Physico-Chemical Water Quality Parameters Analysis on Textile

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Abstract. The prevention of pollutants from textile wastewater is important to ensure a healthy life and sustainability of local development. This paper aims to determine the concentration of the physico-chemical water quality parameters in textile wastewater taken from a textile factory at Sri Sulong, Batu Pahat, Johor of Malaysia. The samples were directly brought to the laboratory for analysis, and the content of textile wastewater quality was characterized using physico-chemical analyses including temperature, pH, electrical conductivity (EC), turbidity, dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BOD), total suspended solids (TSS), colour, alkalinity, total dissolved solids (TDS), and heavy metals (cadmium, copper, ferum, manganese, lead, and zinc). The results also indicated some of the parameters for final discharge textile wastewater could not be safely discharged because they did not comply with the standards of Standard B such as COD, BOD, colour, TSS, cadmium, and zinc. The results of this studies showed that the concentrations of COD, BOD, colour, TSS, cadmium, and zinc were between the range of 55 – 294 mg/L, 7.1 – 85 mg/L, 17 – 140 mg/L, 69 – 205 mg/L, 0.001 - 0.047 mg/L, and 0.488 - 2.220 mg/L respectively, higher than the values in Standard B. Textile wastewater is classified by pollution severity as strong wastewater. This study provides an understanding and assists in selecting suitable treatment for textile industrial wastewater prior to discharge to comply with the standard permissible of the environmental quality act.

1. Introduction
Malaysia’s textile and clothing industry is one of the country's largest established manufacturing sectors. As for the export performance of textile manufacturing, there was an increase of RM 9238 million in 2016 that shows its important component in the national economy [1]. According to Mokhtar et al. [2], besides the largest manufacturing textile, in case of the production side, large quantities of wastewater with various concentrations of pollutants are generated from the textile manufacturing process. Textile facilities are not allowed to discharge their wastewater into an aquatic environment or canalization. Instead, it requires the wastewater treatment plant that has a drainage system and must comply with the emission limit according to the receiving system.
Despite improving economic growth, textile industries also face challenges due to the generated large volumes of effluent, which are extremely variable in composition and pollution load. According to Madhav et al. [3], textile effluents that come from dyeing and finishing processes usually have large extent toxic composition that extremely heterogeneous. Almost all dyes, especially chemicals like finishing chemicals were applied to substrates of textiles from water baths. In addition, most of fabric preparation steps use aqueous systems for desizing, scouring, bleaching, and mercerizing. According to USEPA, 36000 liters of water were consumed to producing 20,000 lb/day of fabric. World Bank also reported that almost 20% of global industrial’s water pollution comes from the treatment and dyeing processes of textiles [4].

Effluent streams that have significant heavy metals’ content usually occur from the hot and coloured dyeing process. The most common toxic heavy metals in textile wastewater include ferum, arsenic, lead, cadmium, chromium, copper, nickel, and zinc [5]. The toxicity of heavy metals have attracted much researches’ interests due to their adverse effects on human health and global environment. Arsenic, cadmium, chromium, and nickel are categorized in class I heavy metals according to the International Agency for Research on Cancer [6]. Moreover, manganese, lead, ferum, and arsenic are the most predominant heavy metals that posing a non-cancer risk while cadmium caused the highest cancer risk [7]. Heavy metals are persistent in the environment, contaminate the food chains, and cause different health problems due to their toxicity [8]. Chemicals released into the waterway can be disrupted to hormones and cause cancer [9]. Other than that, the discharge of textile wastewater is disreputably known to contain strong colour, an exceedingly fluctuating pH, a high temperature, COD, BOD, and substantial amounts of suspended solids [10]. Severe pollution of textile wastewater causes serious health hazards in the neighborhood, damaging the fertility of the land, killing fishes, and aquatic lives [11]. The first step in a pollution’s prevention strategy for water is a thorough audit and characterization of wastewater from textile operations [12].

Department of Environment in the annual report 2018 had stated that 51 rivers in Malaysia were classified as polluted and 25 from that were known as dead rivers. Johor is categorized as the state with the highest number of dead rivers in Malaysia. Therefore, every organization requires to put serious effort into maintaining watercourse or river protection for ensuring it will not seriously be degraded. In line with that, textile industries that operated in Batu Pahat district should ensure the effluent discharge comply with Environmental Quality (industrial effluent), Regulation 2009. According to Gunatilake [13], various treatment options to remove heavy metals from industrial wastewaters such as chemical precipitation, coagulation, complexation, activated carbon adsorption, ion exchange, solvent extraction, foam flotation, electro-deposition, cementation, and membrane operations.

Through this study, an attempt had been made to determine the concentration of the physico-chemical parameters in textile wastewater. The selected parameters were the temperature, pH, electrical conductivity (EC), turbidity, dissolved oxygen (DO), COD, BOD, total suspended solids (TSS), colour, alkalinity, total dissolved solids (TDS), and metals (cadmium, copper, ferum, manganese, lead and zinc). The wastewater discharge should comply with industrial effluent. This is to ensure that the discharge will not harm the habitat in the eco-system. Besides, the human beings can also live a healthy life by receiving clean water.

2. Material and method
The sample of textile wastewater was taken from one of the textile industry at Sri Sulong, Batu Pahat, Johor. The factory focused on all fabric garment trims such as elastics, drawcord, and tapes. The textile wastewater was obtained manually once a week in February to March 2019 from equalizer tank, clarifier, aeration tank and final effluent. Samples were placed in a high-density polyethylene (HDPE) bottle (1 L per sample). All samples were collected between 9 am to 1 pm, which represented the peak flow for the dyeing process. The samples were placed in an ice cold box during the transportation from the sampling site to the laboratory. Procedures of sampling had been carefully followed to avoid any intrusion of impurity particles that would affect the results.

A few parameters were studied for this research such as the temperature, pH, EC, turbidity, DO, and TDS by using a multiparameter water quality checker (Horriba U-5000G) at the time of sample collection. Meanwhile, the special sampling and handling requirements were based on the Standard
Method of Examination of Water and Wastewater, APHA [14]. COD test was done using to DR 6000 for high range concentrations (1500 mg/L) using HACH’s reagent. Prior to measurement, the COD vial was firstly filled with 2 mL of sample and preheated on a reactor for 2 hours at 150 °C. BOD was measured using the standard method of APHA 5210. Next, TSS was measured using the Whatman filter paper 47 mm nominal pore size and vacuum pump (Gravimetric Method). Colour concentration was measured as apparent colour by DR 6000 (HACH, USA) spectrophotometer and the wavelength was fixed at 97 nm (Program number 300 ADMI). Alkalinity was measured by APHA 2320B. The concentrations of the metal ions were determined by mass spectroscopy inductively coupled plasma (ICP-MS).

3. Result and discussion

3.1. Physico-chemical parameters

Characterization of textile effluent streams is a very important factor for strategies development in water treatment and reuse. In order to assess the pollution content, several parameters were analyzed and the results were compared to the Standard B of Environmental Quality (industrial effluent) in Regulation 2009. The physico-chemical parameters of the textile wastewater at the textile factory were summarized as in Table 1.

| Table 1. Statistics of physico-chemical parameters of textile wastewater at the textile factory, Sri Sulong, Batu Pahat, Johor. |
| --- |
| Sample Parameter | Equalizer tank | Clarifier | Aeration | Final discharge | Regulation 2009 Standard B |
| Temperature (°C) | 30.75 - 41.53 | 30.73 - 36.13 | 29.92 - 32.36 | 30.13 - 32.7 | 40 |
| pH | 5.82 - 10.78 | 6.01 - 9.11 | 6.46 - 8.34 | 6.27 - 8.80 | 5.5 - 9.0 |
| EC (mS/cm) | 1.02 - 6.56 | 1.59 - 5.19 | 1.78 - 8.48 | 2.12 - 5.79 | nr |
| Turbidity (NTU) | 21.7 - 140 | 5.67 - 45.9 | 13.8 - 24.1 | 5.89 - 26.6 | nr |
| DO (mg/L) | 2.09 - 10.34 | 6.20 - 10.02 | 7.11 - 10.01 | 5.80 - 10.54 | nr |
| COD (mg/L) | 414 - 2720 | 360 - 1680 | 64 - 1146 | 55 - 294 | 250 |
| BOD (mg/L) | 151.7 - 885 | 102 - 550 | 35.25 - 426 | 7.1 - 85 | 40 |
| TSS (mg/L) | 20 - 160 | 10 - 200 | 18 - 160 | 17 - 140 | 100 |
| Colour (ADMI) | 280 - 2050 | 140 - 430 | 169 - 234 | 69 - 205 | 200 |
| Alkalinity (mg/L) | 150 - 745 | 100 - 275 | 74 - 125 | 20 - 200 | nr |
| TDS (mg/L) | 434 - 4080 | 938 - 3250 | 1040 - 3260 | 1250 - 3610 | nr |
| Cadmium (mg/L) | 0.002 - 0.026 | 0.001 - 0.024 | 0.001 - 0.026 | 0.001 - 0.047 | 0.02 |
| Ferum (mg/L) | 0.754 - 4.590 | 0.080 - 3.400 | 0.751 - 7.060 | 0.013 - 2.810 | 5 |
| Manganese (mg/L) | 0.061 - 0.515 | 0.139 - 0.863 | 0.264 - 1.460 | 0.280 - 0.660 | 1 |
| Zinc (mg/L) | 0.302 - 2.760 | 0.398 - 1.520 | 0.312 - 1.350 | 0.488 - 2.220 | 2 |
| Copper (mg/L) | 0.173 - 1.430 | 0.072 - 0.360 | 0.083 - 0.143 | 0.059 - 0.174 | 1 |
| Lead (mg/L) | 0.022 - 0.150 | 0.002 - 0.182 | 0.002 - 0.073 | 0.011 - 0.132 | 0.5 |

# Not reported.

The characteristics of textile wastewater in Table 1 clearly indicates that the wastewater needs further treatment process after primary treatment. These results also showed that a single treatment process was not enough to treat textile wastewater. Based on the observations, the secondary treatment should be adopted for COD, colour, and heavy metals treatment before final discharge. The proposed aforementioned treatments would beneficially allow the water reuse, if only the treated textile wastewater complies with the regulatory effluent discharge requirements.
All the textile sampling had their effluents having temperatures between 30.13°C to 32.7°C given by Table 1 which are followed the set limit by Regulation 2009 (Standard B). According to Yadav et al. [15], temperature is basically an important factor for chemical and biological reactions taking place in water. Fluctuations of short term temperature in watercourses near the textile and dyeing industries might cause death to aquatic organisms and a total change in the fish population [16]. Increase of temperature leads to (i) decrease in the dissolved oxygen (DO) content, which is very essential for the survival of the aquatic system, (ii) reduction in crop growth, and (iii) deleterious effects on aquatic organisms [17].

In the textile processing units, pH is a simple parameter yet very much an important factor. It is regulated at various steps for better results. Meanwhile, most of the chemical reactions occur in the aquatic environment are regulated by any change in its value due to the sensitivity to pH changes. It also needs pH control or monitoring in the biological treatment processes [18]. The pH of water is a significant parameter because it can determine the solubility and biological availability of nutrients, specifically metals such as iron [19]. The pH final discharge of wastewater in this study varied between pH 6.27-8.80. These values were within the standard limit (5.5 – 9.0) of pH for wastewater in Standard B. However, the unbalance of pH effluent may disrupt the pH buffer systems and also disorder the ecological system. The changes in pH may have a strong effect on the toxicity of metals.

The electrical conductivity (EC) of water is a measure of the ability of a solution to conduct an electric current that depends upon the water temperature as well as the presence, total concentration, and mobility of ions [20]. It is a useful indicator of salinity or total salt content of wastewater. It was found in this study that the final discharge for EC had increase between 2.12 - 5.79 mS/cm. According to Mandal [17], if conductivity levels are high, many forms of aquatic life are affected such as the dehydration on the skin of animals due to dissolved salts.

The turbidity level of water depends on the quantity of solid matters that present in the suspended state. It is a measure of light-emitting properties of water to indicate the quality of waste discharge with respect to colloidal matter [21]. The value of turbidity in this research from final discharge wastewater was between 5.89 – 26.6 NTU. Various turbidity concentrations were observed in this characterization study. Turbidity can seriously affect water quality in many conditions, such as reducing the amount of light received for plant growth, and damaging sensitive gill structures in fish and aquatic organisms.

Dissolved oxygen (DO) is an index of physical and biological processes in water and one of the most important parameters to assess the water quality [22]. The depletion of DO in water is an example of serious effect of textile waste since it is very essential for marine life [23]. Oxygen is needed by living organisms as they oxidize wastes to obtain energy for growth. Therefore, controlling oxygen is required for secondary or biological treatment of wastewater. In this research, the final discharge values for DO were between 5.80 - 10.54 mg/L. According to Kale [24] levels of DO vary depending on factors including water temperature, time of day, season, depth, altitude, and rate of flow. Bacteria or aquatic animals might overpopulate using high concentration of DO in the nearby area. According to Morshed et al. [25], textile effluent contains a DO range starting from 1.95 mg/l to 5.83 mg/l, which is an alarming rate for aquatic life. Untreated textile effluent can contaminate groundwater and water bodies, reduce dissolved oxygen in the water, and affect aquatic ecosystems which may indirectly cause climate change [26].

The COD is a measure of the oxygen consumed in the chemical oxidation of organics [27]. The value of COD parameter for final discharge was between 55 – 294 mg/L, which was three times higher than BOD. Based on the Malaysian Environmental Quality Act (Sewage) Regulations 2009, the value of COD for textile wastewater obtained in certain samplings in this study did not comply with Standard B, which must be below 250 mg/L. The high COD concentrations in the systems of wastewater treatment are toxic to both biological life and aquatic environments such as aquatic plants and fishes [28]. In this study, the final discharge for BOD value was obtained between 7.1 – 85 mg/L. It shows that some of the value had exceeded Regulation 2009 (Standard B). According to Patel and Vashi [28], the value of high BOD is due to the untreated textile wastewater that causes rapid depletion of DO in the surface water source. The remarkable increase in COD levels compared to BOD also indicates that the significant levels of toxicants e.g. heavy metals may be possibly present in the wastewater [29]. Figure 1 shows the concentration COD, BOD, and colour compare to Standard B.
Based on the monitoring, TSS in textile wastewater samples were extremely high up to 140 mg/L for final discharge compared to the allowed standard. The value had resembled strong wastewater and therefore should not be discharged into the environment [18]. Higher concentrations of suspended solids decreased the level of water clarity. This adversely affects the aesthetics and recreation in the surface water bodies. TSS comprise both inorganic and organic materials, which the organic fraction accounts for about 25 to 35 percents of TSS [30]. The high TSS and TDS detected could be ascribed to the high colour from various dyestuffs in the textile mills that might be major sources of the heavy metals [31].

Colour of the textile effluent depends on the dyes used. According to Vigneshpriya and Shanthi [30], the textile effluents with high colour may due to the joint results of pH, temperature, and acidic conditions that hinder the chromophore group of dye to degrade. The value of colour in this study was between 69-205 ADMI. Colour can be considered as the earliest characteristic to be detected in the polluted water. The presence of very small amounts of dyes in water (less than 1 ppm for some dyes) is highly visible and it affects the quality of water bodies. The colour affects the water transparency, aesthetic, and gas solubility of water bodies [15]. The highest concentration of colour compared to the Standard B can be referred to Figure 1. Alkalinity is a criterion for water ability to neutralize acids [32]. The presence of hydroxides, carbonates, and bicarbonates are the main cause of alkalinity in the water [16]. The value of final discharge for alkalinity in this research was between 20-200 mg/L. According to Tafesse et al. [31], high alkalinity is a measure of wastewater strength and it shows the capacity of wastewaters to neutralize acids, which is undesirable.

TDS is a measure of the total organic and inorganic substances contained in the molecular, ionized or suspended forms in water [33]. According to Patel & Vashi [28], TDS are formed due to the chemicals used and the present of soluble organic and inorganic substances in the processing units. These hazardous and harmful substances in the TDS, especially heavy metals (e.g., zinc, copper, chromium, nickle, cadmium, etc.), have strong biological toxicities, causing serious environmental troubles and harms to humans and wildlife [34]. From the experiment, the amount of substances dissolved into the effluent was between 1250-3610 mg/L for final discharge. These higher amounts may be due to the discharge of chemical agents used during various processes in the textile industries.

Dyeing stripping agents, oxidizing agents, and finishing in textile wastewater occurred from heavy metals arising from the complex metal dyes [16]. In this study, it was observed that the concentrations of ferum, manganese, copper, and lead lower than the detection limits. The concentration result of cadmium was between 0.001-0.047 mg/L. According to Halimoon and Yin [35], heavy metals such as lead, chromium, cadmium and copper are widely used for production of colour pigments of textile dyes. Cadmium is one of the heavy metals that is highly toxic to humans, plants, and animals when it presents in high amounts [36]. The measured zinc concentration was found in the range of 0.488 - 2.220 mg/L. Heavy metals such as zinc, copper and ferum is an essential micronutrient for plant metabolism; but when present in excess, they become extremely toxic [37]. Zinc concentration in wastewater increases

![Figure 1. Variation concentration of COD, BOD, and colour compared to Standard B.](image-url)
due to the process of viscous rayon fibers and used of chemical impurities in the textile industries [16]. Excess amounts of zinc can cause system dysfunctions that result in the impairment of growth and reproduction [38]. Figures 2 and 3 show the concentration of cadmium and zinc compared to the Standard B.

4. Conclusion
As a conclusion, derived from the observations and laboratory analyses, there is a crucial need to carry out more studies about the characteristics of wastewater by focusing on the monitoring of textile industrial wastewater. Before final discharge, the secondary treatment should be adopted for COD, colour, and heavy metals. It is recommended to practice nonstop monitoring of water quality to guarantee protection and security of water resources from further degradation. The disposal of industrial wastewater without proper treatment also should be discouraged.

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