International Journal of Engineering & Technology, 7 (3.23) (2018) 45-48

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Characterization of Car Wash Wastewater from Manually dispersed, Snow and Auto Car Wash Stations

Muhammad Shahrul Shafendy Bin Ibrahim[1*], Nor Haslina Hashim[1]

[1] *Department of Civil Engineering, Faculty of Engineering Technology.*
Corresponding author E-mail: msshafendy2@gmail.com

Abstract

Although commonly perceived lightly in the eye of public, car wash wastewater should be taken more seriously as they have the tendency to be harmful and toxic not only towards the environment, but also humans. In this study, car wash wastewater samples were taken from three stations in Johor with different cleaning methods; manually-dispersed car wash (MCW), snow car wash (SCW) and auto car wash (ACW). At each station, samples were taken during the initial rinsing (IR), and final rinsing (FR) of the vehicles. The samples taken were analyzed for its pH, chemical oxygen demand (COD), biological oxygen demand (BOD), oil and grease (O&G), total suspended solids (TSS), anions (anionic surfactant, nitrate, sulphate, chloride, fluoride, orthophosphate) and heavy metals (iron, zinc, magnesium, chromium, manganese, copper, lead, silver). The results obtained shows that there appears to be no specific pattern to differentiate between the IR and FR samples due to the different washing methods, chemicals and equipment used. The level of contamination of the car wash wastewater was SCW>MCW>ACW. Overall, the result shows that some of the samples did not pass the standard discharge limit; pH, COD, BOD, O&G, TSS, AS and Fe. This shows that car wash wastewater produced in the cleaning activities should be given more concern and need to be treated before being released to the water body.

Keywords: *Car wash wastewater, organic contaminants, anions, heavy metals*.

1. Introduction

Nowadays, transportation is being a compulsory need for most people for professional and personal usage. In Malaysia, it was reported that overall sales of the entire vehicle in the first half of 2012 (January to June) is 301224 units and is expected to reach a new record of 615000 units by the end of 2012, compared to 605,156 units and 600,123 units in 2010 and 2011, respectively. This resulted in increased of car wash service center. Car wash stations has been one of the many uprising service abundance in every cities [1].

Moreover, based on a summary done by the Malaysia Automotive Info, the total of new passenger and commercial vehicles registered in Malaysia in 2015 was 666,674, while on 2016, the amount decreased to 580,124 (MAA, 2017). Though the amount decreases, the number of cars on the road is still so abundant. These cars will need to be cleaned from time to time for the convenience of the user. This resulted in the increased of car wash station in both rural and developed area.]

The car wash industry uses huge amount of water during the cleaning process. An average of 100 gallons of fresh water was used to wash a car based on a case study done at Kuwait (2007). The usage of various chemical agents for cleaning and appealing efforts also contributes to deterioration of the environment. After the cleaning process, large quantities of derivatives are discharged into aquatic and terrestrial environments [2]. Car wash activities leave behind degreasers, surfactants and other chemicals [3]. It is generally perceived by public that car wash wastewater is not severely contaminated compared to other industrial wastewaters. However, studies done on car wash wastewater by [4][5][6] and others show high COD, BOD, oil and grease, anionic surfactants, solids and heavy metals concentrations than the permitted value. The contaminants that were found in car wash wastewater and their treatments are discussed in the sections below.

Car wash stations can be differentiated based on the method of washing applied at the service center. In general, car wash station can be classified based on the way the soap was applied onto the vehicles; manually dispersed, snow and auto. For manually dispersed washing method, it required full labour intensive cleaning with desired amount of surfactant being along with buckets of water. While for snow foam washing method, the cleaning process uses high amount of foamed surfactants [7]. Overall, the study will focus on the characterization of samples taken from each different samples and classifying it based on their contamination level.

2. Methodology

2.1. Car Wash Wastewater Sampling

The car wash wastewater was taken from 3 different sites in Johor, from a manually-dispersed car wash (MCW) station, a snow car wash (SCW) station, and an auto car wash (ACW) station. The wastewater samples were taken during initial rinsing (labelled as IR) and final rinsing (labelled as FR) of the cleaning process for each sites (n=8) at their respective drains. IR sample were taken during the vehicles were sprayed with water before washing process, while the FR sample were taken after the vehicles applied with soap and then rinsed, removing the soap and impurities [7]. The wastewater produced during the cleaning process were let flowing through the drain around a minute to ensure exact samples

Copyright © 2018 Authors. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

of IR and FR were taken. Around 5.0 liters of each sample, which were formed through at least three washing of cars, were collected into polyethylene container (5.0 L), so that the composite samples collected represents the washing stages of IR and FR. The samples taken were then stored in the refrigerator at 4 ^{0}C and preserved accordingly based on (APHA, 2012) before being analyzed.

2.2. Data Collections and Analysis

Samples taken were analyzed for the pH value, chemical oxygen demand (COD), biological oxygen demand (BOD), oil and grease (O&G), total suspended solids (TSS), anionic surfactant (AS), nitrate (NO_3^-), sulphate $S0_4^-$), chloride (Cl^-), fluoride (F^-), orthophosphate (PO_4^{3-}), iron (Fe), zinc (Zn), magnesium (Mg), chromium (Cr), manganese (Mn), copper (Cu), lead (Pb), and silver (Ag). The analysis were done accordingly to APHA, 2012 and by using high-end instruments; UV-Vis Spectrophotometer, ICP-MS and Dionex ICS-2000 Ion-Chromatography.

3. Results and Discussions

The samples taken from MCW, SCW and ACW stations, both IR and FR stages were collected and analyzed for their organic contaminants concentration, anions concentrations and heavy metals concentration. Their level of contamination and possible hazard causes were also described briefly.

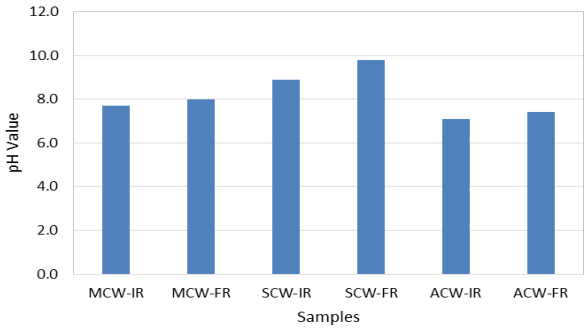

Fig. 1: pH value of IR and FR samples for MCW, SCW and ACW stations

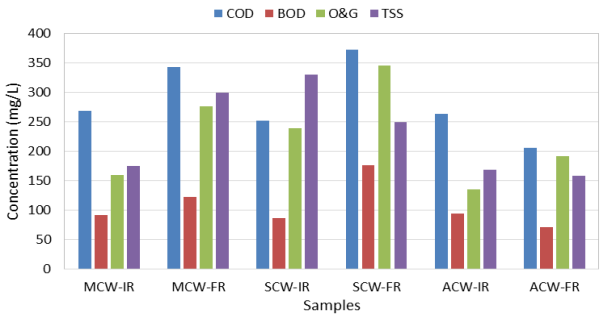

Fig. 2: Concentration of organic contaminants of IR and FR samples for MCW, SCW and ACW stations

Figure 1 shows the pH value of IR and FR samples for MCW, SCW and ACW stations. Apparently, the pH value of all samples appear to be slightly alkaline. This is due to the application of surfactants, which exhibits alkaline properties. However, the samples from SCW-FR seems to be slightly higher as compared to the others, which was at the average of pH 9.8 ± 0.04. Moreover, the samples of FR appear to be slightly higher, due to the application of surfactant at this stage. On the other hand, the sample of SCW-IR was observed to be alkaline though no soap was applied at this stage. This might be due to the excess use of surfactant at SCW station, which uses the foaming machine which can result in abundance of surfactant presence, even at the IR stage.

Meanwhile, Figure 2 shows the concentration of organic contaminants of IR and FR samples for MCW, SCW and ACW stations. In general, COD and BOD concentration in car wash wastewater can come from various sources; their solids, surfactant, oil and grease and other matters washed off the vehicles during the cleaning activities. Based on the findings, COD and BOD concentration were found to be increasing from IR to FR samples at MCW and SCW stations but decreasing for ACW stations. This might be due to the huge volume of water used at ACW station as compared to the MCW and SCW stations. The highest COD concentration was from SCW-FR sample, observed to be at 371.6 ± 75.1 mg/L, and the value appears comparable to a study which also operated in Johor, at concentration COD of 337.33 ± 101.55 mg/L [8].

Furthermore, the concentration of O&G was observed to increase from IR to FR at all three stations. This might be due to the effectiveness of the soap and degreasers applied at the washing stage, thus resulting in increased O&G concentration. O&G in car wash wastewater can also come from any of the petroleum products (hydraulic fluid and motor oil which leaked from the braking system and engine) on the surface of vehicle or leaking from the engine [4][9]. The highest O&G concentration was observed at 344.5 ± 43.8 mg/L from SCW-FR.

Moreover, the TSS concentration shows different pattern from IR to FR at all three stations. At the MCW station, the TSS concentration increased at the FR stage, as the impurities are properly removed from the vehicle's surface with the application of soaps. Meanwhile, the TSS concentration of IR samples at SCW station was higher than at FR stage. This might be due to the usage of water jet pump that shoots very high pressure water at the vehicles that causes more solids to be removed at the IR stage, thus causing the TSS concentration at IR to be higher than at FR stage. While, the TSS concentration at ACW station appears to be almost the same, as there was no clear difference between the samples taken at IR and FR stages. This might be due to the huge amount of water used at this station, thus making it harder to differentiate the samples. The highest TSS concentration found was at 329.2 ± 165.1 mg/L from SCW-IR, which appeared to be comparable to the result obtained from a study in Malaysia, at concentration of 325 mg/L [7].

In general, car wash wastewater produced may contain various organic content. EPA 1995 shows concern on the TSS, pH, O&G, organics, COD, chlorinated solvents, detergents, lubricants and additives [7, 15]. Moreover, the National Water Research Institute (NWRI) of Environment Canada in a study on a highway runoff toxicity found many of the same chemicals discovered in car wash wastewater [10]. Organic contaminants can affect the environment in various ways, especially O&G. O&G can adversely affect water transparency and dissolved oxygen in the water [11]. In addition, the composition of O&G is very complex as it may contain lots of hazardous materials such as benzene, lead, zinc, chromium, arsenic, pesticides, nitrates, phenols, polyaromatic hydrocarbons and other metals in different unit of concentration which are carcinogenic to human beings [4][12][13].

To conclude, all the organic contaminants found in the samples appears to be off the standard discharge limit in the industrial effluents of Standard B. For the pH value, the permitted limit is 5.5-9.0. However, for sample SCW-FR, the mean value is 9.8 ± 0.01, slightly exceeding the limit. On the other hand, the standard limit for COD is 200 mg/L. However, all the samples exceed the standard discharge limit for COD. Moreover, all samples failed to pass the permitted value for BOD, 40 mg/L. Besides that, all samples also exceeded the discharge limit for solids and O&G, with limits of 100 mg/L and 10 mg/L respectively.

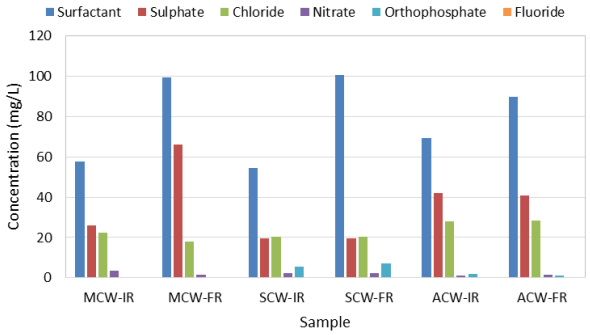

Fig. 3: Concentration of anions found in IR and FR samples from MCW, SCW and ACW stations

Apart from organic contaminants, there are also anions contaminants. Although some anions are highly associated with useful nutrients, some can be toxic towards the environment and human. Figure 3 shows the concentration of anions found in IR and FR samples from MCW, SCW and ACW stations.

Overall, the concentration of AS appears to be the highest as compared to other anions. The highest AS concentration was found to be at 100.6 ± 35 mg/L, from SCW-FR, which was twice the concentration found in another study in Malaysia with AS concentration of 54 mg/L [7]. Moreover, the concentration of AS observed to increase at FR stage while there seems to be not much of difference in values for sulphate, chloride, nitrate, orthophosphate and fluoride ions. However, the concentration of sulphate from MCW station was observed to increase at FR stage. This might be due to the use of sulphate-based soap at this station, thus increasing the sulphate concentration.

Moreover, the concentration of orthophosphate appears to be higher at SCW and ACW stations. This might be due to the use of phosphate-based soap at these stations as the polyphosphate is commonly used as a complexing agent in some detergents (around 18%, by weight) [14]. Other than that, the concentration of sulphate, chloride, nitrate, orthophosphate and fluoride ions can also be affected by the nutrients found in solid soils. As discussed, the TSS concentration of samples from MCW station at FR stage increased as compared to the IR samples, which can contribute to the increase of sulphate concentration.

In Malaysia, other than fluoride, there seems to be no regulations on discharge limit industrially on the other anions that was found in this study. The fluoride discharge limit according to the Malaysia Environmental Act 2009 should not exceed 5.0 mg/L (Standard B). The samples collected and analyzed in this study appear to pass the regulated standard. In the case for anionic surfactant, our neighbour country, Singapore has a regulations on it, with a discharge limit of 15 mg/L (watercourse), and 5 mg/L (controlled watercourse). Moreover, there are also discharge limit for AS following the environmental Latin America regulations; involving Chile (7.0 mg/L), Argentina (5.0 mg/L), Colombia (10 mg/L), Venezuela (8.0 mg/L), Paraguay (5.0 mg/L) and Croatia (10.0 mg/L). Overall, the concentration of AS found in this study appears to be off the discharge limit, thus, are potentially hazardous towards the environment.

Generally, nitrate is a contaminant that can easily dissolved in surface and ground water is becoming one of the major components of polluting ground water due to potential threat to environmental and public health [15]. Moreover, nitrate accumulation and its management is a recurrent problem in recirculating aquatic ecosystem. On the other hand, trace amount of phosphorus in lakes, bays, coastal areas, and inland seas can cause eutrophication of natural waters. This issue has become one of the most worrisome environmental problems worldwide [16]. The World Health Organization (WHO) suggested a minimum discharge limit of phosphorus of 0.5-1.0 mg/L and has been applied in many countries and regions[17]. The concentration of orthophosphates from SCW and ACW stations in this study appears to be higher than the discharge limit from WHO. In addition, anionic surfactant will destroy mucus membrane and gills of fishes to some degree. The gills may lose its natural oils, thus, interrupting oxygen transfer [18]. Furthermore, surfactant can also affect human directly. According to a cytoxicity test, the cytoxicity order of surfactants determined on rabbit corneal epithelial cells was cationic>anionic=amphoteric>non-ionic. On the other hand, at high concentration, sulphate can be a base of catharsis, dehydration and gastrointestinal irritation [19].

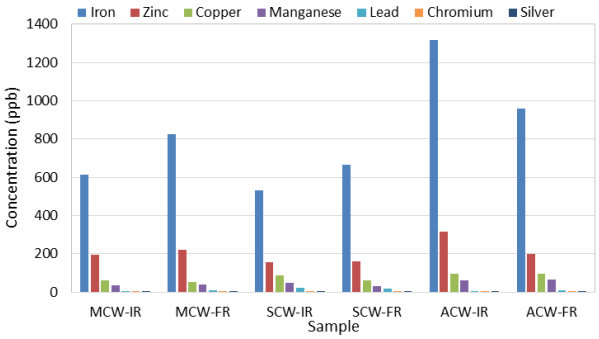

Fig. 4: The concentration of the heavy metals in wastewater from MCW, SCW, and ACW stations.

Other than organic and anions pollutants, there are also heavy metals existing in the car wash wastewater. Although some of the samples concentration of the heavy metals found were as low parts per billion (ppb), some has exceeded the standard discharge limit. Figure 4 shows the concentration of the heavy metals in wastewater from MCW, SCW, and ACW stations.

EPA 1999 has already take note on the concentration of heavy metals produced from car wash activities. Some parameters are observed to exceed the discharge limit, such as antimony, arsenic, beryllium, cadmium, lead, thallium, aluminum, pH, iron and manganese [3]. Thus, the concentration of heavy metals was also monitored in this study. Overall, it was observed that the concentration of iron was far greater for all samples as compared to other heavy metals. There was also a findings which shows that the highest concentration of heavy metals found in car wash wastewater was also iron [20]. Iron found in car wash wastewater can come from the metal parts of the car that dissipated within time. Iron is commonly used as materials for engines manufacturing due to its high strength and low cost [21]. Next, zinc metals were found to be the second highest heavy metals found in all the samples collected, while the concentration of silver, copper, lead, chromium and manganese metals were found although it appeared to be very low. The heavy metals found in car wash wastewater should follow the industrial standard discharge limit by the Environmental Quality Act Malaysia 2009. All the samples analyzed in this study appeared to pass the standard discharge limit of the heavy metals, except for iron. The standard discharge limit of iron is 1000 ppb (Standard B). However, the average iron concentration found in ACW-IR was at 1316.6 ± 495.4 ppb, thus making the wastewater unfit to be released before being treated.

Heavy metals such as lead, cadmium, chromium, nickel, zinc, copper and iron are commonly present in industrial wastewater, and they are not biodegradable and their existence in receiving lakes and streams causes bioaccumulation in living organisms, which leads to several health problems in animals, plants and human beings such as cancer, kidney failure, metabolic acidosis, oral ulcer, renal failure and damage in stomach for the rodent [22]. Moreover, manganese can induce iron deficiency in some algae which can lead to inhibition of chlorophyll synthesis and increased the high risks to the ecosystem [23]. Furthermore, lead discharge into aqua-environment tend to bio-accumulate and excessive con-

centration of lead are linked with various diseases in humans and animals [24]. In addition, excessive intake of copper leads to severe muscle irritation and corrosion, widespread capillary damage, hepatic and renal damage, and central nervous system irritation followed by depression [25].

4. Conclusion

The car wash wastewater obtained from three car wash stations with different cleaning processes were analysed with parameters of COD, BOD, O&G, TSS, AS, NO_3^-, $S0_4^-$, Cl^-, F^-, PO_4^{3-}, Fe, Zn, Mg, Cr, Mn, Cu, Pb and Ag. The level of contamination of the wastewater can be represented by SCW>MCW>ACW, as the concentration of pollutants in SCW appears to be slightly higher than those of MCW and ACW. It was observed that the pH, COD, BOD, TSS, O&G, AS and Fe concentration of some of the samples were found to exceed the permissible limit as permitted by the Environmental Quality Act 2009. This shows that, though appears tame, car wash wastewater deserves to be given equivalent attention as compared to other industrial wastewater released to the water body. Proper treatment of the wastewater produced should be applied to assure the wastewater released are safe and thus conserving the environmental quality for the better future of all beings.

Acknowledgement

This work is funded by the Ministry of Higher Education of Malaysia under the Fundamental Research Grant Scheme (FRGS) Vot. No. : 1565.

References

[1] Bhatti, Z. A., Mahmood, Q., Raja, I. A., Malik, A. H., Khan, M. S., and Wu, D. Chemical oxidation of carwash industry wastewater as an effort to decrease water pollution. *Physical Chemistry Earth*, Volume 36, no. 9–11, (2011) pp. 465–469.

[2] Shahbazi R., Kasra-Kermanshahi, R., Gharavi, S., Moosavi- Nejad, Z., and Borzooee, F. Screening of SDS-degrading bacteria from car wash wastewater and study of the alkylsulfatase enzyme activity. *Iranian Journal of Microbiology*, Volume 5, no. 2, (2013), pp. 153–158.

[3] Oknich, J. The Perceived Environmental Impact of Car Washing. *Ramsey-Washington Metro Watershed District*, (2002).

[4] Lau, W. J., Ismail, A. F., and Firdaus, S. Car wash industry in Malaysia: Treatment of car wash effluent using ultrafiltration and nanofiltration membranes. *Separation and Purification Technology*, Volume 104, (2013), pp. 26–31.

[5] Yasin, S., Iqbal, T., Arshad, Z., Rustam, M., and Zafar, M. Environmental Pollution From Automobile Vehicle Service Stations. Volume 8, no. I, (2012), pp. 61–70.

[6] Kiran, S. A., Arthanareeswaran, G., Thuyavan, Y. L., and Ismail, A. F. Influence of bentonite in polymer membranes for effective treatment of car wash effluent to protect the ecosystem. *Ecotoxicology Environment Saf.*, (2015), pp. 1–7.

[7] Hashim, N. H. Pollutants Characterization of Car Wash Wastewater. Volume 8, (2016), pp. 4–9.

[8] Maya Saphira Radin Mohamed R., Mariam Ibrahim Kutty, N. A., and Hashim Mohd Kassim, A.. Efficiency of Using Commercial and Natural Coagulants in Treating Car Wash Wastewater Treatment. *Australian Journal of Basic Applcation Science*, Volume 8, no. 816, (2014), pp. 227–234.

[9] Jönsson, C. and Jönsson, A.S. The influence of degreasing agents used at car washes on the performance of ultrafiltration membranes. *Desalination*, Volume 100, no. 1–3, (1995), pp. 115–123.

[10] Mayer, T. Environmental characterization of surface runoff from three highway sites in Southern Ontario , Canada : 2. *Toxicology*, (2011), pp. 121–136.

[11] Foo, K. Y. and Hameed, B. H. Decontamination of textile wastewater via TiO2/activated carbon composite materials. *Advanced Colloid Interface Science*, Volume 159, no. 2, (2010), pp. 130–143.

[12] Kwach, B. O. and Lalah, J. O. High concentrations of polycyclic aromatic hydrocarbons found in water and sediments of car wash and kisat areas of Winam Gulf, Lake Victoria-Kenya. *Bull. Environmental Contamination Toxicology*, Volume 83, no. 5, (2009), pp. 727–733.

[13] Wu, L., Ge, G., and Wan, J. Biodegradation of oil wastewater by free and immobilized Yarrowia lipolytica W29. *Journal of Environmental Science*, Volume 21, no. 2, (2009), pp. 237–242.

[14] Droste, R. L., Theory and Practice of Water and Wastewater Treatment. John Wiley & Sons, Inc., 1997.

[15] Song, H. O., Zhou, Y., Li, A. M., and Mueller, S. Selective removal of nitrate by using a novel macroporous acrylic anion exchange resin. *Chinese Chem. Lett.*, Volume 23, no. 5, (2012), pp. 603–606.

[16] Awual, M. R. and Jyo, A. Assessing of phosphorus removal by polymeric anion exchangers. *Desalination*, Volume 281, no. 1, (2011), pp. 111–117.

[17] Su, Y., Cui, H., Li, Q., Gao, S., and Shang, J. K. Strong adsorption of phosphate by amorphous zirconium oxide nanoparticles. *Water Resource*, Volume 47, no. 14, (2013), pp. 5018–5026.

[18] Almeida, C. M. V. B., Borges, D., Bonilla, S. H., and Giannetti, B. F. Identifying improvements in water management of bus-washing stations in Brazil. *Resource Conserv. Recycle*, Volume 54, no. 11, (2010), pp. 821–831.

[19] Gordon, B., Callan, P., and Vickers, C. WHO guidelines for drinking-water quality. *WHO Chron.*, Volume 38, no. 3, (2008), pp. 564.

[20] Abagale, P. T., Sarpong, F. K., Ojediran, D. A., Osei-Agyemang, Shaibu, J. O., R. and Birteeb, A. G. Heavy Metal Concentration In Wastewater From Car Washing Bays Used For Agriculture In The Tamale Metropolis, Ghana. *Int. Journal of Curr. Res.*, Volume 5, no. 6, (2013), pp. 1571–1576.

[21] Nguyen, H. Manufacturing Processes and Engineering Materials Used in Automotive Engine Block. *Material Science Engineering Sect. B, EGR250*, (2005), pp. 11–23, 2005.

[22] Argun, M. E., Dursun, S., Ozdemir, C., and Karatas, M. Heavy metal adsorption by modified oak sawdust: Thermodynamics and kinetics. *Journal of Hazardous Materials*, Volume 141, no. 1, (2007), pp. 77–85.

[23] Al-Odwani, A., Ahmed, M., and Bou-Hamad, S. Carwash water reclamation in Kuwait. *Desalination*, Volume 206, no. 1–3, (2007), pp. 17–28.

[24] Issabayeva, G., Aroua, M. K., and Sulaiman, N. M. Continuous adsorption of lead ions in a column packed with palm shell activated carbon. *Journal of Hazardous Materials*, Volume 155, no. 1–2, (2008), pp. 109–113.

[25] Ajmal, M., Hussain, Khan A., Ahmad, S., and Ahmad, A. Role of sawdust in the removal of copper(II) from industrial wastes. *Water Resource*, Volume 32, no. 10, (1998), pp. 3085–3091.