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PERFORMANCEOF TAPIOCA STARCH IN REMOVING SUSPENDED SOLID, COLOUR AND AMMONIA FROM REAL PARTIALLY STABILIZED LEACHATE BY COAGULATION-FLOCCULATION METHOD

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ABSTRACT

The performance of natural coagulant made from tapioca starch (TS) on real partially stabilized leachate from Matang landfill was investigated. The percentage removals of suspended solid (SS), colour, chemical oxygen demand (COD) and ammonia under the influence of pH and dose by using coagulation-flocculation were recorded. The results revealed that the optimum values of pH and dose were 4 and 2.5 g/L Fe, respectively. At the optimum condition, 12%, 54.7% and 13.2% of SS, colour, and ammonia removals were achieved using TS. TS as a coagulant was able to remove SS, colour and ammonia from partially stabilized leachate. However, the removals obtained using TS were not as good as those obtained using the chemical coagulant.

Keywords: tapioca starch, natural coagulant, coagulation, flocculation, leachate.

INTRODUCTION

Leachate is a liquid flowing out from the landfill as a result of rainwater infiltration and liquid from the solid waste itself. It slowly percolates through the solid waste layer causing the infusion of the organic and inorganic components from the solid waste (Kiley, 1998). Leachate is classified as highly contaminated liquid waste. Usually, the colour is brownish and blackish with a pungent smell. Leachate contains high organic and inorganic elements, heavy metal and other hazardous substances.

The characteristic of leachate varies as the particular landfill ages, and it is related to biodegradability and degradation process of solid waste. Partially stabilized leachate is known as intermediate leachate. The partially stabilized leachate consists of lower amount of organic elements, heavy metals, and chlorinated organic compounds and inorganic salts compared to young leachate (Li *et al.* 2010a). Physical-chemical methods such as coagulation/flocculation are suitable to remove bio-refractory compound from intermediate and stabilized leachate (Abbas *et al.* 2009).

Chemical coagulant is the most commonly used coagulant in coagulation/flocculation treatment. To reduce the use of chemical coagulants, natural coagulants are the best alternative. Natural coagulants are environmentally-friendly materials that would not affect the health of humans and other living organisms.

Plant-based natural coagulant is derived from seeds, leaves, fruits, roots, and barks. However, the most common part of the plant used is the seed of plants (nirmali, grape seed, moringa oleifera)(Yin, 2010; Sutherland *et al.* 1994; Jeon *et al.* 2009; Beltran-Heredia *et al.* 2011). Natural coagulantis classifed as a polyelectrolyte, and can be specified as anionic and cationic depending on its source. Moringa oleifera and chitosan are sources of cationic coagulants, whereas tannin and grape seed are sources of anionic ones (Sutherland *et al.* 1994; Jeon *et al.* 2009; Beltran-Heredia *et al.* 2011; Ahmad *et al.* 2006).

Sources of natural coagulant include plants, minerals, and animals. Plant-based coagulants are popular because of their practicability and suitability for mass production. Natural coagulant is relatively cost effective, biodegradable, non-toxic, renewable, and produce less sludge (Muyubi et al, 2004, Yin, 2010; Jeon *et al.* 2009; Antov *et al.* 2010; Dwirianti, 2008; Ozacar and Senghil, 2003). Furthermore, NC has a wider effective dose range and does not alter the pH of treated water (Yin, 2010; Moussass and Zouboulis, 2009). However, the development of most natural coagulant applications has so far been confined to laboratories.

Tapioca is scientifically known as Cassava (Manihotesculenta Crantz) and commonly grown in Asia, South America and Africa (Munyikwa *et al.* 1997; Sriburi *et al.* 1999). Starch can be applied as a coagulant or flocculant by using its natural form or modified from. Starch destabilizes colloid through bridging mechanism (Bratby, 2005).

The applicability of TS in water, wastewater, and leachate treatment is still at its infancy. Thus, this study is an attempt to determine the ability of TS as a coagulantin removing suspended solid, colour and ammonia frompartially stabilized leachate under the influence of pH and dosage.

METHODOLOGY

Samples of partially stabilized leachate leachate were collected from Matang landfill site (MLS) located in Taiping, Perak, Malaysia. The sampling procedures for leachate were conducted according to the method of collection and preservation of the samples (APHA, 2005).

All the collected samples were immediately transported to the laboratory and stored in a cold room at 4 ^{0}C to minimize biological and chemical reaction. Prior to analysis, the samples were placed under room temperature for 2 hours. All parameters were measured according to the APHA standard method. The characteristics of the raw MLS leachates are shown in Table-1. The value of the BOD/COD ratio for MLS is 0.12–0.16. This value indicates that MLS is a mature landfill with partially stabilized leachates (BOD/COD>0.1) (Hong-Xiao and Stumm, 1987).

Jar test was conducted by using a jar test apparatus (SW6 Stuart, Bibby Scientific Limited, UK). The jar test was performed considering the factors listed in Table-2. NaOH (0.1 mol) and HCL (0.1 mol) were used to adjust leachate (500 mL) pH. Percentage removals of ammonia, colour and suspended solid were calculated by measuring concentration of aforesaid parameters before and after the jar test.

Table-1. Characteristics of raw leachate at MLS.

No.	Parameters	Value		#MEQA (1974)
		Range	*Average	
1	Temperature (^{0}C)	28-31	29	40
2	pH	7.96-8.17	8.1	6.0-9.0
3	BOD5 (mg/L)	60-184	109	20
4	COD (mg/L)	470-1261	770	400
5	SS(mg/L)	222-303	271	50
6	Ammonia-N (mg/L NH^3-N)	311-693	500	5
7	Total phosphorus (mg/L $PO^3{}_4$-TNT)	22-54	42	-
8	Iron (mg/L)	2.3-3.1	2.7	5
9	Turbidity(NTU)	15-41	28	-
10	BOD/COD	0.12-0.16	0.14	-

* Average of 12 samples taken from December 2011 to April 2012
# Malaysian Environmental Quality (Control of Pollution from Solid Waste Transfer Station Landfill) Regulations 2009, undertheLaws of Malaysia Environmental Quality Act (MEQA) 1974

Table-2. Optimum coagulation factors determined from preliminary experiment.

Coagulation factors	Unit	Value
Rapid Mixing speed	rpm	100
Rapid mixing time	minutes	4
Slow mixing speed	rpm	40
Slow mixing time	minutes	25
Settling time	minutes	60

RESULT AND DISCUSSION

The range of doses tested for TS was between 0 and 3 g/L (Figure-1). At the beginning, no increment of removal was recorded for SS, colour, and ammonia. However, at a dose of 2.5 g/L of TS, increment of colour and ammonia removals were recorded. As for colour, the removal became slightly better at 3 g/L of TS. For ammonia, the same removal percentage was recorded for 2.5 g/L and 3 g/L. Reduction of removal was recorded for SS after 1.5 g/L dose of TS and, at a dose of 3 g/L no removal was recorded. The primary removal of the natural polymer is not charge neutralization, but more into particle bridging and electrostatic patching mechanism (Bratby, 2006). At higher doses, the linkage produced bigger floc but weak floc strength. At a dose of 0.3 g/L, the applied shear strength during mixing probably broke the floc and increased the SS content in the leachate. According to Alias (2004), higher dose of polymer will envelope the suspended particle and it will remain in suspension, which increases the SS content. Based on the graph, a dose of 2.5 g/L TS was selected as the optimum dose of TS.

The range of pH tested for TS was 2-12 (Figure-2). Highest removal of SS and colour were found at pH 4 with 12% and 54.7% removal respectively. The sudden increment of colour removal was noted at pH 4, probably resulting from the pH adjustment process. However, just 13.2 % of ammonia removal was recorded at pH 4. The highest ammonia removal was at pH 12 with 32.8% removal. The increment of ammonia removal was recorded at pH >7. Adding NaOH results in chemical oxidation and precipitation during pH adjustment process and improves the removal of ammonia (Lo, 2012). The initial range of MLS leachate was 7.9-8.5. At this range, the removals by TS were minimal. Thus, the performance of TS without pH adjustment is not the best option. TS performed better underacidic condition for SS and colour.For ammonia, however, the highest removal was recorded at the base value. It is common for coagulants from a starch source to work at highly acidic and alkaline conditions (Lo, 2012). Overall, pH 4 was selected as the optimum pH for TS. Based on a series of TS jar test, it can be concluded that the removal of all parameters is considered low, except for ammonia. The removal of ammonia is probably because the negative charge of TS could attract the positive charge of ammonium and increase the removal ability.

Based on the optimization process, 12%, 54.7% and 13.2% of SS, colour, and ammonia were removed respectively at optimum pH 4 and optimum dose of 2.5 g/L. Alias (2004) found that at 0.2 g/L dose and pH 4, no removals of SS, turbidity, and COD were recorded for TS for semi aerobic leachate sample, and only 5.4% of colour removal was recorded by Alias (2004). Based on the findings of previous studies as well as of the present study, it can be concluded that TS is not able to achieve a high removal percentage of the pollutant if used as a single coagulant for leachate treatment.

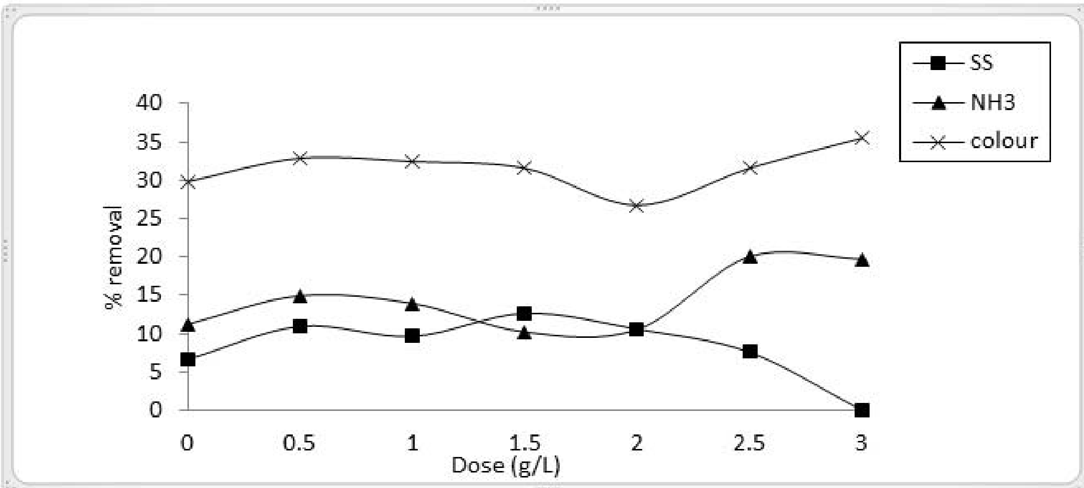

Figure-1. Application of TS on MLS leachate by varying dose and fixing the other factors (coagulant dose: 2 g/L, rapid mixing speed: 100 rpm, rapid mixing duration: 4 minutes, slow mixing duration: 25 minutes, slow mixing speed: 40 rpm, settling duration: 60 minutes and pH:5).

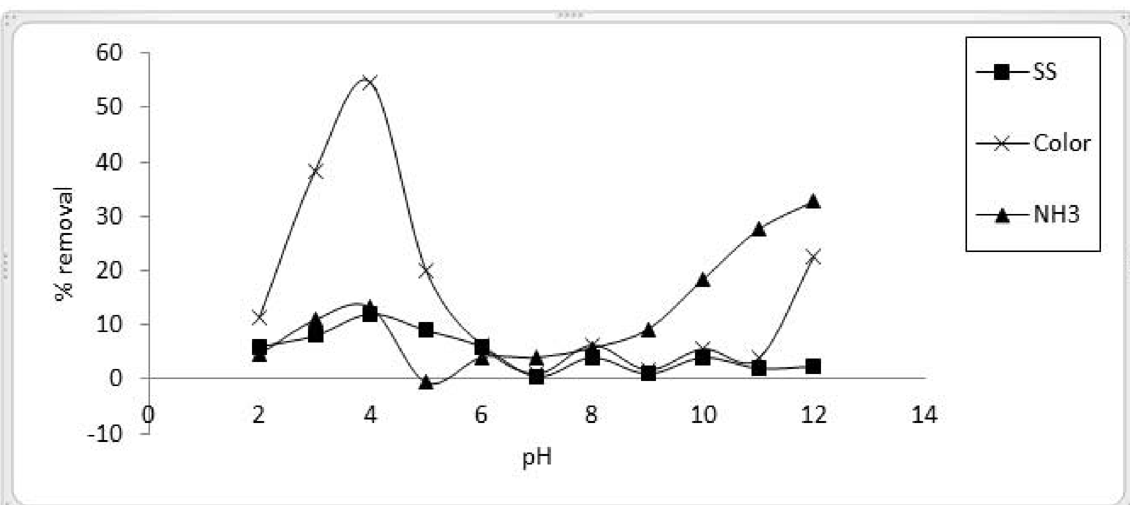

Figure-2. Application of TS on MLS leachate by varying pH and fixing the other factors (coagulant dose: 2.5 g/L, rapid mixing speed: 100 rpm, rapid mixing duration: 4 minutes, slow mixing duration: 25 minutes, slow mixing speed: 40 rpm, and settling duration: 60 minutes).

CONCLUSIONS

The optimization of the coagulation-flocculation process of TS on partially stabilized MLS leachates was investigated. The optimum values of pH and dose were 4 and 2.5 g/L, respectively. At the optimum condition, 12%, 54.7% and 13.2% of SS, colour, and ammonia were removed respectively. Based on this study it can be said that TS might not be the best coagulant compared to chemical coagulants, but it is still able to remove SS, colour and ammonia from partially stabilized leachate. Combining TS as acoagulant aid in future might improve the coagulation-flocculation performance.

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