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# Consequence model of contamination of ammonia in sewage wastewater

R. F. Alicia, S. Syafiie *

*Department of Chemical and Environmental Engineering, University Putra Malaysia, Serdang, Malaysia*

**Abstract:** The paper present the comparison study of consequence modeling of ammonia toxic dispersion distance calculated using PHAST software before and after ammonia removal treatment by means of magnetic biochar as an adsorbent. Each sample were tested using Ultra Violet (UV) Visible Spectrometer, where absorbance rate and wavelength are the parameters used to develop a linear calibration curve graph using ammonia stock solution to calculated ammonia concentration for the samples collected. An equation of y = 0.0101x + 0.1570 were developed. At each sample point four collections were done for accuracy purpose. Every 100ml of samples collected from Company 'X' underwent ammonia removal treatment where the samples were agitated at a constant speed of 120rpm for 120 min using 0.5g of magnetic biochar. Approximately an average of 67% of ammonia was removed from all the four sample points. Toxic dispersion distance for sample point 1 which is the nearest to residential area were reduced to 4.37m with 76% drop while for sample point 2, 3.86m of dispersion distance has been reduced. Dispersion distance for sample point 4 reduced up to 3.97m and finally which has the highest concentration of ammonia, reduces up to 4.17m of dispersion distance. Hazard of ammonia to the surrounding vicinity is reduced to an average 67% for all the sample points. The removal of ammonia using magnetic biochar as an adsorbent has proven to reduce of ammonia to nearby residences. Higher the removal percentage, higher the reduction of dispersion distance therefore reduces the hazard of ammonia to the surrounding vicinity.

**Key words**: Ammonia; Wastewater; PHAST; Hazardous

## 1. Introduction

Risks of hazard of ammonia from sewage waste water effluent are very high among the residence residing nearby the sewage treatment plant. Besides that, it is also hazardous to flora and fauna along the discharged path and its final flow to the river. Sewage treatment plant near residential area where the final effluent will pass by the drainage before it reaches the final discharge point which typically will be the nearest river.

Thus, the hazard of ammonia is exposed along the path of the residential area which could lead them several health complications such as eye irritation, skin burn. By using software called PHAST, we can determine the initial hazard consequence diagram among the residences based on dispersion calculation (Hubisz et al., 2010) then compared it after treatment using magnetic biochar as an adsorbent via absorption process. PHAST software are widely used to calculate and produce report for various functions such as Jetfire, fire pool, toxic dispersion, fire dispersion model and discharge point (Zhou et al., 2011). For this purpose of this study, toxic dispersion model will be used. The process of ammonia removal is based on speed of the mixer, agitation time and quantity of the adsorbent. Based on literature review, magnetic biochar is expected to remove approximately 99% of ammonia from sewage wastewater effluent (Mubarak et al., 2013a). Hazard consequences among the residence near by the sewage treatment plant will be reduced drastically.

## 2. Material and method

Magnetic biochar was obtained from university of Malaya produced from empty fruit brunch. A stock solution which will act as the synthesis wastewater sample was prepared by using dilution method where ammonia solution was set at 1.0 mg/l. Based on the research done (Mubarak et al., 2013b), it was concluded 120 rpm and 120 minutes was set for agitation speed and agitation time, while adsorbent dosage at 0.09 grams was the best optimized condition in the removal of ammonia. PHAST was used to develop the consequence model of before and after ammonia removal.

## 3. Results and discussion

### 3.1. Overview of sampling point

Four different samples were taken from company 'X' sewage treatment plant as in Fig. 1. Distance between the sewage treatment plant and the nearest residential area is approximately 10 meters while

* Corresponding Author.

the drainage that transports the effluent to the nearest river is about five meters away from the corner lot house. Sample was taken at every meter as the total length of the final effluent chamber is about 20 meters.

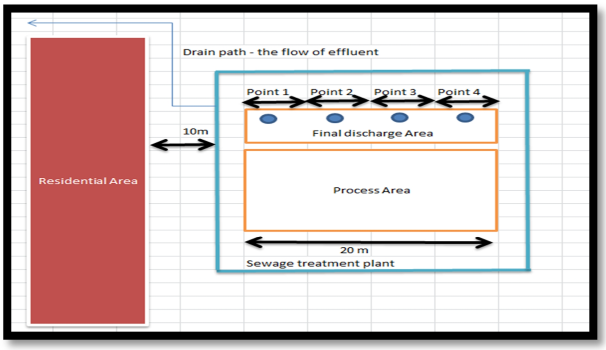


**Fig. 1:** Sampling point and distance of the residential area to the sewage treatment plant

### 3.2. Ammonia concentration and absorbance (analysis from UV spectrometer)

UV Spectrometer was used to measure absorbance and the UV light wavelength wave of a sample. The wavelength that was selected for this studies was with the range of 200nm to 450nm ("Instrument Ownership Data Series."2010). Five calibration samples (10mg/L, 20 mg/L, 30 mg/L, 40 mg/L and 50 mg/L) were prepared and tested including the blank as first level. Based on the highest peak of wavelength for each calibration sample read by the spectrometer, a graph was plotted as a standard graph. This graph will identify the concentration of sewage effluent sample before and after treatment. Fig. 2 shows that at the highest concentration, the absorbance rate is higher than at the lowest concentration of ammonia. Absorbance rate will be higher when organic solution in the sample is high as there are more turbidity and obstacles for UV light to pass through the sample.

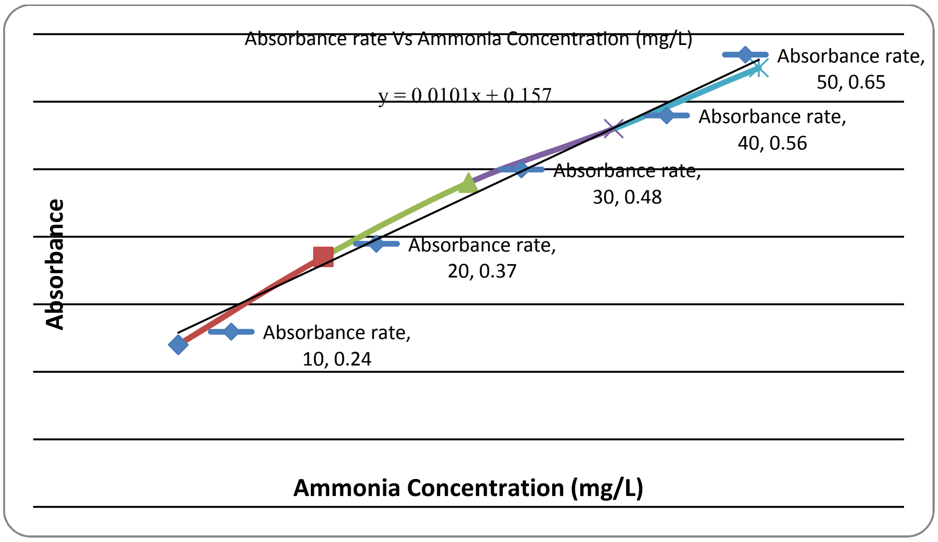


**Fig. 2:** Calibration linearity curve of absorbance Vs ammonia concentration

Based on Fig. 3, point one is the end point of the final effluent chamber where the concentration is slightly lesser. Concentration of ammonia at that point is lesser compared to point four because there are minor dilution. As the final effluent chamber is approximately 30m3 with 20 meter length, the existing effluent will always be mixed with the new final effluent discharged to the final chamber. From the above graph, as the wavelength increases, the absorbance rate becomes lower. Absorbance of a sample will be proportional to the number of absorbing molecules which are ammonia. Usually wavelength below 200nm will not be able to be detected it is not stable below that point. Initial absorbance at 433nm before treatment is 0.06 absorbance rate while after treatment is 0.03 of absorbance rate. This show about 59% of absorbance rate for after treatment.

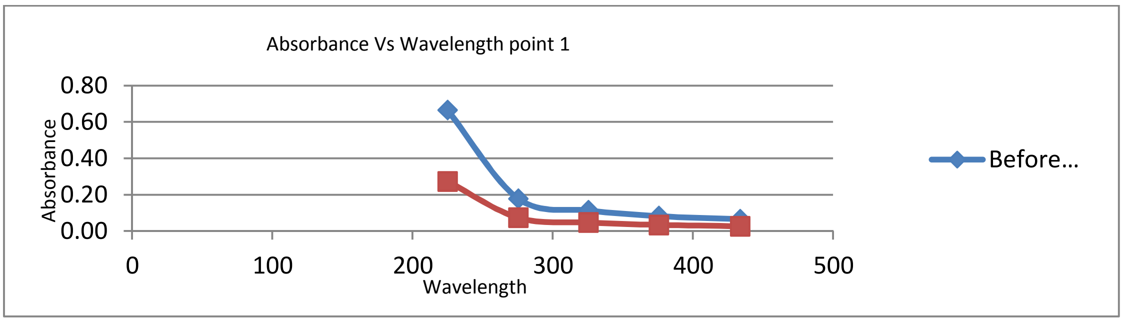


**Fig. 3:** Adsorbent Vs Wavelength for point one

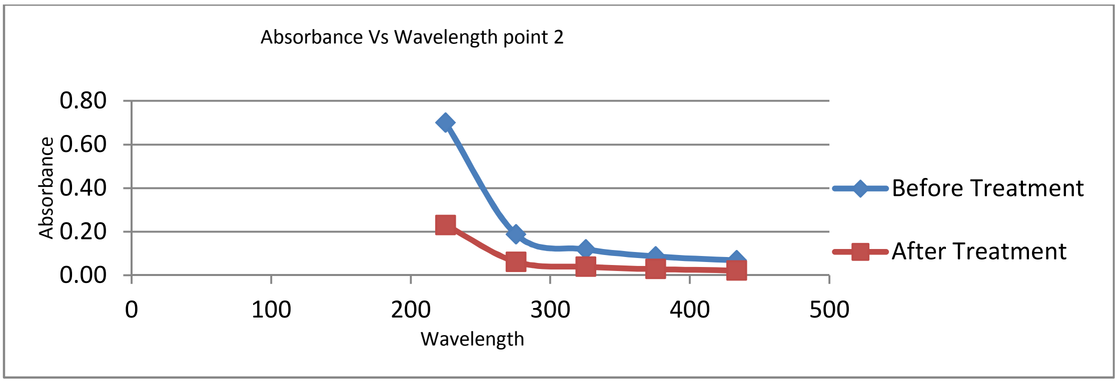


**Fig. 4:** Adsorbent Vs Wavelength for point two

Fig. 4 shows that the absorbance rate of sample at point two. Comparing graph from sample point one and two, the absorbance rate is higher at sample point two with 14.8% of different. At higher concentration of ammonia in form of nitrogen atoms, the absorbance is lower as there are more molecules of nitrogen to be absorbed by UV light. At 433nm the absorbance rate is 0.07 before treatment using magnetic biochar while 0.02 of absorbance rate for after treatment. While at 225nm the absorbance rate is at 0.70 before treatment and 0.23 after treatment. This shows about 60% of absorbance rate for after treatment. This shows a good absorbance rate, as the concentration of ammonia becomes lesser, the absorbance rate decreases as well.

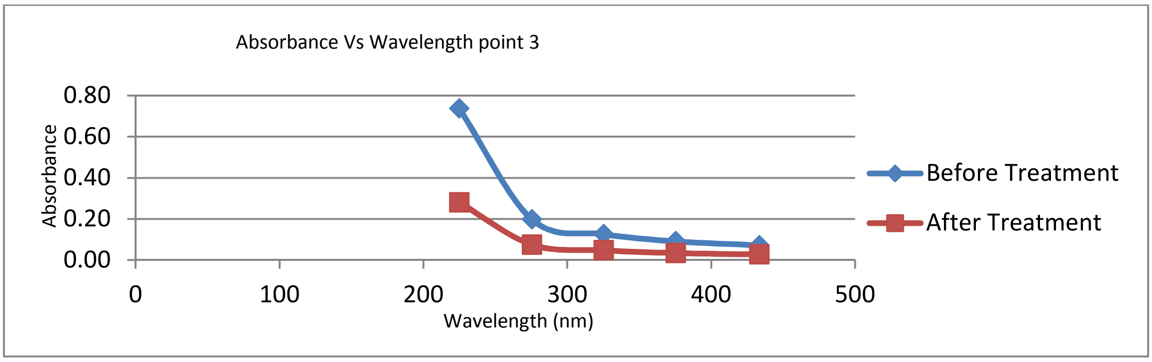


**Fig. 5:** Adsorbent Vs wavelength point three

Fig. 5 shows the absorbance rate of the third sample point, from sample point one and two; the difference of absorbance rate at 225nm is approximately 17%. At 433nm the absorbance rate for before treatment is at 0.07 while after treatment is above 0.03. While at 325nm absorbance rate before treatment is 0.13 while after treatment is 0.05. The percentage different is 62%. Once wavelength reach 333nm, the absorbance rate remains constant where the UV could not detect any interaction between UV light and sample. The ultraviolet electronic absorption is caused by the interaction of light with electrons in the valence band of the ammonia molecule (Burton et al., 1993).

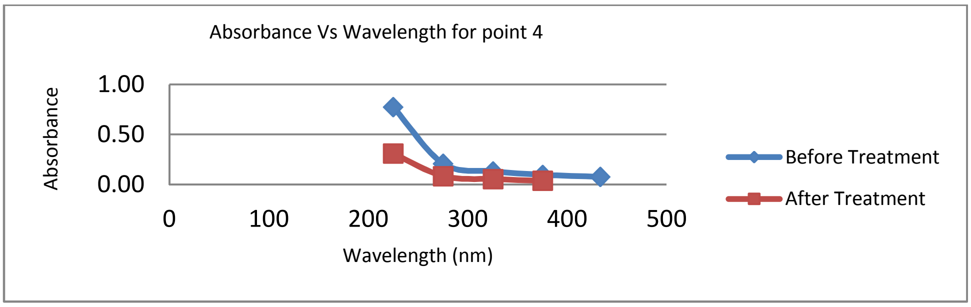


**Fig. 6:** Adsorbent Vs wavelength point four

Fig. 6 shows the sample point number four which is the nearest from the treatment process to final effluent chamber where the mixing to existing effluent is tentatively lesser compared to the other sample point especially sample point four. From the graph it can be interpreted that absorbance rate of before and after treatment is about 60%. At 225nm, the absorbance rate for before treatment and after treatment is 0.77 and 0.31 respectively. While at 433nm, absorbance rate before treatment is 0.08

and 0.03 for after treatment. Comparing absorbance rate for sample one and sample four, the percentage difference of absorbance is about 12.9%. Absorbance rate is at the highest peak for sample point four as that is where ammonia is most concentrated. Magnetic biochar has exhibit as a good adsorbent for the removal of ammonia in sewage wastewater. Smaller particles of magnetic with larger surface area exhibit better sorption capacity compared to smaller surface area (Zheng et al., 2010)

### 3.3. Analysis of dispersion rate for before and after ammonia removal treatment

Based on Fig. 4.2, Calibration linearity curve of Absorbance Vs Ammonia Concentration, concentration of ammonia before and after treatment can be determined. Based on the equation generated from the linear graph, ammonia concentration is identified. Using these concentrations of ammonia in mg/L, PHAST software can develop a dispersion report based on the wind speed. Since company "X" is located at Shah Alam the wind speed is at 3.13 m/s. Based on the area wind stability, neutral – little sun and wind or overcast/windy night.

Equation from Fig. 3 as below:

$$y = 0.0101x + 0.157 \quad (1)$$

$$x = (y - 0.157)/0.0101 \quad (2)$$

Where,

x= Concentration of ammonia (mg/L)

y= Absorbance

**Table 1:** Average concentration result of sample point one till sample point four

| Sample Point | Before Treatment (mg/L) | After Treatment (mg/L) | Removal Percentage |
|---|---|---|---|
| One | 32.98 | 12.78 | 61.25 |
| Two | 31.78 | 12.33 | 61.20 |
| Three | 30.35 | 12 | 60.46 |
| Four | 29.83 | 11.28 | 62.19 |

At one sample point, four samples were collected and the average of the four samples at one point is tabulated at table 1. Four samples for each sampling point were collected for accuracy purposes, thus an average reading will be calculated. Based on the tables above, it is observed that at sample point one, concentration of ammonia is lesser by average of 26% to sample point four.

Concentration of ammonia at sample point four is the highest at it is the most concentrated point of 32.98 mg/L while the lowest is at sample point one with 29.83 mg/L. Percentage different for sample point one, two, three and four are 61.25%, 61.20%, 60.46% and 62.19% respectively. The endotherm city of Ammonia ion (ammonium), it requires 4+ energy to break off the hydro bonding and higher surface sorption of ammonia molecules (Reddy et al., 2012). Magnetic biochar will condensed its macromolecular structure because of its aromatic composition. Thus, for biochar in the removal of ammonia or ammonium ions ($NH_4^+$) are more suitable environmentally. Sorption of ammonium ion is considered higher compared to any other organic compound due to its chemical interaction of physical sorption (Zeng et al., 2013)

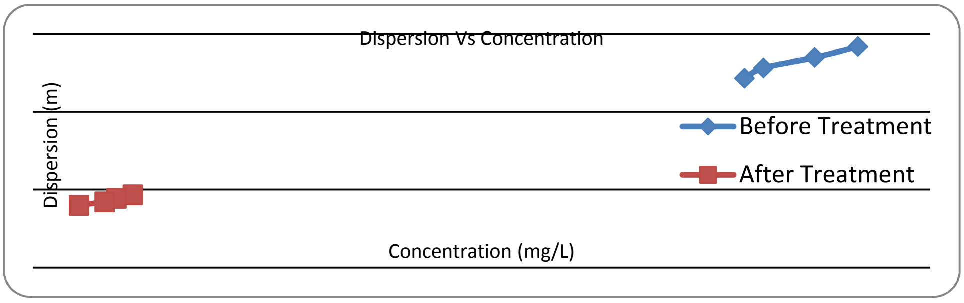


**Fig. 7:** Before and after treatment - dispersion vs ammonia concentration.

Fig. 7 shows the ammonia dispersion for both before and after treatment. Before treatment at higher concentration, dispersion reaches up to 5.67 meters at ammonia concentration of 32.98 mg/L. Even at the furthest sampling point one at 29.83 mg/L of ammonia, the dispersion is approximately at 4.86 meters. The distance of end point of the final effluent chamber to the nearest residential area is approximately 10meters. Within the 10 meters distance, children and by passer frequently uses the area.

This is a complete hazard to every living being that passes by the area. This could lead to acute and chronic diseases from the exposure of ammonia. The residences are bared to prolong exposure of ammonia. Since the chronic and acute limit are different for adults and infants, the hazard and danger are higher for infants.

**Table 2:** Dispersion data for before and after treatment for sample point four to one (Average)

| Sampling Point | Concentration Before Treatment (mg/L) | Dispersion (m) | Concentration After Treatment (mg/L) | Dispersion (m) |
|---|---|---|---|---|
| Four | 32.98 | 5.67 | 12.78 | 1.87 |
| Three | 31.78 | 5.39 | 12.33 | 1.78 |
| Two | 30.35 | 5.12 | 12.00 | 1.69 |
| One | 29.83 | 4.86 | 11.28 | 1.50 |

It can be observed that at Table 2, the percentage reduction of dispersion before and after treatment for all the four points in average are within 65% to 67%. Dispersion of ammonia averagely within 3.8 m to 3.36 m for all the sampling point.

### 3.4. Consequence model of contamination of ammonia in sewage wastewater effluent

Using PHAST software, a consequence model using dispersion calculation was generated using excelling file. Since four samples points was chosen along the final effluent chamber, and at each sample point four sample were taken for accuracy purposes. Thus initial sample are 16 and the same initial sample were experimented using magnetic biochar as an adsorbent to reduce the ammonia content in the sample, therefore in total there were 32 samples tested using UV spectrometer for the absorbance rate and PHAST for the dispersion distance. Using the result calculated in PHAST, consequence models at an average reading of all the four sample points were developed.

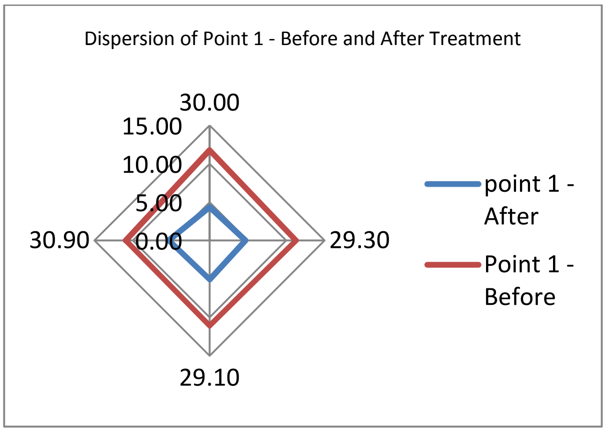


**Fig. 8:** Consequence Model of Dispersion of ammonia before and after treatment for sample point one

From Fig. 8, it can be observed that there is drastic reduction in the dispersion of ammonia to the surrounding vicinity. The red line indicated dispersion distance for before removal of ammonia treatment while the blue indicated after treatment's dispersion distance. The dispersion distance was measured in meters.

Based on Malaysian Sewerage Industrial Guideline (MSIG) report in 2009, sewage effluent discharge should not exceed 20mg/L for ammonia plant that fall under category 1, standard A. From the graph, it can be discussed that the initial concentration of ammonia at sample point one which is the nearest to the residential area has failed to complied. Percentage of excess is about 33 % and the maximum dispersion is 4.37 meters

The nearest residential area is about 10 meters away from the STP but the along the distance, it was observed that residence park their vehicles and used the road as pedestrian walkway. Besides that, children were also observed to play surrounding the area. Therefore, this clearly shows that both adults and children are exposing to hazard of ammonia on daily basic which eventually could lead to chronic ammonia exposure related diseases.

It can be calculated that the after removal, the concentration of ammonia reduced up to 61%. From 30.0 mg/L reduced up 11.80 mg/L, meaning the effluent have comply to the standard requirement by MSIG and advance of 41%. This also shows that the dispersion of ammonia has reduced from 4.37 meters to 1.44 meters where about 67% of dispersion of ammonia has been reduced successfully. It clearly indicated that concentration of ammonia is not at a hazardous or alarming level. The chances of eye irritation, skin burn and pungent odor are very unlikely to happen. At a constant wind speed of 3.12 m/s in Shah Alam, dispersion of ammonia reduces its effect to the environment and human.

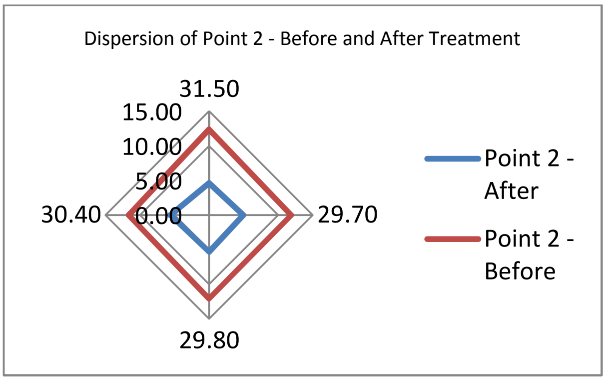


**Fig. 9:** Consequence model of dispersion of ammonia before and after treatment for sample point two

It can be discussed that at sample point two has also failed to comply with the standard regulation based on Malaysian Sewerage Industrial Guideline. Percentage of excess is about 37 % and the maximum dispersion is 5.62 meters. Concentration of ammonia reduced up to 61% after treatment for removal of ammonia using magnetic biochar as an adsorbent. From 32.3 mg/L reduced up 12.40 mg/L, meaning the effluent have comply to the standard equipment by and advance of 38%. This also shows that the dispersion of ammonia has reduced from 5.10 meters to 1.68 meters where about 67% of dispersion of ammonia has been reduced effectively.

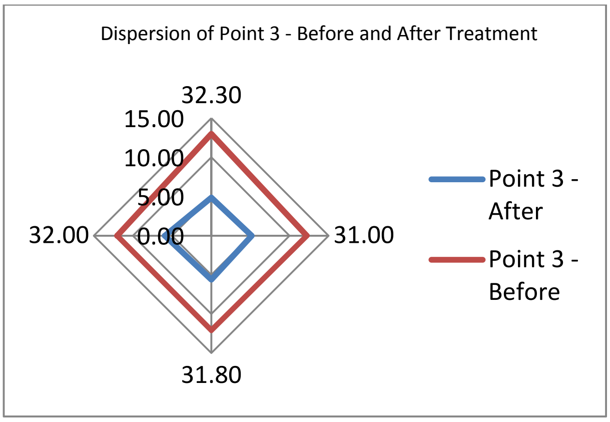


**Fig. 10:** Consequence model of dispersion of ammonia before and after treatment for sample point three

Sample point three has also failed to comply with the standard regulation according to Malaysian Sewerage Industrial Guideline with percentage failure of 38%. The failure percentage also indicates the hazard level to the surrounding vicinity.

Concentration of ammonia reduced up to 59% after treatment for removal of ammonia using magnetic biochar as an adsorbent. From 32.3 mg/L reduced up 13.00 mg/L, meaning the effluent have comply to the standard requirement by and advance of 38%. This also shows that the dispersion of ammonia has reduced from 5.92 meters to 1.95 meters where about 67% of dispersion of ammonia has been reduced effectively. From sample one and two, ammonia concentration at these point is slightly higher because it is nearer to the final effluent chamber.

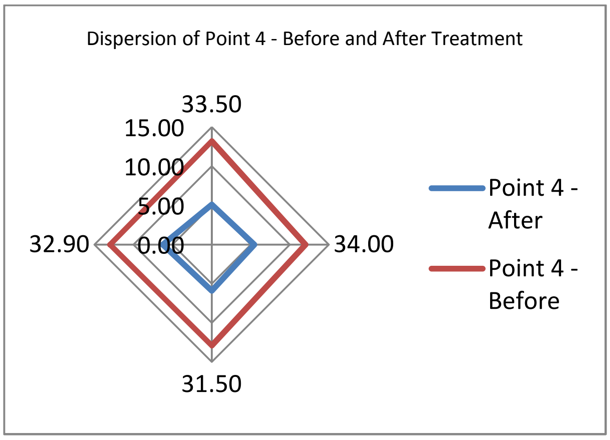


**Fig. 11:** Consequence model of dispersion of ammonia before and after treatment for sample point four

Sample point four is the nearest to process area first point to the final effluent chamber whereby the concentration of ammonia is considerably higher compared to other sample points. Ammonia concentration was at 33.5 mg/L and after removal treatment using magnetic biochar, concentration reduced to 13.2 mg/L with 61% of ammonia being absorbed by the adsorbent.

Ammonia compliance also failed at this with the highest failure percentage of 41%. After removal process, concentration of ammonia is complying with the standard requirement with an excess 34% of success rate.

## 4. Conclusions

As a conclusion, removal of ammonia is crucial for the safety and health of the surrounding residence that lives nearby sewage treatment plant. Besides that, it is also important for the betterment of our future generation and for an improved and sustainable environment. Thus sewage effluent must comply with the standard regulatory that has been set by each country for their discharge point. This study compared four different consequence models that were developed from PHAST software using the result obtained from UV spectrometer for four sample point taken from Company 'X'. Both before treatment and after treatment data were input to generate the consequence model. It can be concluded at 120rpm, 120 minutes and 0.5 grams of adsorbents can remove approximately 67% of ammonia in a 100ml sample. The removal of ammonia using magnetic biochar as an adsorbent with absorbance theory has proven to reduce of ammonia to nearby residences that resides within 10 meter distance to the sewage treatment plant with reduction of 4.12 meter of dispersion distance with approximately 60% of dispersion reduction from all the four sample points.

## 5. Recommendation

Based on the four sample point tested, the best point where the adsorbent can be placed would be at point four which is the nearest point to process area. This is because percentage removal of ammonia is highest at sample point four compared to other sample point. This will reduce the ammonia toxicity dispersion distance. A mixed and a filter must be installed so that agitation of the adsorbent to the effluent can be carried properly and the filter functions to trap the adsorbent so that it will not be discharged to the final discharge point.

The optimization parameters ranged in a different span can be used. Increase in agitation time could increase the removal percentage. The magnetic properties of magnetic biochar cause the adsorbent to attach to the magnetic stirrer while the experiment is conducted. Thus magnetic biochar could be produced in less magnetic property but with the same or better efficiency of rem. oval of heavy metal. Higher the removal percentage, higher the reduction of dispersion distance therefore reduces the hazard of ammonia to the surrounding vicinity.

## Acknowledgment

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