# Peat Water Treatment by Two Stages Coagulation Processes Using Natural Clay Based Liquid Coagulant

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**Abstract:** ***This research is aimed to reduce the turbidity, organic substances and color of peat water using liquid coagulant based derived natural clays. The liquid coagulants were synthesizedby two steps processes which are calcination of natural clays on 700°C for 1 hour, and followed by extraction of calcined clays using a solution of 0.6 moles sulphuric acid at 80°C ($KLC_{80}$) and 100°C ($KLC_{100}$) for 2 hours, respectively. The liquid coagulants then characterized cations content using AAS method and pH. Afterward the liquid coagulants were used in a two stages coagulation process having coagulant-peat water rasio of 1:50; 1:20 and 1:10(V/V) respectively. It has found of both coagulants have a very acidic pH with nearly equal content of $Al^{3+}$ and $Fe^{3+}$. Investigation of two stages coagulation treatments of peat water using liquid coagulant has given a satisfactory finding on 1: 10 (V/V) rasio. As a result $KLC_{80}$ has proved on reducingpeat water turbidity 89.5%, organic substances 22.5% and 49.5% color, respectively, which there were higher than $KLC_{100}$does. The turbidity of post-coagulation process of peat water by$KLC_{80}$ and $KLC_{100}$ coagulants have fulfilled PERMENKES No.416/ MENKES/ PER/IV/1990on "Water Quality Requirements and Supervision" with values of 1.21 and 1.42 NTU.***

**Keywords:** liquid coagulant, natural clay, peat water, two-stages coagulation

## 1. Introduction

Natural clay is a potential local natural resources of Riau Province, one of which is Cengarclayswhich is located on the edge of Kuantan River of Cengar Village in Kuantan Singingi Regency. Cengar clay has been reported comprices of $Al_2O_3$ and $Fe_2O_3$ content of 14.73% and 1.01%respectively[1].The excistent of Al and Fe content makes the Cengar clay potential to serve as a liquid coagulant.

Several literatures have revealed that natural clay is used as an additional coagulant as followed. Having dosageof 15 mg/L Poly Aluminum Chloride (PAC)coagulant could eliminate the color equal to 63.7% and 47.2% ofCOD.The addition of wet clay doses of 20 mg/L increased the efficiency of color removal to 70.4% andCOD to 63%, respectively. On the use of alumcoagulant, removaloptimum of color and COD achieved at 40 mg/L doses are 24.8% and 27%. The addition of wet clays doseof 20 mg/L increased the efficiency of color removal to 32.1% and COD to 32.2%, resectively [2]. It is also revealed that the use of alum alone in the coagulation process is not very effective, but haveadded with clay which is easily dispersed into water makes the coagulation process more efficient [3].The use of clays as natural coagulants having the addition of auxiliary coagulants such as PAC has found proved an effectiveness in wastewater treatment.NaturalShendiclays and Lion clays which have added PAC have proved that each of them be able to remove 78.1% and 80.7% of color of wastewater [4]. The use of clay with the addition of PAC has an economical advantage so as to reduce the processing costs depending on the characteristics of wastewater.

The use of clay as the main coagulant in the coagulation process has been done in the Research Material Science Laboratory of FMIPA Universitas Riau. Cengarclay basedliquid coagulant for peat water treatment has been done [5]. The method used was Cengar clays were calcined at 700 ° C for 1 hour, followed by leaching the calcined clays with 0.2moles $H_2SO_4$ at 80 and 100 ° C for 2 hours. The research conducted in a two-stage coagulation process that has proved on reduce of color 92.78%, turbidity 99.86%, and organic matter 77.04%, respectively.This fact proved that natural clays act as independent coagulants in the peat water coagulation process and show high efficiency. The study also found that the turbidity parameter was met PERMENKES No.416 /MENKES /PER /IX /1990 on " Water Quality Requirements and Supervision".A study with the same calcination and leaching time have conducted, but the coagulation process was done in one stage [6].Apparently the coagulant can only reduce color as much as 6.3%, turbidity 13.2%, and organic substances 5.9%, respectively.But, the results of peat water coagulation reported by both researchers suggested that color and organic matter parameters are not yet fulfilled PERMENKES No.416 /MENKES /PER/IX/1990.Therefore, the study will focus on leach conditions using 0.6 mole $H_2SO_4$ with other conditions similar to previous researchers. The using of this leach concentration has obtained the concentration of $Al^{3+}$ and $Fe^{3+}$cation content were 28.1 mg/L and 26.8 mg/L, respectively [7].

## 2. Experimental Work

### Chemical and Instrument

The materials used were peat water samples originated from RimboPanjang Village, natural clay samplesoriginated from

DesaCengar, 98% $H_2SO_4$ (E-Merck), KMnO4 (p.a), $H_2C_2O_4.2H_2O$(p.a), Whatman filter paper No. 42, aluminum foil, buffer solution pH 4, 7 and 9. The instrument used are *Spectrophotometer Ultraviolet-Visible* (UV-Vis) *Genesys 10S*, *Atomic Absorption Spectrophotometry* (AAS) *Perkin Elmer 3110*, turbidimeter*HI 93703*, *Flocculator* VELP JLT4 (*jar test)*,pH meter *pen pH-009(I)*, *ovenHeraeus Instrument D-63450*dan*Memmert UNB 400(53L)*, *furnaceVULCAN A-130*, *magnetic stirrer*, balance of *Mettler Toledo AL 204*, *hotplate stirrer REXIM RSH-1DR L120*, sieve of 100 and 200 *mesh*, desiccator*CSN Simax*, wooden mortars, sampling bottles and other glassware used in the laboratory.

**Preparation and Characterization of Liquid Coagulant**

Liquid coagulants are prepared by 2 steps i.e. natural clay calcination and leaching of the calcined clay. At the calcination stage, the clay washed with aquadest, dried, crushed, and sieved clay to sized of 100≤x≤200 mesh. The clay powder is dried 105ºC in oven for 1 hour and weighed (repeated to obtain constant weight). Furthermore, the clay was calcined in a muffle furnace at a temperature of 700 ºC for 1 hour. At the leaching stage, 50 g of calcined clay was extracted with a 600 mLof solution0.6 mol $H_2SO_4$while heating over an hot plate stirrer having a stirring speed of 700 rpm at 80 ºC ($KLC_{80}$) and 100 ºC ($KLC_{100}$) for 2 hour. The mixture was allowed to stand for ± 24 hours to have solids precipitate and filtered using Whatman no. 42. The filtrate obtained is a liquid coagulant and then is used for the treatment of peat water. Liquid coagulants are measured of pH and the content of $Al^{3+}$, $Fe^{3+}$, $Na^+$, $K^+$, $Ca^+$, and $Mg^+$cations using Atomic Absorption Spectrophotometry (AAS).

**Two Stage Coagulation Process of Peat Water**

On preperation, peat water test samples taken from the location of DusunTigoRimboPanjang. Water sample on the site were taken from base, center and surface parts, and then allthree sample parts are composited in a sampling bottle and measured pH. Peat water is put into a polyethylene bottle that has been rinsed with peat water. Then the polyethylene bottle is wrapped with aluminum foil and put into a box containing ice cubes, taken to the laboratoryand preserved by stored in the refrigerator. Water parameters such as turbidity, organic matter, color, and pH are measured.

The liquid coagulants of $KLC_{80}$ and $KLC_{100}$ are contacted with peat water using a ratio of coagulant: peat water (V/V) 1:50, 1:20 and 1:10. Half of the coagulant volume (according to the ratio above) is added to 500 mL of peat water for initial coagulation. The coagulation process was performed using a test jar with a speed of stirring of 160 rpm for 2 minutes and 40 rpm for 10 minutes. The mixture is allowed for ± 24 hours. The parameters of turbidity, organic matter, color, and pH of post-coagulation peat water were determined. Coagulation proceeds to the second stage by adding half the remaining coagulant volume by means and the same parameter analysis as the initial step. All values of peat water parameters obtained were compared to PERMENKES No. 416/MENKES/PER/IX /1990.

## 3. Results and Discussion

### 1) Characterization of liquid coagulant

The pH and cation content of coagulant results were presented in Table 1.Liquid coagulants are formed from the reaction between the trivalent metal cation and the strong acid [7].The use of 0.6 moles of $H_2SO_4$ as a leachate solution of natural clay produces a liquid coagulant containing $Al_2(SO_4)_3$ and $Fe_2(SO_4)_3$, since the clays contain alumina oxide and silica[1].

**Table 1:** Cation concentration and pH of liquid coagulant

| Coagulant | Concentration ($mgL^{-1}$) | | | | | | pH | Fe/Al |
|---|---|---|---|---|---|---|---|---|
| | $Al^{3+}$ | $Fe^{3+}$ | $Na^+$ | $K^+$ | $Ca^{2+}$ | $Mg^{2+}$ | | |
| $KLC_{80}$ | 2,13 | 0,48 | 0,15 | 1,67 | 0,15 | 3,98 | 1,2 | 1: 4 |
| $KLC_{100}$ | 2,03 | 0,54 | 0,24 | 1,67 | 0,08 | 4,38 | 1,0 | 1: 4 |

$KLC_{80}$: natural clay based liquid coagulant, leaching on80 °C for 2 hours
$KLC_{100}$ :natural clay based liquid coagulant, leaching on100 °C for 2 hours

The use of $H_2SO_4$ as a leachate in over acid conditions can increase the amount of $Al^{+\ 3}$which reacted with $H_2SO_4$.According to voltaic series, Al which is farther away from H is more reactive than Fe which is closer to H [8], due tothe amount of$Al^{+\ 3}$more extracted than $Fe^{3+}$ in to liquid coagulant. The amount of Al and Fe cations generated in the $KLC_{80}$ and $KLC_{100}$ coagulants is almost the same, although with different leaching temperature. As a result both liquid coagulants also have the same ofFe /Al ratio. In addition, the $Mg^{2+}$cation content in both coagulants is twice aslarger than the $Al^{3\ +}$cation. In addition to the presence of montmorillonite minerals in the raw material of natural Cengarclay [1], sulfuric acid is also more strongly attracting Mg ions out of the montmorillonite framework than the Al and Fe cations. Another fact that the inclusion of small amount of $K^+$ cation into the liquid coagulants derives from the dissolution of the $K^+$cationof the muscovite mineral present in the clay.The mutual existence of monovalent $K^{+,}$ divalent $Mg^{2\ +}$ and trivalent $Fe^{3\ +}$cations is suspected to interfere with the destabilization of colloidal particles in the water by their own trivalent cations.

The resulting coagulant has a very acidic pH, whether leached at 80 or 100 °C for 2 hours. The highly acidic of the coagulants of this study is not much different from other coagulants made from the same clay as the leach solution of 0.2 moles $H_2SO_4$[6]. The acidic coagulants are also suspected to be supported by excess sulfur content in the coagulant [10].

### 2) Characteristic of Peat Water

In Table 2has presented the characteristics of early peat water taken during hot weather (dry season). High color content in peat water is presumed by a high content of organic substances as well. In the peat water organic substances foundhumic acid, fulvic acid and humin so as to give the brownish red of watercolor. On the contrary with high organic acid content causes very acidic water conditions with low pH. More concentrated colors occur due to the binding of Mn or Fe cations to organic molecules in the form of soluble compounds.

**Table 2:** Characteristic of peat water and benchmark standards

| Parameters | Characteristic of peat water | PERMENKES No.416/ MENKES/PER/ IV/1990 |
|---|---|---|
| Color (TCU) | 1280 | 15 |
| Organic substances ($mgL^{-1}$) | 252,8 | 10 |
| Turbidity (NTU) | 11,51 | 5 |
| pH | 2,4 | 8,5 |

The turbidity of peat water is belived comes from sand, mud and organic acids. Another thing that causes high turbidity levels in peat water is that surface charge in a similar (negatively charged) colloid causes the ionic strength in peat water to be low so that the colloidal particles will remain stable and difficult to settle. Based on the Table 2, the parameters of color, turbidity, organic matter and pH of peat water crossed the threshold of PERMENKES No.416 /MENKES/PER/IV/1990. Therefore, peat water is not feasible to be used as a source of clean water, so that innevitably required processing, which in this research will be done two-stage coagulation process.

**3) Coagulation of peat water by liquid coagulants**

The results of the two-stage coagulation process on peat water presented in Figure 1for $KLC_{80}$ coagulant and Figure2 for $KLC_{100}$ coagulant. Given the Al and Fe cation content of the $Al_2(SO_4)_3$ and $Fe_2(SO_4)_3$coagulants, the colloidal particles of negatively charged peat water will bind to the cation of coagulant so that the charge is destabilized. Negative charge on peat water is unstable because of the repulsive force to form an aggregate in peat water, which is ultimately easier to separate.

According to the two figures, the greater the coagulant volume used in the coagulation process, the efficiency is increasing and applicable at each coagulation stage.This condition is supported by the amount of Al and Fe cations possessed by each coagulant. The greater the volume used, the more Al and Fe cations are involved.These two cations play a role in the neutralization and destabilization of colloidal particles in peat water.

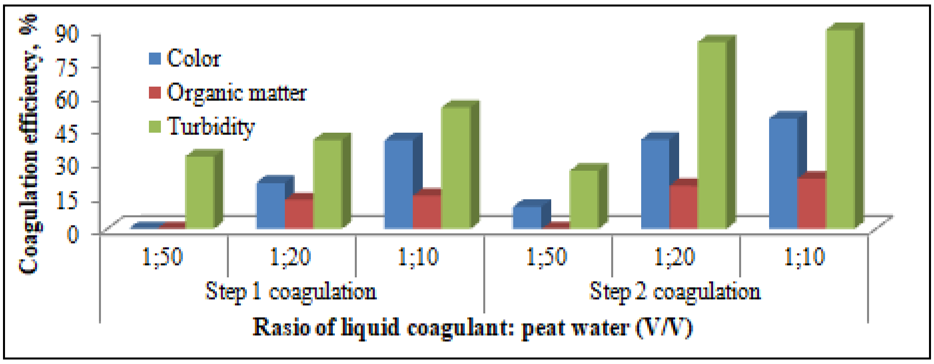


**Figure 1:** Efficiency of coagulation process of peat water by $KLC_{80}$ coagulant

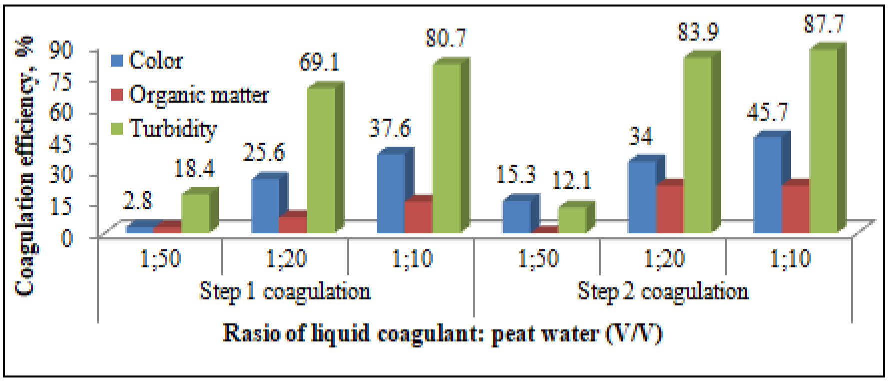


**Figure 2:** Efficiency of coagulation process of peat water by $KLC_{100}$ coagulant

From the two stagescoagulation performed, proved that afterthe second stage coagulation the value of the peat water parameter decreased, or coagulant working efficiency increased. The phased coagulation process is only capable of excluding hydrophobic organic particles, because the hydrophilic particles are bound very strongly with the water medium [11]. To exclude these hydrophilic organic particles requires a further coagulation step. Based on Figures 1 and 2, two-stage post-coagulation peat water not only showed reduced organic compounds, but also decreased color and turbidity parameters eventhough the turbidity of post-coagulation peat water has met PERMENKES No.416 / MENKES / PER / IV / 1990.

Based on Figure 3, it is shown that the coagulant obtained on the leaching temperature of $80^oC$ ($KLC_{80}$) is more efficient than leaching at $100^oC$ ($KLC_{100}$). This is occured because the Al cation content is much more in $KLC_{80}$ than $KLC_{100}$, thus further act on destabilizing colloidal particles from peat water.

## 4. Conclusion

1) Natural clay-based coagulant was able to overcome the condition of peat water, by decreasing turbidity of 89.5%; color 49.5% and organic substances 22.5% through two-stage coagulation on liquid coagulant : peat water ratio of 1: 10 (V/V).
2) Liquid coagulants made with leaching temperature at 80 °C are more effective than 100 ° C. Both coagulants have a ratio of Al / Fe 1: 4.
3) Parameter of turbidity is most influentialed by both coagulant, $KLC_{80}$ and $KLC_{100}$. Turbidity of post-coagulation peat water has met PERMENKESNo.416/ MENKES/ PER/IV/
4) 1990on "Water Quality Requirements and Supervision".

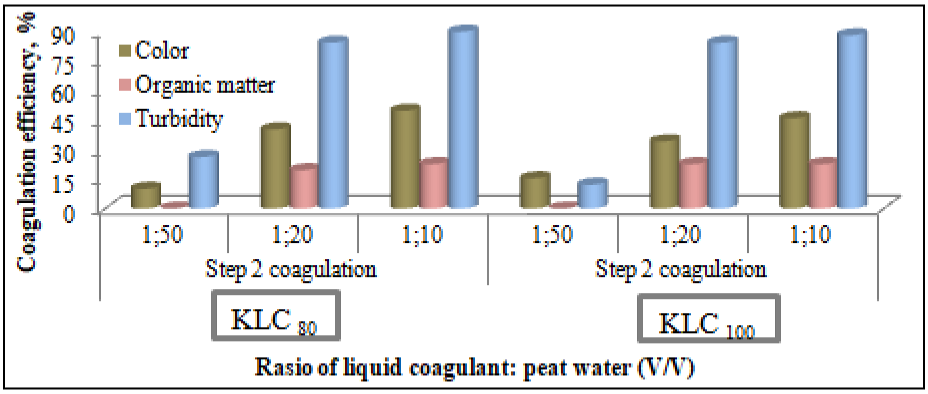


**Figure 3:** Comparison of coagulation efficiency of peat water by coagulant $KLC_{80}$and$KLC_{100}$

## References

[1] Muhdarina., 2011. Pencirian Lempung Cengar Aslidan Berpilarserta Sifat Penjerapannyaterhadap Logam Berat. *Disertasi*. PerpustakaanTun Seri Lanang. Universiti Kebangsaan Malaysia.
[2] Zahra, N danNotodarmojo, S. 2012. Aplikasi Lempung Lokalsebagai Koagulan Pembantudalam Menyisihkan Senyawa Organik Zat Warna Tekstil.*Skripsi*. JurusanTeknikLingkungan FT, ITB, Bandung.
[3] Obaje, S.O., Omada, J.I., and Dambatta, U.A. 2013.Clays and Their Industrial Applications: Synoptic Review. *International Journal of Science and Technology*.3(5): 264-270.
[4] Awad, M., Li, F., and Hongtao, W. 2013.Application of Natural Clays and Poly Aluminium Chloride (PAC) for Wastewater Treatment.*IJJRS*.5(2): 287-291.
[5] Muhdarina.Linggawati, A. Yanti, P.H. 2016a.,PotensiLempungAlam Daerah Aliran Sungai (DAS) Kuantansebagai Koagulandan Resin Penukar Ion (Tahun 4). *Laporan Hasil Penelitian Unggulan PerguruanTinggi*. Universitas Riau(Documentation).
[6] Muhdarina, Bahri,S. Linggawati,A, Yanti, P.H. Anggraini, N. Nopiyani,S. 2016b.,Penggunaan KoagulanCair Dan Adsorben Berbasis Lempung AlamUntukPengolahan Air Gambut, *Prosiding Seminar Nasional Kimia*, Lombok,10-11 Agustus 2016, 356-368.
[7] Muhdarina, Bahri, S, Nurhayati, Amri, T.A, Hamid, A. 2013, Sintesis Koagulan Cair Berbasis Lempung Alam Cengar, *Prosiding Semirata FMIPA* Universitas Lampung,269-273.
[8] Wang, L.K., Hng, Y.T. dan Shamas, N.K. 2007. Physicochemical Treatment Processes.*Handbook of Enviromental Engineering*. Humana Press, Totova.
[9] Darnas, Y. 2013. EkstraksiAluminiumdari Tanah LempungGambutsebagaiKoagulanCair.*JurnalTeknikLin gkungan*. 10(1): 11-19.
[10] Amir, R. 2010. Penentuan Dosis Optimum Aluminium Sulfat Dalam Pengolahan Air Sungai Cileueur Kota Ciamis dan Pemanfatan Resirkulasi Lumpur Dengan Parameter pH, Warna, Kekeruhan, dan TSS. *Jurnal*. Fakultas Teknik, ITB.
[11] Sharp, E.L., Parsons, S.A., and Jefferson, B. 2006. Coagulation of NOM: Linking character to Treatment. *In Proceedings of: IWA Particle Separation Conference*. Seoul, Korea.

## Author Profile

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