Malaysian Journal of Chemistry, 2026, Vol. 28(1), 134-141
(Special Issue: *3rd International Conference on Industry-Academia Initiatives in Biotechnology & Chemistry, iCIABC2025*)

Characterization of Wastewater from a Malaysian Cosmetic Manufacturing Industry

Jol Gee Chee and Joo Hui Tay*
Faculty of Industrial Sciences and Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, Lebuhraya Persiaran Tun Khalil Yaakob, 26300 Kuantan, Pahang, Malaysia
*Corresponding author (e-mail: tayjoohui@umpsa.edu.my)

Cosmetic manufacturing generates highly polluting effluents due to the complexity of formulations and the wide range of raw materials used. A pilot study was conducted to investigate the chemical characteristics of wastewater produced by a local cosmetic manufacturing facility in Malaysia. Standard water quality parameters, including temperature, pH, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), ammoniacal-nitrogen (AN), and oil and grease (O&G), were analysed in wastewater collected during the utensil cleaning stage and from drainage systems. Highest levels of COD and BOD were observed in wastewater from the cleaning of utensils used for Hair Tonic production (741 mg/L and 244 mg/L, respectively), followed by Sculpting Lotion (215 mg/L and 82.0 mg/L) and Shampoo (374 mg/L and 145 mg/L). Wastewater samples collected from the drainage system showed significant decline across all measured water quality parameters. These findings provide valuable insights into the characteristics of cosmetic wastewater and highlight the need for effective treatment strategies to minimise the environmental impact associated with cosmetic industrial effluents.

Keywords: Water quality, cosmetic wastewater, COD, hair tonic, Malaysia, industrial effluent

Received: June 2025; Accepted: November 2025

The cosmetic industry in Malaysia is continuously growing, with 338 cosmetic manufacturers currently holding active licenses registered under the National Pharmaceutical Regulatory Agency (NPRA), Malaysia [1]. These manufacturers produce a wide variety of products depending on functionality and customer demand, including facial care items, cleansers, toiletries, body washes, shampoos, and hair dyes. However, the manufacturing processes in this sector generate a large volume of wastewater. Reports had shown that wastewater from the cosmetic industry typically contains a wide range of chemical substances, including fragrances, dyes, preservatives, as well as other organic and inorganic compounds [2, 3].

Cosmetic product wastewater often shows elevated COD and BOD levels, owing to the presence of poorly biodegradable chemicals [4, 5]. Without proper handling and treatment, these compounds can lead to severe environmental pollution. For example, surfactants and oil-based chemicals commonly used in shampoo and body wash production can cause excessive foaming in water bodies and alter water surface tension, substantially impacting marine ecosystems. Emulsifiers and thickening agents, such as carbomers, are also frequently added to cosmetic formulations to adjust viscosity by retaining and absorbing water. However, exposure to these compounds may raise health concerns due to their potential toxicity [6]. Preservatives such as formaldehyde-releasing agents and parabens, although widely used to extend product shelf life, have been proven to be endocrine disruptors, posing risks to both marine and human health [7]. Furthermore, fragrances in some cosmetic products, such as shampoos and cleansers, have been associated with allergies, dermatitis, and respiratory disorders [8]. Growing concerns have emerged over the environmental impact of these effluents, particularly their potential to contaminate water resources and pose risks to both human health and the environment.

Managing wastewater is a paramount environmental challenge with significant impacts for sustainability and public health. To tackle this, detailed chemical analysis of effluents, particularly focusing on their chemical properties and respective concentrations, is essential for designing effective wastewater treatment methods [6]. Although public awareness about environmental protection has grown in recent years, comprehensive investigations into the chemical composition of effluents or wastewater generated at different stages of cosmetic production, especially from small or cottage-scale cosmetic makers whose discharges enter municipal sewers, remain limited. This gap highlights the need for further in-depth scientific investigations to better understand these effluents. Such information is crucial for developing better wastewater management strategies that aim at minimising the environmental impact of cosmetic industry discharges. Therefore, this study was conducted to evaluate the water quality parameters of wastewater generated during the production of

†Paper presented at the 3rd International Conference on Industry-Academia Initiatives in Biotechnology & Chemistry

Shampoo, Hair Tonic, and Sculpting Lotion by a local cosmetic manufacturer in Johor.

EXPERIMENTAL

Sampling

Wastewater sampling was carried out in October 2024 at a local cosmetic manufacturing facility in Tangkak, Johor, categorised as a small and medium enterprise (SME). Sampling was conducted only once in accordance with the manufacturer's production schedule. Wastewater samples were collected using the grab sampling technique during the production of Sculpting Lotion, Hair Tonic, and Shampoo. For each production process, two wastewater samples (1L each) were collected after completion of the production: one from the utensil cleaning area located inside the facility (sampling point 1) and another from the drainage system located outside the facility (sampling point 2) (Figure 1). The samples were stored in high-density polypropylene (HDPE) bottles and transported to the laboratory within four hours in a cooler box.

Characterization Methods

Water quality parameters were analysed using Standard Methods for the Examination of Water and Wastewater by the American Public Health Association (APHA), the HACH method, and the USEPA method, with immediate analysis following sample collection. Temperature and pH were measured in situ. Biological oxygen demand (BOD) and chemical oxygen demand (COD) were determined using the HACH BOD Trak instrument and the HACH DR 5000 Method 8000, respectively. Ammoniacal nitrogen was analysed using an in-house method based on APHA 4500 NH_3-N. Total suspended solids were measured using the gravimetric method, while oil and grease content was determined gravimetrically following EPA Method 1664A.

RESULTS AND DISCUSSION

The characteristics of the investigated wastewater are presented in the following sections. In general, lower values were observed for samples in the drainage systems, indicating sufficient dilution after utensil cleaning. Since the effluent from this facility is not directly discharged into natural water bodies but is instead conveyed through an underground piping system to a wastewater treatment plant serving the industrial zone, Standard B set by the Department of Environment (DOE) Malaysia was chosen as the reference for evaluation of water quality parameters.

Temperature

The wastewater temperatures during utensil cleaning were recorded at 24.0°C for all products and ranged between 23.0°C and 24.3°C across all samples in the drainage system (Figure 2). These consistent temperature values suggest the absence of exothermic reactions during production, indicating that the manufacturing process does not significantly contribute to thermal pollution, as cold blending is employed. All measured values complied with the acceptable threshold of 40.0°C under Standard B. Maintaining lower temperatures is essential, as it supports dissolved oxygen retention and promotes microbial activity essential for biodegradation [9]. Studies have shown that increasing water temperature can lead to dissolved oxygen depletion, which alters species distribution, disrupts aquatic ecosystems, and affects habitat suitability [10]. These findings reinforce the importance of monitoring thermal discharge to prevent ecological disruption [11].

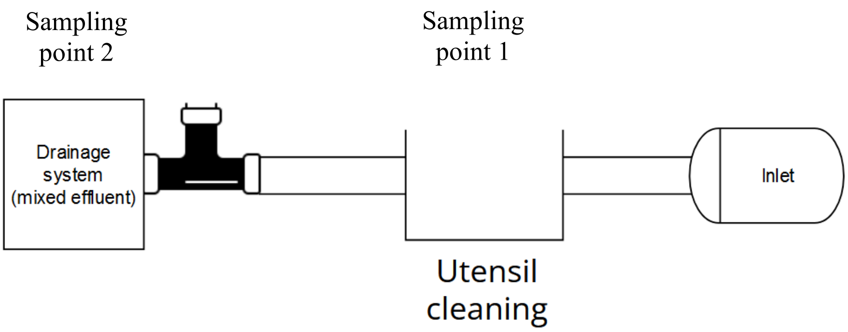

Figure 1. A schematic diagram showing the sampling locations within the cosmetic manufacturing facility.

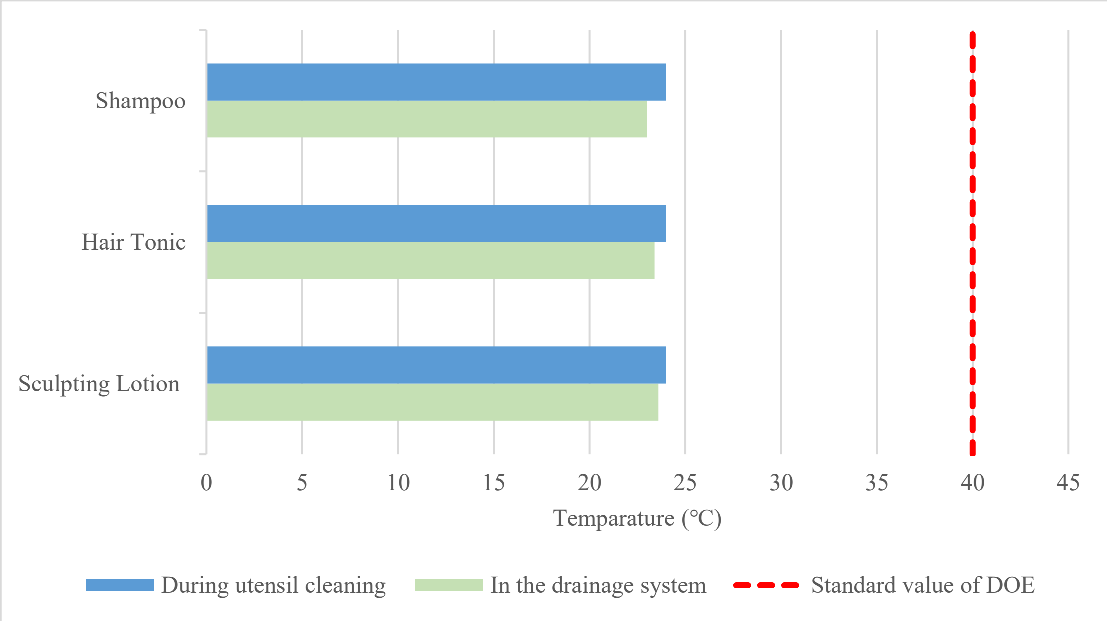

Figure 2. Temperature comparison among wastewater samples collected during the production of Shampoo, Hair Tonic and Sculpting Lotion.

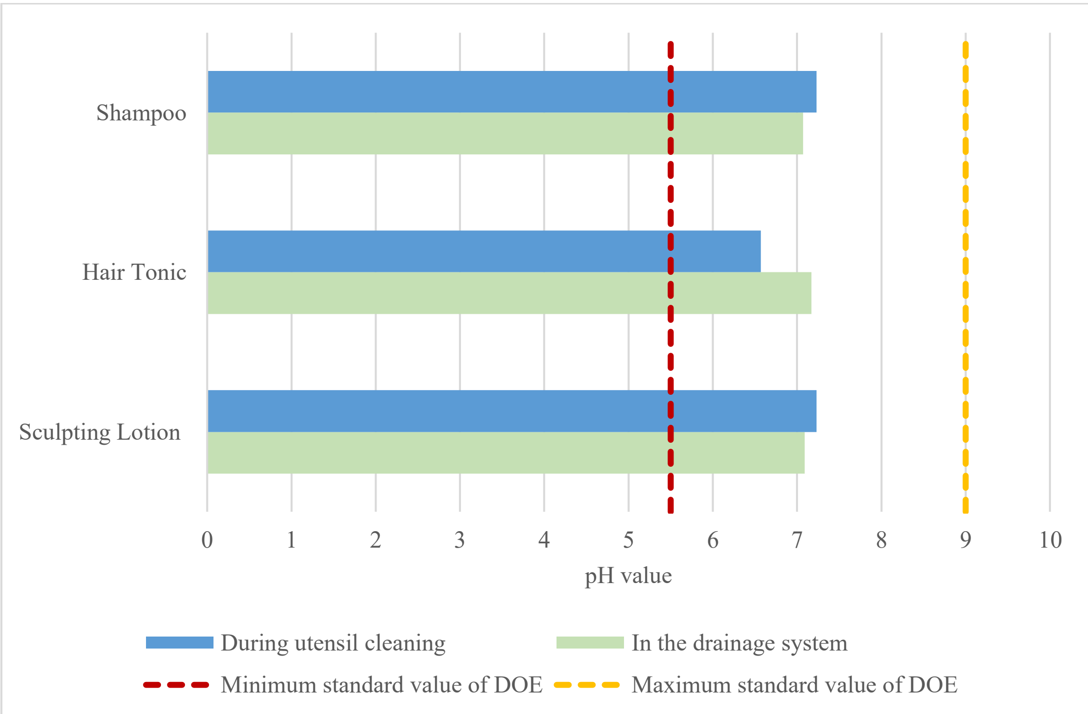

Figure 3. pH for wastewater samples collected from the production of Shampoo, Hair Tonic and Sculpting Lotion.

pH

The pH values of the wastewater samples ranged from 6.57 to 7.23 during utensil cleaning and from 7.07 to 7.17 in the drainage system (Figure 3), remaining within the regulatory range of 5.50 to 9.00 under Standard B of DOE [12]. This suggests that the manufacturing process has a negligible impact on the wastewater's pH, ensuring regulatory compliance and posing minimal risk to receiving water bodies [13]. The slight variations in pH among samples may be influenced by the raw materials used during cosmetic production, such as surfactants and preservatives. Our results fall within the pH range reported for raw wastewater collected from various cosmetic industries in Brazil [4] and Poland [6], but they are slightly higher than those reported in Tunisia (pH between 4.93 and 6.08) [14] and Spain (pH=4.10) [15]. Neutral pH levels are essential for maintaining aquatic ecosystem stability. Moreover, changes in pH can affect chemical solubility, metal toxicity, nutrient abundance, and aquatic organisms, all of which have implications for water treatment strategies.

Biochemical Oxygen Demand

The BOD values in wastewater samples varied significantly, with the highest levels observed in wastewater generated during utensil cleaning from Hair Tonic production (59.0 mg/L), while wastewater from Sculpting Lotion and Shampoo production recorded 34.0 mg/L and 12.0 mg/L, respectively (Figure 4). In the drainage system, the BOD levels decreased to 18 mg/L for Hair Tonic, 20.0 mg/L for Sculpting Lotion, and 8.50 mg/L for Shampoo, meeting DOE's Standard B requirements. Our BOD values are between one and three orders of magnitude lower than those reported in Spain (77.0 mg/L) [15], Brazil (ranging from 198 to 30000 mg/L) [4, 16], Poland (48.0-168 mg/L) [6] and Tunisia (mean value of 1.62×10^3 mg/L) [14], which could be attributed to differences in production scale as well as product type. Cosmetic industry effluents generally contribute to higher BOD and COD levels compared to other industries due to the extensive use of organic chemicals such as surfactants, fragrances, and waxes in product formulation [4]. Elevated BOD levels indicate a substantial organic load that can deplete oxygen levels in aquatic ecosystems, potentially disrupting biodiversity [17].

Chemical Oxygen Demand

COD levels were initially high during the utensil cleaning stage (ranging from 215 to 741 mg/L) but were significantly reduced in the drainage system (82.0 to 244 mg/L) (Figure 5). Wastewater from the Hair Tonic sample slightly exceeded the 200 mg/L threshold under Standard B, indicating a substantial presence of non-biodegradable organic compounds such as surfactants, emulsifiers, and fragrances. However, COD levels for Shampoo and Sculpting Lotion samples complied with the DOE Malaysia's Standard B, suggesting that product-specific formulations play a key role in determining the pollution load of generated effluents. Our COD values are several orders of magnitude lower than those reported in studies from Brazil (ranging from 901 to 49300 mg/L) [4, 5, 16], Poland (758-2120 mg/L) [6], Turkey (9160 mg/L) [18], Spain (21300 mg/L) [15] and Tunisia (13.6×10^3 mg/L) [14], which may be attributed to different production scales, as well as the fact that those studies did not collect wastewater based on specific product types. In general, cosmetic wastewater can exhibit COD levels exceeding 100000 mg/L, significantly higher than those in many other industries, highlighting the importance of proper treatment to ensure water quality [19]. For all the investigated wastewater samples, biological treatment is unlikely to be effective due to the low BOD/COD ratio (Table 1) [6].

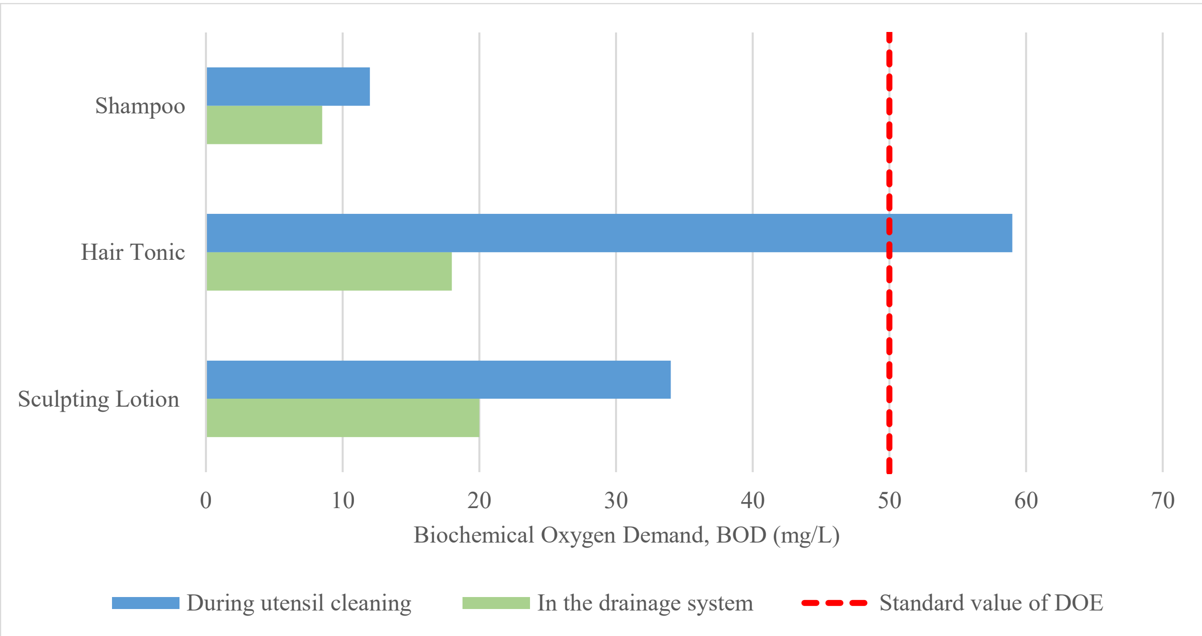

Figure 4. BOD in wastewater samples from the production of Shampoo, Hair Tonic and Sculpting Lotion.

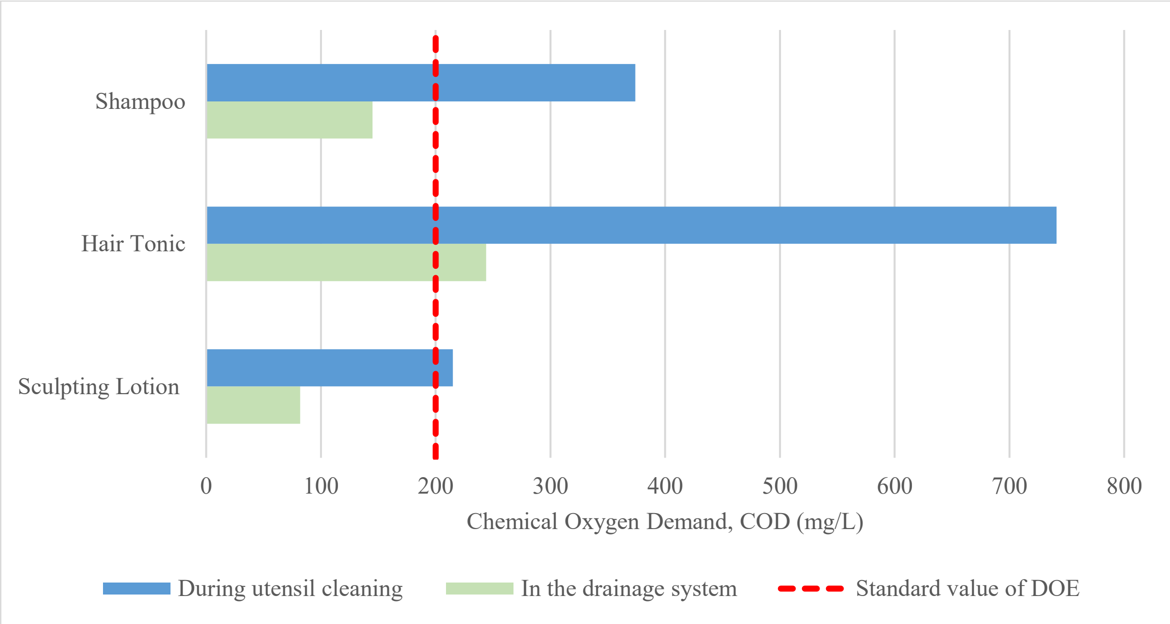

Figure 5. Variation in COD concentrations among wastewater samples collected from the production of Shampoo, Hair Tonic and Sculpting Lotion.

Table 1. BOD/COD ratios of cosmetic wastewater samples.

Parameter	BOD/COD	
	During utensil cleaning	In the drainage system
Sculpting Lotion	0.16	0.24
Hair Tonic	0.08	0.07
Shampoo	0.03	0.06

Total Suspended Solids

TSS concentrations in wastewater collected during utensil cleaning ranged from 10.0 to 108 mg/L. In the drainage system, all samples complied with the acceptable limit of 100 mg/L under Standard B of DOE (Figure 6). Our results fell within the TSS ranges reported in Brazil [4, 16], Spain (167 mg/L) [15] and Poland (129-811 mg/L) [6], but were much lower than those measured in Turkey (3000 mg/L) [18] and Tunisia (2.34 $\times 10^3$ mg/L) [14]. In the cosmetic industry, TSS typically originates from residual raw materials and other substances involved in manufacturing processes. High TSS levels can obstruct sunlight penetration, impairing photosynthesis in aquatic plants and reducing dissolved oxygen levels, contributing to turbidity or water cloudiness, which further affects aquatic ecosystems [20, 21]. TSS may also induce secondary pollution, as contaminants such as heavy metals can adsorb onto suspended solids and later be released into the environment as the solids settle. The application of membrane bioreactors (MBRs) in the cosmetic industry has proven effective in reducing TSS levels, producing high-quality and disinfected effluents [22].

Ammoniacal-Nitrogen

Ammoniacal-nitrogen (AN) levels were below the detection limit (<2.00 mg/L) for all samples except for the Sculpting Lotion wastewater, which recorded 2.60 mg/L during the utensil cleaning stage. This value is well below the 20.0 mg/L threshold under Standard B, suggesting that nitrogen-containing raw materials (such as ammonium-based compounds) are well-regulated during production. In the cosmetic industry, ammonia is commonly used as a raw material for pH adjustment and in the formulation of products such as hair dye, curling solutions, and hair rebonding creams. In hair dye production, ammonia functions as an alkaline agent to raise the pH and open the hair cuticle, facilitating dye penetration. Low AN levels help reduce the risk of eutrophication and algal blooms, which can have detrimental effects on aquatic ecosystems [23]. Excessive ammoniacal nitrogen can also cause odour pollution, resulting in water with an unpleasant odour and smell [24].

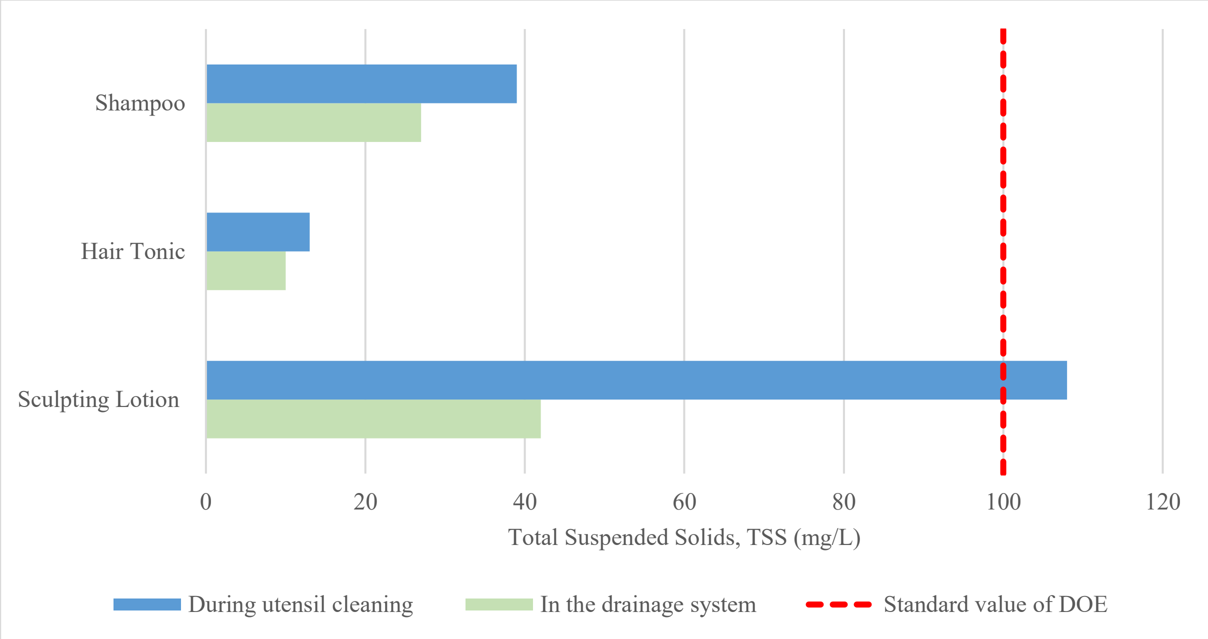

Figure 6. TSS concentrations in wastewater samples collected from the production of Shampoo, Hair Tonic and Sculpting Lotion.

Oil and Grease

Oil and grease (O&G) levels were significantly reduced in the drainage system compared to the utensil cleaning stage, dropping from 36.0 mg/L (Sculpting Lotion), 28.0 mg/L (Hair Tonic), and 48.0 mg/L (Shampoo) to 10.0 mg/L, 8.00 mg/L, and 10.0 mg/L, respectively (Figure 7). These reductions ensured compliance with the regulatory limit of 10.0 mg/L under Standard B. Among the samples, effluent from Shampoo production demonstrated the highest initial O&G levels, likely due to the extensive use of surfactants and emulsifying agents. Although these compounds are categorised under O&G due to their low water solubility, they also contribute to other water quality parameters such as BOD, COD, and TSS, making their removal particularly challenging [24]. Our findings are higher than that reported by Müller Tones et al. [25] in Brazil (0.19 mg/L for wastewater generated during the production of body and antiseptic soap, alcohol gels, and body moisturisers), but much lower than other measurements reported in Brazil for different cosmetic products [4].

Limitations of the Study

This study primarily focuses on the basic water quality characterization of wastewater generated during the production of Shampoo, Hair Tonic and Sculpting Lotion, from a local cosmetic manufacturer in Johor. Due to production schedule constraints, only single samples were collected at each point. We acknowledge that replicate sampling would help account for variability and provide additional data for statistical analysis. Parameters beyond the basic water quality measurements were not included in this study due to budget limitations.

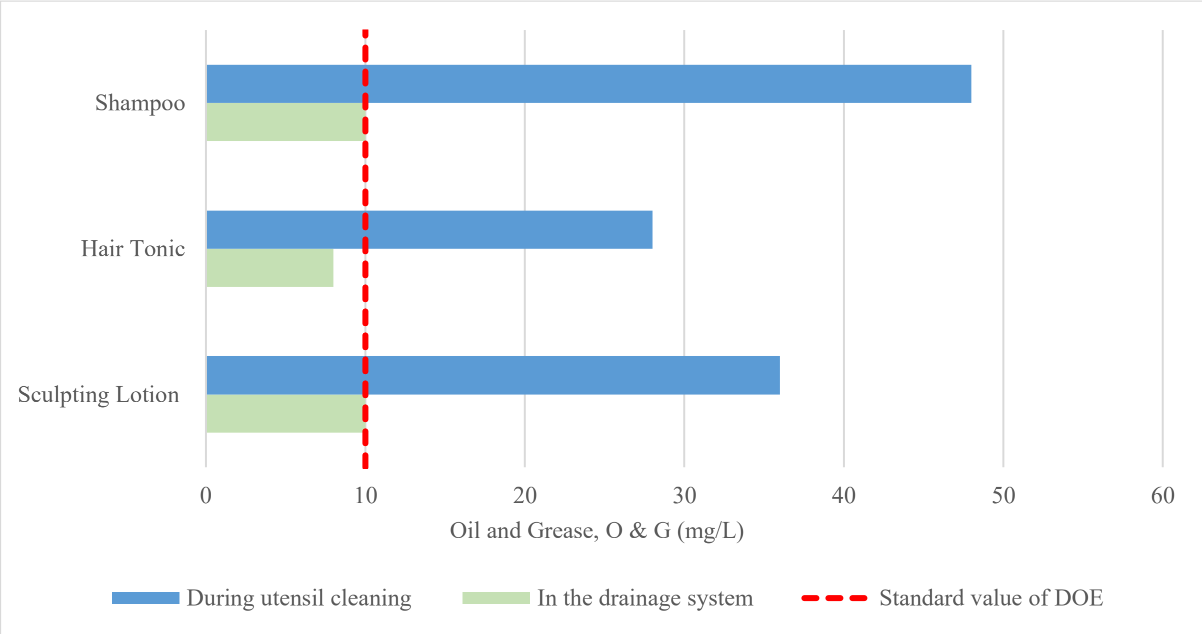

Figure 7. Oil and grease levels in wastewater generated by the production of Shampoo, Hair Tonic and Sculpting Lotion.

CONCLUSION

In this study, wastewater generated from the production of three hair care products, namely Sculpting Lotion, Shampoo, and Hair Tonic, was characterised. Samples were collected during the utensil cleaning stage and from the drainage system before being sent to a wastewater treatment facility. Overall, higher levels of BOD, COD, TSS, and O&G were observed during the utensil cleaning stage. However, wastewater samples collected from the drainage system were found to be in compliance with the DOE Malaysia's Standard B for effluent discharge, except for the Hair Tonic sample. Regardless, the wastewater is further treated at a local treatment facility serving the industrial area before final discharge into nearby aquatic systems. Our results revealed significant differences in the composition of wastewater depending on the product type, reflecting the use of different raw materials. Further studies and detailed characterisation of cosmetic wastewater are essential to determine suitable treatment technologies that enhance pollutant removal efficiency and protect water resources.

ACKNOWLEDGEMENTS

This study was funded by the Faculty of Industrial Sciences and Technology (FIST), Universiti Malaysia Pahang Al-Sultan Abdullah (UMPSA), through a grant for final year project student (JGC). The authors would like to express their gratitude to the cosmetic industry in Tangkak, Johor, for their cooperation in the sample collection process.

REFERENCES

1. Agency, N. P. R. (2022) List of Cosmetic Manufacturers in QUEST System. Retrieved from https://npra.gov.my/index.php/en/informationen/quest-list-of-manufacturers-wholesalers-importers/quest-cosmetic-manufacturer-list.html

2. Monsalvo, V. M., Lopez, J., Mohedano, A. F. & Rodriguez, J. J. (2014) Treatment of cosmetic wastewater by a full-scale membrane bioreactor (MBR). *Environmental Science and Pollution Research*, **21(22)**, 12662–12670.

3. Bautista, P., Mohedano, A. F., Gilarranz, M. A., Casas, J. A. & Rodriguez, J. J. (2007) Application of Fenton oxidation to cosmetic wastewaters treatment. *Journal of Hazardous Materials*, **143(1)**, 128–134.

4. Lima, J. P. P., Melo, E. D. & Aguiar, A. (2022) Characteristics and ways of treating cosmetic wastewater generated by Brazilian industries: A review. *Process Safety and Environmental Protection*, **168**, 601–612.

5. Melo, E. D. D., Mounteer, A., Reis, E., Costa, E. & Vilete, A. (2018) Screening of physicochemical treatment processes for reducing toxicity of hair care products wastewaters. *Journal of Environmental Management*, **212**, 349–356.

6. Naumczyk, J., Jan, B., Piotr, M. & and Kowalik, P. (2014) Cosmetic wastewater treatment by

coagulation and advanced oxidation processes. *Environmental Technology*, **35(5)**, 541–548.

7. Badmus, S. O., Amusa, H. K., Oyehan, T. A. & Saleh, T. A. (2021) Environmental risks and toxicity of surfactants: overview of analysis, assessment, and remediation techniques. *Environmental Science and Pollution Research,* **28(44)**, 62085–62104.

8. Khalid, M. & Abdollahi, M. (2021) Environmental Distribution of Personal Care Products and Their Effects on Human Health. *Iran J. Pharm. Res.*, **20(1)**, 216–253.

9. Ren, L., Huang, J., Wang, B., Wang, H., Gong, R. & Hu, Z. (2021) Effects of temperature on the growth and competition between Microcystis aeruginosa and Chlorella pyrenoidosa with different phosphorus availabilities. *Desalination and Water Treatment*, **241**, 87–111.

10. Intergovernmental Panel on Climate, C. (2022) The Ocean and Cryosphere in a Changing Climate: Special Report of the Intergovernmental Panel on Climate Change. *Cambridge University Press, Cambridge*.

11. Loucks, D. P. & van Beek, E. (2017) Water Quality Modeling and Prediction, in Water Resource Systems Planning and Management: An Introduction to Methods, Models, and Applications, eds. D. P. Loucks & E. van Beek, *Springer International Publishing: Cham*.

12. Environmental Quality (Industrial Effluent) Regulations 2009, P.U. (A) 434 (2009) Retrieved from https://www.doe.gov.my/portalv1/wp-ontent/uploads/2015/01/Environmental_Quality_Industrial_Effluent_Regulations_2009_-_P.U.A_434-2009.pdf

13. Staunton, S. (2023) pH, in Encyclopedia of Soils in the Environment (Second Edition), eds. M. J. Goss & M. Oliver, *Academic Press: Oxford*.

14. Friha, I., Karray, F., Feki, F., Jlaiel, L. & Sayadi, S. (2014) Treatment of cosmetic industry wastewater by submerged membrane bioreactor with consideration of microbial community dynamics. *International Biodeterioration & Biodegradation*, **88**, 125–133.

15. Carbajo, J. B., Perdigón-Melón, J. A., Petre, A. L., Rosal, R., Letón, P. & García-Calvo, E. (2015) Personal care product preservatives: Risk assessment and mixture toxicities with an industrial wastewater. *Water Research*, **72**, 174–185.

16. Melo, E. D. D., Mounteer, A. H., Leão, L. H. D. S., Bahia, R. C. B. & Campos, I. M. F. (2013) Toxicity identification evaluation of cosmetics industry wastewater. *Journal of Hazardous Materials*, **244-245**, 329–334.

17. Bartram, J. & Ballance, R. (2020) Water Quality Monitoring: A practical guide to the design and implementation of freshwater quality studies and monitoring programmes. *CRC Press*.

18. Karakaş, İ. & Kızıl, S. (2025) Characterization of Cosmetics Industry Wastewater and Treatment by Coagulation-Flocculation Process. *Afyon Kocatepe Üniversitesi Fen Ve Mühendislik Bilimleri Dergisi*, **25(3)**, 576–584.

19. Gkika, D. A., Mitropoulos, A. C., Lambropoulou, D. A., Kalavrouziotis, I. K. & Kyzas, G. Z. (2022) Cosmetic wastewater treatment technologies: a review. *Environmental Science and Pollution Research*, **29(50)**, 75223–75247.

20. Fernández del Castillo, A., Garibay, M. V., Senés-Guerrero, C., Orozco-Nunnelly, D. A., de Anda, J. & Gradilla-Hernández, M. S. (2022) A review of the sustainability of anaerobic reactors combined with constructed wetlands for decentralized wastewater treatment. *Journal of Cleaner Production*, **371**, 133428.

21. Sugiarti, Rohaningsih, D. & Aisyah, S. (2023) Study of Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) in Estuaries in Banten Bay Indonesia. *IOP Conference Series: Earth and Environmental Science*, **1201(1)**, 012045.

22. Zhang, S., van Houten, R., Eikelboom, D. H., Doddema, H., Jiang, Z., Fan, Y. & Wang, J. (2003) Sewage treatment by a low energy membrane bioreactor. *Bioresource Technology*, **90(2)**, 185-192.

23. Tchobanoglous, G., Metcalf, Eddy, Stensel, H. D., Tsuchihashi, R., Burton, F. L., Abu-Orf, M., Bowden, G. & Pfrang, W. (2014) Wastewater Engineering: Treatment and Resource Recovery. *McGraw-Hill Education*.

24. Yushchenko, V., Velyugo, E. & Romanovski, V. (2023) Influence of ammonium nitrogen on the treatment efficiency of underground water at iron removal stations. *Groundwater for Sustainable Development*, **22**, 100943.

25. Müller Tones, A. R., Almeida Alves, A. A., Hoffmann, I. F., Eyng, E., Bergamasco, R., Cusioli, L. F. & Fagundes - Klen, M. R. (2020) Cylindrical electrochemical reactor in continuous upward flow: Influence of operational parameters in the treatment of cosmetic effluent. *Chemical Engineering and Processing - Process Intensification*, **157**, 108120.