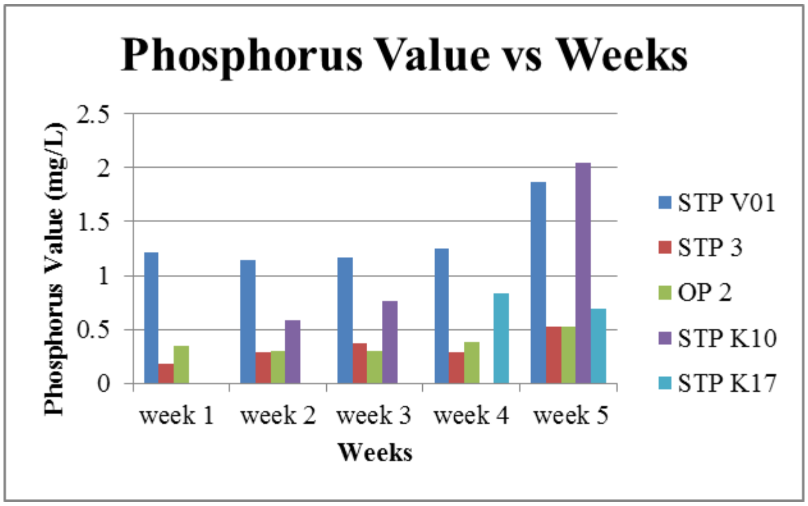


**Figure 8** Graph of Nitrate Nitrogen Value vs Week.

## 4. CONCLUSION

The results obtained from this testing is in the range of the specification from Environmental Quality Act. Thus, it is safe and will not bring harms to the environment. The effect of population equivalent on the quality of the effluents was determined from the results obtained through the two months of monitoring. This data can be useful in determining the efficiency of the wastewater treatment plant and to decide whether to upgrade or build a new wastewater treatment plant using latest technology. The current STPs works efficiently with low population equivalent load and shows increase in concentration of ammonia exceeding the maximum limit of Standard B when population equivalent load is high. The results obtained shows that the ammonia values for all STPs exceeded the maximum values in Standard B when most of the student present in the campus. The STPs should be upgraded for higher population equivalent and ammonia removal treatment should be maintained regularly to ensure the effluent discharged into water bodies follows the regulation. On the other hand, oxidation pond has no problem in maintaining the parameters value below the maximum limit of the Standard B.

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