Determination of Heavy Metal Contamination from Batik Factory Effluents to the Surrounding Area

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***Abstract*—** A study was carried out to determine heavy metal contamination from batik factory effluents to the surrounding area from October 2010 to December 2011. Three different types of samples (batik effluent, soil and plant) were collected within three different batik factories in Kota Bharu, Kelantan, Peninsular Malaysia. Cadmium (Cd), Lead (Pb), Zinc (Zn), Copper (Cu), Chromium (Cr) and Iron (Fe) were chosen for the heavy metals contaminant study. Heavy metal concentrations were detected using Flame Atomic Absorption Spectrophotometer (FAAS). The results indicated that heavy metal concentration in soil and plants did not exceed the critical limits set by international and national regulatory. However, this study also found that heavy metal concentrations in the soil and plant samples were positively correlated with the heavy metal concentrations in batik effluents ($P < 0.05$). So, an extensive treatment for batik effluents is required before they are discharged in to the environment.

***Keywords*—**Batik, effluents, environment, heavy metals.

I. Introduction

TEXTILE industries are a source of income in some countries. The increase in the demand for clothing and apparel has brought both positive and negative consequences to these countries. One positive result has been an improvement in their economies. In contrast, environmental pollution is a major downside of textile factories. . Textile industries have been dubbed as the worst offenders of pollution as they use more than 2,000 types of chemicals and over 7,000 types of dyes [2]. They also produce heat, which is released with effluent, and increase water pH as well as saturate water with dyes. Besides the dyes, heavy metal constituents in effluent also have negative ecological impacts on the water body and environment and cause deterioration in human health.

Heavy metals enter into the environment mainly via three routes: (i) deposition of atmospheric particulates, (ii) disposal of metal-enriched sewage sludge and sewage effluents and (iii) release of by-products from metal mining processes [1]. These heavy metals which are transferred to the environment are highly toxic and can accumulate in the human body, aquatic life, and natural water-bodies and possibly become trapped in the soil [5]. Heavy metals are present as impurities in dyes or are part of the dye molecule. In metal complex dyes, the metal forms chemical bond with the organic dye molecule and governs the speed at which materials absorb the colours; thus, heavy metals are an indispensable constituent of the dye.

Batik is a very popular traditional handmade craft in Malaysia. The production of batik in Malaysia started in the 1960s. Since then, it has developed through time. In Malaysia, especially in the state of Kelantan and Terengganu which are located in East Coast of Peninsular Malaysia, batik is generally produced by cottage industries.

It is known that textile industries, such as batik, consume a large amount of water especially in the dyeing process. Most of the batik entrepreneurs in Kelantan state use traditional methods for producing batik, thus releasing untreated toxic effluents that contain dyes, waxes, and heavy metals, and have a high chemical oxygen demand (COD) and total suspended solid (TSS) contents.

Some of the batik factories were built alongside the river or even at the back of an owner's house. Batik industries involve the use of mostly azo dyes that normally contain high concentrations of pollutants such as high colour pigments, carcinogenic dyes and toxic heavy metals [3]. Batik factories usually continuously discharge wastes in to a special vessel or directly in to a river or drainage system. Wastes from these dyes will be the main sources of pollution in the river, land or the drainage system. These discharges make the colour of the soil, and the water in the river and in the drainage around the factory darker and malodorous. With time, there is an obvious effect on water quality and also other aspects of the environment. The stage of the pollution can be determined from the colour of water and soil, the decrease in biotic life and the quality of water.

The aim of this study was to determine heavy metal concentrations in batik effluents and in soil and plants around selected batik factories. Pearson's correlations were used to

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investigate the relationship between heavy metal concentrations found in the effluents, soil and plants. This analysis was performed using Statistical Package for the Social Sciences (SPSS 16 for Windows).

II. Materials And Methods

A. Sampling sites

This study was carried out to determine heavy metal contamination from batik factory effluent to areas surrounding three batik factories located in Kota Bharu, Kelantan. The factories are labeled as site A (N 06° 11.433' E 102° 16.232'), site B (N 06° 08.693' E 102° 14.361'), and site C (N 06 ° 06.300 'E 102 ° 13.889' in this article. This study was conducted from October 2010 to December 2011. Eight samples of each effluent, plant and soil were collected from each site. Water effluents were stored in polyethylene bottles, while plant and soil samples were dried, ground, passed through a 2 mm sieve and kept in a polyethylene zip- lock bag until being digested in preparation for heavy metal analysis.

B. Water Digestion

For each water sample, 100 mL was transferred to a conical flask. Then 5 mL of concentrated HNO_3 and a few boiling chips were added. The digestion was conducted under a slow boil and concentrated HNO_3 was added until digestion was complete, which was as shown by a light-coloured, clear solution. The sample did not dry out during digestion. After that, the flask walls were washed with water and then were filtered. Filtrate was transferred into a 100 mL volumetric flask with two 5 mL portions of water. The filtrate was cooled and diluted to 100 mL in the volumetric flask. About 10mL this solution was taken for metal determination.

C. Soil Digestion

1.0 g of sample was weighed. Then, 5 mL of concentrated HNO_3 was added to the soil sample and heated for 30 minutes. The last step was repeated until the digestate had completely digested by the HNO_3. After that, the mixture of the digestate and HNO_3 was evaporated to 5 mL. It was then left to cool at ambient temperature. The digestion was continued by adding 2 mL of deionized water and 3 mL of 30% H_2O_2, then 1 mL aliquots of H_2O_2 continued to be added until bubbling subsided. The volume was also reduced to 5 mL. Then, 10 mL of concentrated HCl was added and heated for 15 minutes. Finally, the digestate was filtered and made up to 100mL with deionized (DI) water.

D. Plant Digestion

Portions of plant material were ground in a 30-50 mL porcelain crucible, and weighed to the nearest gram. After that, porcelain crucibles were placed in a furnace, and the temperature was increased gradually to 550°C. Ashing was continued for 5 hours after attaining 550°C. The furnace was shut off and the door was opened cautiously for rapid cooling. After cooling, the porcelain crucibles were taken out carefully. The cooled ash was dissolved in 5 mL portions of 1 N hydrochloric acid (HCl), and was mixed. After 20 minutes, the volume was made up to 100 mL using deionized (DI) water.

E. Heavy metals analysis

The digested samples (effluents, plant and soil) were then analysed using a flame atomic adsorption spectrophotometer (FAAS - Perkin Elmer PinAAcle 900F) to determine the concentrations of cadmium (Cd), lead (Pb), zinc (Zn), copper (Cu), chromium (Cr), iron (Fe) and manganese (Mn).

III. Results And Discussion

The results obtained from the analysis are tabulated in tables I to III.

TABLE I
Heavy metals concentartion in batik effluents

Elements	Standard B of Effluents, EQA 1974 [6] (ppm)	Site A (ppm)	Site B (ppm)	Site C (ppm)
Cd	0.02	0.01	0.01	0.00
Pb	0.5	0.16	0.20	0.17
Zn	2.0	0.16	0.34	0.47
Cu	1.0	0.19	0.57	0.02
Cr	1.0	0.00	0.00	0.00
Fe	5.0	0.62	2.90	0.30

The average concentrations of each heavy metal measured in the effluents from the three sites were compared with the Environmental Quality Act 1974, Environmental Quality (sewage and industrial effluents) Regulations, 1979, Malaysia, with parameter limits of effluents of standard B. All heavy metal concentrations detected in the batik effluents were below the standard limits (Table I).

TABLE II
Heavy metals concentration in plants growing around batik factories

Elements	Trace Elements in Plants [4] (ppm)	Site A (ppm)	Site B (ppm)	Site C (ppm)
Cd	5 – 30	0.11	0.02	0.01
Pb	30 – 300	0.20	0.23	0.25
Zn	100 – 400	0.80	1.00	3.90
Cu	20 – 100	0.17	0.21	0.22
Cr	5 – 30	0.58	0.21	0.10
Fe	*	14.79	30.99	51.54

*Do not mention by Kabata-Pendias, 2011

The average concentrations of each heavy metal measured in plants from the three sites did not exceed the critical limits of toxic concentrations in plants as proposed by [4].

The average concentrations of each heavy metal measured in the soil from the three sites were compared with U.S. EPA regulatory limits on heavy metals applied to soil, 1993. The results indicate that the average values of all the heavy metals were still within the standard limits.

Pearson's correlation showed that there were strong positive correlations between the concentrations of heavy metals in soil (0.931) and plants (0.933) with the concentrations of heavy metals in the batik effluents ($P<0.05$). This outcome indicates that the concentrations of heavy metals in soil and plants are influenced by heavy metals in batik effluents.

TABLE III
HEAVY METALS CONCENTRATION IN PLANTS GROWING AROUND BATIK FACTORIES

Elements	U.S. EPA regulatory limits on heavy metals applied to soil [7] (mg/kg or ppm)	Site A (ppm)	Site B (ppm)	Site C (ppm)
Cd	85	0.01	0.03	0.02
Pb	420	0.36	0.68	0.77
Zn	7500	1.00	5.11	2.63
Cu	4300	0.14	0.80	0.34
Cr	3000	0.36	0.19	0.55
Fe	*	164.47	196.82	321.81

*Do not mention by U. S. EPA

IV. CONCLUSION

Although concentrations of the heavy metals did not exceed critical limits of stipulated by national and international regulatory bodies, the value from the Pearson's correlation analysis showed that the concentrations of heavy metals in soil and plants were strongly influenced by the concentration of heavy metals in batik effluents. This may have been due to exposure from batik effluents which had been discharged without prior treatment. If this activity continues, it will sooner or later increase the concentration of heavy metals in the plants and soil around the batik factories.

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