Natural coagulant of laban wood (Vitex pubescens Vahl) for turbidity water treatment

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Abstract. The groundwater physical condition in Sleman Regency, Indonesia is generally cloudy and contains high amount of iron (Fe) so it is not sufficient to use for daily needs drinking water. High levels of Fe are dangerous for humans. This study aims to process and purify ground water and reduce iron content using laban wood (Vitex pubescens Vahl). This media was chosen because it is a local waste furniture industry in Sleman Regency. Indeed, it is conducted as charcoal. Then, the charcoal is chemically activated by soaking with H2SO4 for 24 hours. Furthermore, it is activated physically by heating up to 120°C for 30 minutes. Laban wood (Vitex pubescens Vahl) activated charcoal was characterized using UV-Vis to determine iron (Fe) levels after filtration. In addition, the filtration water is measured using a pH meter to determine the degree of acidity, TDS meter and the efficiency of light transmission to determine the turbidity. To summarize, Laban wood activated charcoal was effectively used as a filtration media. It gives an effect for increasing the light transmission efficiency, decreasing TDS value, and absorption of iron (Fe) levels efficiency. However, it does not affect the pH value. The highest light transmission efficiency value is found in the composition of laban activated charcoal which is equal to (6.91 ± 0.005)% at a mass of 500 grams. As for the TDS value, the highest decrease in TDS value was TDS value of (140.0 ± 0.5) ppm when it was 500 grams. The highest efficiency of absorption of iron content is found in the composition of laban activated charcoal which is equal to Fe to (87.27 ± 0.2)%.

1. Introduction
Water is the most vital element of the natural resources [1,2]. Water quality is concern on human life due to the uses for cooking [3-9], drinking [1,4-7,9-30], laundering [5,31] and bathing [4,6,7,10,32-34]. Moreover, drinking water is a vital natural resource for all human beings [5,24]. However, accessing the clean drinking water is a crucial issue throughout the world especially in many developing countries [1,5,11]. Some of developing countries mostly pay a high attention and cost to solve water turbidity [1,5,18,20,23,29,35] since there are negative effects of iron and other chemicals compound in the water [28,35]. The more iron salt grade, the more treated water is triggered the...
diseases [3,6,7,11,13,15]. Aluminum salts is known concerning the Alzheimer's disease [5,13], strong carcinogenic properties [6,12,14,35,37] and other serious problem diseases [35]. Therefore, there has been considerable interest for applying the natural coagulants to decrease Fe and Al salt in water.

This phenomenon critically happens in some area of Indonesia [38]. Based on local observations in Sleman Yogyakarta, the groundwater condition is highly polluted [30,39] due to it has turbid and slightly yellowish [6,20,28,40,41]. A lot of people lack clean and safe water [5]. In the case of Sleman, the rapid migration worsens the tremendous load on water consumption there [38]. Somehow, the real effort of producing potable water from both surface water and ground water involves treatment steps to remove the unwanted substances [28]. Indeed, water treatment process is so important avoiding possible water borne diseases [5] due to the more turbid water will be attacked responsibly.

Even though ground water is the main source of water for the community Sleman Regency, Yogyakarta to fulfill daily needs [30]. The ground water or well water is the raw material for drinking water for the local community. Wells are the main source of clean water supplies for residents living in rural and urban areas of Indonesia [9,17,30,42]. Turbid and yellowish water indicates that the water has a high metal content [23,29,40]. Even though the levels of metal Fe which are quite high are dangerous [11,15,32]. They are used to meet their daily needs, especially as raw material for drinking water [16]. According to RI Minister of Health Regulation No. 492/Menkes/Per/IV/2010, the quality requirements of drinking water must meet the requirements of physics, chemistry (organic and inorganic), microbiology and radioactivity requirements [30,43]. According to the maximum level of drinking water allowed for iron is 0.3 mg/L, pH 6.5-8.5 and turbidity 5 NTU [44].

One of various efforts of the Sleman area is reducing Fe content to ground water have been carried out [45]. One of the efforts is the alum provision. However, it is not sufficient to overcome the problem of high Fe content in the area [30,45]. Therefore, a filtration medium is needed which utilizes local industrial waste to overcome the decrease in iron (Fe) levels [36,45].

On the other hand, the proliferation of wood furniture industries in the Sleman area is able to produce 1307 products / month [38]. The industry uses various types of wood, including jackfruit wood, sour wood and laban wood (Vitex pubescens Vahl). The high productivity of the furniture industry triggers a pile of wood waste [14,46]. The amount of wood waste in Sleman Regency reaches 10% has many adverse impacts, such as air, water and land pollution [47].

Laban wood is the raw material for making frames and joglo houses because it is easily obtained and has a strong class II and durable class I-II [48]. After the production process, laban wood waste is mostly disposed of by wood craftsmen, even though this local industrial waste contains an average water content of 21.15%, an average juice content of 0.4889%, carbohydrates, minerals and proteins has a lot of potential to developed. One of them is activated charcoal [48-50] which has a high absorption of Fe [49]. Therefore, to overcome the problem of water in Sleman Regency, a creative alternative solution is needed in the form of an effective and practical water purifier binding iron (Fe) ions in the media of local furniture industry waste in the form of laban wood.

2. Methodology of research
This study uses quantitative methods. It was held in Sleman Regency, Yogyakarta.

2.1. Preparation of laban wood charcoal (Vitex pubescens Vahl)
For the filtration media, laban wood is carried out by pyrolysis. Pyrolysis is the charcoal making process from wood without oxygen by using a closed drum and using a cloth / tarpaulin so that the drying does not continue with ignorance [9]. Furthermore, Laban wood charcoal is processed and sifted using 6 mesh sieves to form a granule. After that, Laban wood charcoal is activated chemically and physically. In chemical activation, activated charcoal laban is then immersed in H2SO4 solution with a concentration of 40% for 24 hours to obtain charcoal with optimal filtration power. Physically, Laban wood charcoal was activated using 120°C for 30 minutes. After the activated charcoal laban was finished, testing of the quality of water control consisted of: testing of turbidity levels, pH and
iron (Fe) levels for each filtration material and testing variations in the mass of laban wood charcoal to decrease in iron (Fe).

2.2. Testing of turbidity, pH and iron (Fe) levels for each filtration material
To find out the ability of Laban wood charcoal in overcoming turbidity, pH and iron (Fe) levels, then Laban wood activated charcoal is inserted in a burette with a volume of 50 mL which is connected to the stool, then water is put into the burette until full. After that, the burette faucet was opened so that the sample water from the test with a variation of 5 laban wood charcoal can be obtained. The filtering results were measured for quality by using Lux meters and TDS meters to measure turbidity, pH meters for acidity and UV-Vis spectrophotometry to determine iron content. To find out the efficiency of light transmission can be calculated by the equation as follows:

\[
E_T = \frac{I_t}{I_{max}} \times 100\%
\]  

With \(E_T\) is the efficiency of light transmission (%), \(I_t\) is the measured intensity of light filtering (lux), \(I_{max}\) is the final concentration of waste according to the maximum light intensity of mineral water of 43.3 (lux).

2.3. Test the variation of laban (Vitex pubescens Vahl) wood charcoal against a decrease in iron (Fe) content
To find out the best amount of laban wood charcoal in iron (Fe) reduction, a mass variation of laban wood was carried out 5 times in the range 100 – 500 g as it can be seen in figure 1. The water collected in the 5th pipe measured iron (Fe) using UV spectrophotometry -Vis. To determine the decrease in iron content can be calculated by the formula of absorption efficiency of iron levels as follows:

\[
E_p = \frac{(A_o - A_t)}{A_t} \times 100\%
\]  

With \(E_p\) is the efficiency of absorption of iron (%), \(A_o\) is the initial concentration of waste before the filtration process (mg/l), \(A_t\) is the final concentration of waste after the filtration process (mg/l). The water quality control test aims to determine turbidity, pH and iron (Fe) levels in water in Caturtunggal Village, Depok District, Sleman Regency, Yogyakarta which cannot be visually observed. Testing the clean water control quality Sleman Regency is carried out with turbidity parameters, pH levels and iron (Fe) levels in accordance with the REGULATION of the MINISTER OF HEALTH Number: 416/MEN> KES/PER/IX/1990.

3. Result and discussion
Testing the iron content of groundwater in Sleman Regency, Yogyakarta showed that iron (Fe) before filtration was 2.15 mg/L. The high level of iron (Fe) causes the water colour to be yellowish, smelling metal, and cloudy.

3.1. Testing the level of turbidity, pH and iron (Fe) levels for each filtration material
3.1.1. Light transmission efficiency. The intensity of light transmission of mineral water is calculated in advance to determine the maximum intensity of clean water. The measured \(I_{max}\) = (43.3 ± 0.6) lux. The results of the efficiency of light transmission from the water the filtration process for the five various types of Laban wood shows in figure 1. It generates that it can be seen the efficiency of light transmission from wood activated Laban charcoal. The results of the efficiency of light transmission from activated Laban wood charcoal showed an increase in mass of 100 grams to 500 grams. Your active charcoal adsorbent has experienced an increase in the efficiency of the light transmission of each mass increase. The results of the efficiency of light transmission of activated charcoal from
Laban amounted to (96.9 ± 1)\% at a mass of 500 grams.

**Figure 1.** Effect of Laban wood charcoal mass \((Vitex pubescens Vahl)\) adsorbent on light transmission efficiency.

**Figure 2.** Effect of laban wood adsorbent mass \((Vitex pubescens Vahl)\) on total solute.

### 3.1.2. Total Dissolved Substance (TDS)

The total dissolved solids (TDS) from Samirono Hamlet, Caturtunggal Subdistrict, Depok Subdistrict, Sleman Regency, Yogyakarta were measured in advance to determine the initial conditions. From the results of the measurement obtained a value of \((182.0 ± 0.5)\) ppm. For water from the filtration process using the four types of adsorbent is presented in figure 2.

Figure 2 signify that TDS values obtained from the four types of adsorbent. The TDS results from the filtration process water using Laban wood activated charcoal decreased in the mass of 100 grams to 500 grams. The total dissolved solids from the wood adsorbent Laban showed a decrease along with the increase in mass adsorbent. The highest decrease in TDS value of TDS is \((140.0 ± 0.5)\) ppm when it has a mass of 500 grams.

### 3.1.3. Degree of acidity (pH)

The degree of original acidity of the clean water of Sleman Regency, Yogyakarta was measured first. The degree of acidity (pH) is initially equal to \((7.1 ± 0.05)\). After filtering, the results of filtration using laban wood, zeolite, active sand and coconut fiber were presented in the following table 1.

**Table 1.** Effect of laban wood mass adsorbent on acidity (pH).

| Adsorbent Mass (g) | pH       |
|--------------------|----------|
| 100                | 6.91±0.005 |
| 200                | 6.91±0.005 |
| 300                | 6.91±0.005 |
| 400                | 6.91±0.005 |
| 500                | 6.91±0.005 |

Based on table 1, the acidity of clean water after filtration using the four types of adsorbent with various variations of mass shows a constant pH, which is equal to \((6.91 ± 0.005)\). This shows that the administration of adsorbent does not affect the change in pH. Constant water pH may be due to the condition of acidity in clean water still in good condition and in accordance with clean water quality standards in accordance with the MINISTER OF HEALTH REGULATION Number: 416 / MENKES / PER / IX / 1990.

### 3.2. Absorption of Iron Content by Adsorbent Type

The iron content of raw water is \((2.150 ± 0.005)\) mg / L. For the results of the filtration process, each change in mass adsorbent is presented in the following figure 3.
Figure 3. Effect of mass type on iron content adsorbent.

Figure 3. Evidence that the results of the fitting in the graph show that the iron content equation for changes in mass in the form of linear \( y = mx + c \), which is \( y = -0.0002x + 0.319 \). In the volume range that has been determined in the study, if the value of X increases, the concentration of Fe will decrease further. Meanwhile, the efficiency of absorption of iron content is done by measuring the initial iron content in clean water that has not been treated \( A_0 \) and the iron content of the treatment \( A_t \) in figure 2.

Based on the result that laban wood adsorbent can reduce iron content effectively. Efficiency of absorption of iron (Fe) levels with active carbide wood carbide with a value of (87.27 ± 0.2)%.

The results also qualify as clean water with a threshold of 1 mg/l. This may be due to the structure and pores in activated charcoal having a high absorption of chemicals, waste and toxic substances, so that iron (Fe) can be absorbed properly.

4. Conclusion
The type and volume of adsorbent influences the efficiency of light transmission, TDS, and the efficiency of absorption of iron (Fe). But it does not affect the value of acidity (pH). In a variety of mass adsorbents, the greater the mass of the adsorbent, the greater the light transmission efficiency. The highest efficiency of light transmission is found in the type of adsorbent activated charcoal laban which is equal to (96.9 ± 1)% at a mass of 500 grams. As for the TDS value, the more mass adsorbents used, the more TDS decreases. The highest decrease in TDS value of TDS is (140.0 ± 0.5) ppm when it has a mass of 500 grams. The mass adsorbent did not affect the acidity (pH), because from the measurement results of the three adsorbent types showed a constant value of (6.91 ± 0.05). Laban wood activated charcoal is able to be used to reduce iron content up to (87.27 ± 0.2)%.

So that the active charcoal of laban wood can be used to reduce iron (Fe) levels according to water requirements net stipulated by Minister of Health Regulation Number 416 / MENKES / PER / IX / 1990.

References
[1] Asrafuzzaman M, Fakhruddin A N M and Hossain M A 2011 Reduction of turbidity of water using locally available natural coagulants Int. Scholarly Res. Netw. 2011 1-6
[2] Ramezani O, Kermanian H, Razmpour Z and Rahmuminia M 2011 Water consumption reduction strategies in recycled paper production companies in Iran CEUR Workshop Proc. 1152 865-77
[3] Abbaspour N, Hurrell R and Kelishadi R 2014 Review on iron and its importance for human health J. Res. Med. Sci. 19 164-74
[4] Baker B H, Omer A and Aldridge C A 2013 Water availability and use Water Resources of North America (Berlin Heidelberg: Springer-Verlag) pp 163-174
[5] Binayke M S R A and Jadhav M V 2013 Application of natural coagulants in water purification Int. J. Adv. Technol. Civil Eng. 2 118-23
[6] Glass B R L, Brabets T P, Frenzel S A, Whitman M S and Ourso R T 2001 Water quality in the cook inlet basin Virginia: U.S. Geological Survey Retrieved from http://www.usgs.gov/%0A

[7] Pimentel D, Berger B, Filiberto D, Newton M, Wolfe B, Karabinakis E and Nandagopal S 2017 Water resources: Agricultural and environmental issues BioScience 54 909-18

[8] Sinani V, Sana M, Seferi E and Sinani A 2004 The impact of natural water quality on baking products in Albania J. Water Resour. Protect. 6 1659-65

[9] Suparno and Besty F M 2013 Coconut shell activated carbon as an alternative sedimentation agent in water purification system Acad. J. Sci. 2 111-7

[10] Ajibade F O, Adewumi J R, Ojo O M, Babatola J O and Oguntuase A M 2015 Issues, challenges and management of water supply and sanitation in Nigeria: An overview 2015 Conf. Proc. National Development Strategies Toward Sustainable Civil Infrastructure pp 16-43

[11] Aryal J, Gautam B and Sapkota N 2012 Drinking water quality assessment J Nepal Health Research Council 10 192-6

[12] Bakır B, Babayigit M A, Tekbaş Ö F, Oğur R, Kılıç A and Ulus S 2015 Assessment of drinking water quality in public primary schools in a metropolitan area in Ankara, Turkey Int J Health Sci. Res. 5 257-66

[13] Campbell A 2002 The potential role of aluminium in Alzheimer’s disease Nephrology Dialysis Transplantation 17(2) 17-20

[14] Chien H L, Liu L-T and Noburu F 2017 Source water purification of bamboo activated carbon prepared from bamboo charcoal by using the multi – layer filtration method J. Fac. Agr. Kyushu Univ. 62 459-67

[15] Crisponi G, Fanni D, Gerosa C, Nemolato S, Nurchi V M, Crespo-Alonso M and Faa G 2013 The meaning of aluminium exposure on human health and aluminium-related diseases Biomol. Concept. 4 77-87

[16] Gupta V B, Anitha S, Hegde M L, Zecca L, Garruto R M, Ravid R and Jagannatha Rao K S 2005 Aluminium in Alzheimer’s disease: Are we still at a crossroad? Cell. Mol. Life Sci. 62 143-58

[17] Islami N, Nor M and Rahmad M 2015 Physical and chemical characteristics interpretation for groundwater quality assessment in the coastal area, North Kelantan, Malaysia J. Manusia Dan Lingkungan 22 281-8

[18] Kotlarz N, Lantagne D, Preston K and Jellison K 2009 Turbidity and chlorine demand reduction using locally available physical water clarification mechanisms before household chlorination in developing countries J. Water Health 7 497-506

[19] Sarkar P, Das S, Abbay T, Joshi V and C Vinay 2017 Effect of Proximity to Polluted Lake on Groundwater and Air Quality of Adjoining Areas 5(3)179-188

[20] Pastay P, Koppad V and Keerthi Gowda B S 2017 Application of natural coagulants in removal of turbidity and hardness Conf. ICGCSC March 2017 (Moodnidri, India: Mangalore Institute of Technology & Engineering) pp 344-6

[21] Pimentel D, Berger B, Filiberto D and Newton M 2004 Water resources: Agricultural and environmental issues BioScience 54 909-18.

[22] Primawati F S and Suparno 2016 The groundtank lppmp uny water purification system as drinking water by utilizing coconut shell activated carbon, Indrayanti beach activated sand and Krakas River activated gravel Jurnal Fisika 5 169-78

[23] Ramavandi B 2014 Treatment of water turbidity and bacteria by using a coagulant extracted from Plantago ovata Water Resour. Ind. 6 36-50

[24] Rout C and Sharma A 2011 Assessment of drinking water quality: A case study of Ambala cantonment area, Haryana, India Int. J. Environ. Sci. 2 933-45

[25] Siong Y K, Idris J and Atabaki M 2013 Performance of activated carbon in water filters Water Resour. January 2013
Siwar C and Ahmed F 2014 Concepts, dimensions and elements of water security Pakistan J. Nutr. 13 281-6

Suparno and Mumpuni W S 2013 Coconut cell activated carbon as sedimentation agent in water purification system Acad. J. Sci. 2 483-90

Sweetman M J, May S, Mebberson N, Pendleton P, Vasilev K, Plush S E and Hayball J D 2017 Activated carbon, carbon nanotubes and graphene: Materials and composites for advanced water purification J. Carbon Res. 3 1-29

Vicky K, Norzila O and Syazwani A 2017 Applications of natural coagulants to treat wastewater – A review MATEC Web of Conferences Malaysia 103

Wijayanti Y, Yuniasih B, Verma N, Krisdiarto A W and Safitri L 2018 Groundwater quality mapping of Yogyakarta City, Sleman, Kulonprogo and Bantul regency area of Yogyakarta Province Earth Environ. Sci. 1951-10

Cameron B A 2011 Detergent considerations for consumers: Laundering in hard water — How much extra detergent is required? J. Extension 49 1-11

Suprihatiningsih W, Izzati T and Santoso B 2018 Analysis of groundwater quality in industrial of Bekasi regency and residential of Bekasi City, West Java, Indonesia Mat. Sci. Eng.45 31-7

Taufiqurahman, Harsono T, Barakbah A, Tamami N and Romadhon M S 2019 Water contaminant measurement using pollution indexing in case of ground water Iconiscse 1196 1-12

Barloková D and Ilavský J 2010 Removal of iron and manganese from water using filtration by natural materials Pol. J. Environ. Stud. 19 1117-22

Muda CA H Birima, Hammad H A, Desa M N M and Muda Z C 2013 Extraction of natural coagulant from peanut seeds for treatment of turbid water Earth Environ. Sci. 16 1-4

Bermejo F and García-López S 2009 A guide to diagnosis of iron deficiency and iron deficiency anemia in digestive diseases World Journal of Gastroenterology 15 4638-43

Carver A and Gallicchio V S 2013 Heavy metals and cancer Austin Web of Science 29 1-19

Badan Pusat Statistik Kabupaten Sleman 2010 Kabupaten Sleman dalam Angka 2010 (Sleman: Badan Pusat Statistik) Available at https://doi.org/34044.1101

Nuranto S and Ali S 2018 Tinjauan Teknis Dan Ekonomi Beberapa Bahan Koagulan Untuk Pengolahan Air Minum Dengan Air Kali Progo Sebagai Air Baku Pada Spam Regional Yogyakarta, Sleman dan Bantul Jurnal Nasional Teknologi Terapan 2 244-54

Abdul F and Wasik H 2018 Analisa Penggunaan Beberapa Jenis Arang Lokal Sebagai Reduktor dalam Proses Pembuatan Besi Spon (Sponge Iron) dari Bahan Baku Pasir Besi Menggunakan Metode Reduksi Langsung Jurnal Iptek Media Komunikasi Teknologi 22 45-52

Santhosh C, Malathi A, Dhaneshvar E, Bhatnagar A, Grace A N and Madhavan J 2018 Iron oxide nanomaterials for water purification Nanoscale Materials in Water Purification Chapter 16 pp 431-446 (Elsevier Inc.)

Rozano B and Yan W 2018 Monitoring the transformation of Yogyakarta’s urban form using remote sensing and geographic information system Earth Environ. Sci. 148 1-12

Febrina L and Ayuna A 2015 Studi penurunan kadar besi (Fe) dan mangan (Mn) dalam air tanah menggunakan saringan keramik Jurnal Teknologi 7 35-44

Kementerian Kesehatan 2006 Peraturan Menteri Kesehatan RI 416/MENKES/PER/IX/2006 tentang syarar-syarar dan Pengawasan Kualitas Air 1-10

Kurniawati S D, Santjoko H and Husein, A 2017 Pasir Vulkanik sebagai Media Filtrasi dalam Pengolahan Air Bersih Sederhana untuk Menurunkan Kandungan Besi (Fe), Mangan (Mn) dan Kekeruhan Air Sumur Gali Jurnal Kesehatan Lingkungan 9 20-5

Rahmat B, Pangesti D, Natawijaya D and Sufyadi D 2014 Generation of wood-waste vinegar and its effectiveness as a plant growth regulator and pest insect repellent BioResources 9 6350-60

Purwanto A, Sriyono E and Sardi 2018 Assessing the potential of sleman tambakboyo retention
basin for raw water supply in Yogyakartai Rekayasa Teknologi Industri Conference 2(12) 373-5

[48] Wahyudi A 2014 Pertumbuhan Tanaman gaharu di areal perkebunan kelapa sawit Prosiding Seminar Nasional Mapeki XVII pp 257-63 Retrieved from http://www.mapeki.org/download/Prosiding-Seminar-Nasional-MAPEKI-XVII-Medan.pdf

[49] Kasmawarni 2013 Proses aktivasi arang kayu laban (vitex pinnata l) dengan cara pemanasan pada suhu tinggi Jurnal Litbang Industri 3 117-24

[50] Matilda F, Biyatmoko D, Rizali A and Abdullah A 2019 The improvement of quality of tofu industry wastewater effluent on activated sludge system with flow rate variation using ironwood (Eusideroxylon zwageri) activated charcoal Environ. Scientiae 12 207