Study on removal of pollutant from batik wastewater using coal bottomash (CBA)

M Z Jamaludin
Department of Civil Engineering, Politeknik Sultan Idris Shah, Sungai Lang, Sungai Air Tawar, 45100 Selangor Malaysia
Email: zamri_jamaludin@psis.edu.my

ABSTRACT: Batik, which is a hand-painted product which is richly colored pattern. It is a textile industrial wastewater and usually releases their industrial effluents into the river without any proper treatment. Coal bottomash (CBA) derived from coal combustion for electricity generation in power plants or some industries and the characteristic of CBA may depend upon the raw coal source, size, type of coal burner and the operating conditions of the burner. The main objectives of this study were to identify the efficiency treated and untreated CBA in the treatment of batik wastewater effluents and to determine the size of bottom ash suitable for the fixed-bed column treatment mechanism. CBA was washed, treated with HCl, HNO₃, and H₂O₂ and dried for the preparation fixed bed column. Batik waste water treatment efficiency was enhanced by the use of treated CBA fixed-bed column with size 0.45 mm and reduced the TSS, BOD, and turbidity by 41.6%, 65.3% and 75.6%, respectively. CBA is an effective and inexpensive for the removal of color, BOD, TSS and turbidity due to its high porosity and adsorption capacity. Problems of environmental pollution can also be minimized by utilization of CBA-fixed bed column in batik industries waste water treatment.

1. Introduction
Batik, which is the product of hand-painted and richly colored patterns, is a Malaysian-made textile and is a major contributor to the economy of several states especially in the east coast, such as Kelantan and Terengganu [1-3]. Commonly the manufacturers of batik textile discharge their wastewater into environment without appropriate treatment. Batik industries create very high volume of the waste water, contents high level of dyes [4]. According to Awang et al (2016) [1], operator of this industry mostly operates on a small scale usually release their industrial effluents into the environment without any proper treatment, thus a causing a widespread pollution through the industrial wastewater containing dyes, waxes, and heavy metals with high Chemical Oxygen Demand (COD) and Total Suspended Solid (TSS).

According to Taufiq et al (2018) [5], commonly the dyes used in the batik textile industry is classified into three classes: (i) anionic dyes (direct, acid, and reactive), (ii) cationic, and (iii) nonionic. To produce the satisfied batik method dyeing, it depends on the composition of batik wax and the selection of dyeing agent [6]. Remazol Red contains a mixture of azo dyes; Remazol Blue contains a mixture of diazo-divinylsulfone dyestuff and formazan–vinylsulfone–copper complex dyestuff [7]. Some azo dyes contain coordination metals in their structure, which is an additional problem for the environment and may affect wastewater treatment [1-3].

In Malaysia, coal has been identified as an important source of fuel, where it is widely used in the production of electricity, steel and cements manufacturing [8]. Coal bottomash (CBA) derived from coal combustion for electricity generation in power plants or some industries [9,10].
Coal bottomash (CBA) has particle size in the range of 0.1–10 mm, with apparent dark grey color. However, this bottom ash is still treated as waste under Environmental quality act and put in impoundment ponds, silos or landfills [8]. Due to the high composition of silica and other metal oxides, there is possibility to remove dye from wastewater [10,11]. CBA may depend upon the raw coal source, size, type of coal burner and the operating conditions of the burner [8,11].

Use of coal bottomash (CBA) as a potential adsorbent as removal of toxic dyes has been extensively researched and has been found that bottom ash and de-oiled soya mixture can be used effectively to remove water soluble azo dyes from textile wastewaters [11]. Other common dye types such as Vertigo Blue 49 (CI Blue 49), Orange DNA13 (CI Orange 13) and Malachite green from textile wastewaters were also effectively treated using CBA [9-11]. The main objectives of this study were to identify the efficiency treated and untreated CBA in the treatment of batik wastewater effluents and to determine the size of bottom ash suitable for the fixed-bed column treatment mechanism.

2. Methodology

Effluent sample of batik wastewater was collected from Master Wan batik effluent release point at Dengkil, Selangor and coal bottomash (CBA) was obtained from TNB Janamanjung Sultan Azlan Shah power station, Perak. TNB Janamanjung Sultan Azlan Shah Power Station is located in the district of Manjung, Perak Darul Ridzuan on 325 hectares a reclaimed island off the Lekir coastline in Manjung district Perak. Master Wan batik is small and medium-sized enterprises (SMEs) and TNB Janamanjung generates 3,100MW of electricity from its three units of 700MW coal-fired and one unit of 1,000MW ultra-supercritical boiler technology power plant [5,13]. The sequence adopted for the experimental work is shown in Figure 1. The type of dyes use in this batik textile production was fiber reactive dyes namely Remazol classed in anionic dyes (direct, acid, and reactive).

![Figure 1. An adsorption process using CBA fixed-bed column.](image)

2.1. Adsorbent bed preparation using coal bottom ash (CBA) and screening

Coal bottomash (CBA) was washed, treated and dried for the preparation fixed bed column. Concentrated hydrochloric acid 1N, nitric acid 1-N and 30% hydrogen peroxide and stirred for 1 hour and left for 24 hours under room temperature. The CBA was repeatedly washed with deionized water to eliminate the surplus amount of acid and dried at 105°C for 2 hours to ensure that it is free from any moisture. After that it was burned in the furnace at 500°C for 1 hour. Then, the particle size distribution was conducted by sieving the bottom ash using the sieve sizes measuring 10mm, 5mm, 2.36mm to separate coarse bottom ash and fine bottom ash. After that, the CBA was sieves for fine bottom ash with sieve sizes measuring 1.18mm, 850μm and 450μm for sample preparation to determine the effect of mesh size to efficiency of the treatment.
2.2. Design and construction of the fixed-bed column

Fixed bed column study was conducted using columns with dimension of 2 cm diameter and 15 cm length. The column was packed with bottom ash between two supporting layers of pre equilibrated glass wool and glass beads. The schematic diagram of the column study is shown in Figure 2. The batik wastewater effluent was fed through the fixed-bed column in the down flow mode. Before operation, the bed was rinsed with distilled water and left overnight to ensure a closely packed arrangement of particles with no void, channels, or cracks.

![Figure 2. Schematic diagram of lab-scale column study.](image)

2.3. Laboratory analysis

Laboratory scale testing of collected wastewater sample, pre and post-treatment process was performed for BOD, TSS and turbidity using standard laboratory conducted in accordance with the APHA (2005) 21th Edition of the Standard Methods of the Examination of Water and Wastewater. Among needed test are the biochemical oxygen demand (BOD), total suspended solid (TSS), and turbidity. The experiments were carried out twice and each experiment runs for 5 days for BOD. Total Suspended solid (TSS) analysis was conducted using gravimetric method according to Standard Method APHA 2540-D procedure. Turbidity was determined by using nephelometric principle of turbidity measurement using HACH Model 2100P Portable Turbidimeter [14].

3. Results and discussion

The effluent pollutants adsorption study was carried out by use of coal bottom ash (CBA) adsorbents with different of size and also treated and untreated samples. Effluent from the batik industry was analyzed before and after the treatment with adsorbent fixed-bed column. The rate of adsorption resulting from reduction wastewater parameter concentration of biochemical oxygen demand (BOD), total suspended solid (TSS), and turbidity in the effluent at the exit of the fixed-bed column.

3.1. Effect of size and treated for CBA fixed-bed column TSS reduction

The batik wastewater effluent for total suspended solid (TSS) level improved significantly after passing through the adsorbents in fixed-bed column (P<0.05). From the experiment shows that for untreated coal bottomash (CBA) was lowest TSS removal efficiency compare to the treated. coal bottomash (CBA) as show in Figure 3. These studies show the size 0.45 mm for treated CBA.
adsorbents in fixed-bed column were more efficient in reducing TSS than 0.85mm and 1.18mm lab-scale column study. As illustrate in Figure 3 also found that coal bottomash has shown good capacity of settling, that makes it possible to eliminate suspended solids by acting as a settling aid. According [10,15] effective treatment of effluent by means of adsorption depends upon chemical structure, adsorption capacity, surface area, particle size and porosity of bottom ashes. Increasing adsorption on the surface of the powders, the possibility of formation of a product which is expressed as the concentration of reactants that can be adsorbed will increase [4,16].

Figure 3. Effect of TSS removals for CBA fixed-bed column treatment on batik wastewater effluent.

3.2. Effect of size and treated for CBA fixed-bed column turbidity reduction
Both untreated CBA and treated CBA achieved highest removal for lab-scale column study as drawn in Figure 4. According to ANOVA test, the differences were significant (P<0.05). As the water passed through the fixed-bed column, there was a gradual decrease. From the experiment shows turbidity removal efficiency for treated coal bottomash (CBA) was slightly higher compare to the untreated coal bottomash (CBA). According to Shah et al (2015) [10], effluent’s material causing turbidity was detained in the bottom ash adsorbent pores and the maximum turbidity removal rate achieved due to high porosity and surface area.

Figure 4. Effect of turbidity reduction for CBA fixed-bed columns treatment on batik wastewater effluent.
3.3. Effect of size and treated for CBA fixed-bed column BOD reduction
Both untreated CBA and treated CBA achieved higher BOD removal in fixed-bed column as illustrate in Figure 5. As the wastewater passed through the fixed-bed column, there was a gradual decrease. For untreated CBA show there is slightly different efficiency turbidity removal between particles sizes of CBA. This study shows the 0.45 mm size for treated coal bottomash (CBA) adsorbents were more efficient in reducing BOD than 0.85 mm and 1.18 mm lab-scale column study. According to ANOVA test, the differences were significant (P<0.05). “According to kuasmiyati et al (2017) [9] and Shah et al (2015) [10], the adsorbent surface area is very important in the adsorption process, due to the effective surface area increased as the particle size decreased and as a consequence.

Figure 5. Effect of BOD reduction for CBA fixed-bed columns treatment on batik wastewater effluent.

4. Conclusion
The adsorption experiments indicated that coal bottomash (CBA) was effective as batik effluent wastewater treatment. The percentage removal of batik effluent wastewater increased with decreased particle size of the CBA and also increased with treated of adsorbent CBA used. Treated CBA fixed-bed column is an effective and inexpensive for the removal of BOD, TSS and turbidity due to its high porosity and adsorption capacity. Batik waste water treatment efficiency was enhanced by the use of treated CBA fixed-bed column with size 0.45 mm and reduced the TSS, turbidity and BOD by 41.6%, 65.3% and 75.6%, respectively. Problems of environmental pollution can also be minimized by utilization of CBA in batik industries waste water treatment. Therefore, further studies are required to explore the applications of bottom ash as wastewater treatment.

References
[1] Awang N Ehlam S N F and Kok Meng C 2016 Journal of Chemical and Pharmaceutical Sciences 9 4 pp 3221-3226
[2] Birgani P M Ranjbar N Abdullah R C Wong K T Lee G Ibrahim S Park C Yoon Y Jang M 2016 Journal of Environmental Management 184 pp 229-239
[3] Rashidi H R Sulaiman N M K Hashim N A Hassan C R C and Emami S D 2016 Desalination and Water Treatment 57 pp 151–160
[4] Salamah S and Wahyuni E T 2018 IOP Conf. Series: Materials Science and Engineering 403 012007
[5] Taufiq A Hidayat P and Hidayat A 2018 MATEC Web of Conferences 154 01037
[6] Pancapalaga W, Bintoro P, Pramono Y B and Triatmojo S 2014 *International Journal of Applied Science and Technology* **42**

[7] Punzi M 2015 *Treatment of Textile Wastewater by Combining Biological Processes and Advanced Oxidation*. Printed in Sweden by Media-Tryck, Lund University Lund 2015

[8] Ramzi N I R Shahidan S Maarof M Z and Ali N 2016 *IOP Conf. Series: Materials Science and Engineering* **160** 012056

[9] Kusmiyati Listyanto P A Indra D V R Islamica D and Hadiyanto 2017 *Journal Sci & Tech* **14** 5 pp 427-439

[10] Shah S F A, Aftab A, Soomro N, Nawaz M S and Vafai K 2015 *Journal Anal. Environ. Chem.* **16** 2 pp 48 – 56

[11] Jayaranjan M L D Eric D V H and Ajit P A 2014 Reuse options for coal fired power plant bottom ash and fly ash. *Reviews in Environmental Science and Bio/Technology* April 2014

[12] Salim M F 2004 Manjung Power Station – The New Experience. JURUTERA (December 2004) pp 24-27

[13] Din S A M Yahya N N H N and Abdullah A 2013 *Procedia - Social and Behavioral Sciences* **85** pp 92 – 99

[14] HACH 2008 Portable Turbid meter Model 2100P Instrument and Procedure Manual HACH Company

[15] Nidheesh PV Gandhimathi R Ramesh S T Sarasvathy T and Singh A 2012 *Journal of Urban and Environmental Engineering (JUEE)* **6** 1 pp 18-29

[16] Ganapathy C Nivetha K Kumar E O and Pratheep T 2018. *International Research Journal of Engineering and Technology (IRJET)* **05** pp 680-683