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The Effect of Chicken Bones Powder Adsorbent Mass and its Contact Time on Reducing Color Concentration in Peat Water Treatment

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Abstract: Peat water is surface water or ground water which is found abundantly in tidal, swampy and lowland areas. It has a reddish-brown color, with an acerbic taste (high acidity), and has a high organic content. Peat water can be treated using the adsorption method. Adsorption is a physical phenomenon in which the molecules of the adsorbed material are attracted to a solid surface, which acts as an adsorbent. In this study, the authors used the adsorption method to reduce the color concentration of peat water using activated chicken bones powder as an adsorbent and observing the changes that occur when mass of powder to the amount of 0.1, 0.2, 0.3, 0.4, 0.5, 1.0, 1.5 and 2.0 grams were added to 50 ml of peat water with contact time that varied from 20, 30, 40, 50 and 60 minutes. From this study, we conclude that the optimum yield was obtained when the mass and contact time were at 0.5 grams and 40 minutes, which yield a percentage of reduction of 95.59%, wherein the initial color concentration of peat water at 337.816 was reduced to 14.89 Pt-Co, which is in line with the standard color for clean water as specified in a Regulation by the Minister of Health of the Republic of Indonesia No. 492/MENKES/PER/IV/2010, which state the standard color for clean water is 15 Pt-Co.

Keywords: Adsorbent Mass; Chicken Bones Powder Adsorbent; Contact Time; Peat Water Treatment; Reducing Color Concentration

Introduction

Peat water is surface water or ground water which is found abundantly in tidal, swamps and lowland areas. It has a reddish-brown color, with an acerbic taste (high acidity), and has a high organic content (Rahmi, 2022). Moreover, peat water has a low pH and a high heavy metal content, with high TSS, TDS, BOD and COD values (Naswir et al., 2019). In general, peat water does not meet the clean water quality requirements as regulated by the Indonesian Ministry of Health through the Minister of Health Regulation No. 492/MENKES/PER/IV/2010 (Rosita et al., 2019).

Before it can be used as a source of water for domestic purposes, peat water requires a special treatment (Rahmi, 2022). In general, the process and stages involved in peat water treatment are not much different from any other method for treating fresh water. The main issue in peat water treatment is related to its specific characteristics. Peat water has a reddish-brown color that is close to black (124-850 Pt-Co), has a high organic content (138-1560 mg/lt Kmn04), and is acidic (pH 3.7–5.3) (Rahmi, 2022). The color of peat water can classified into two types: true color, caused by dissolved materials, and apparent color, resulting from the presence of not only dissolved materials but also suspended matters, including those that are colloidal (Widiyanto et al., 2015). The color of peat water is the result of the decomposition of natural organic substances, i.e., humus (humus acid and fulvic acid),

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wherein lignin is a group of compounds that have similar properties.

Colored water can be treated using various methids, including oxidation, adsorption, coagulation-flocculation, and separation process with membrane filtration. The oxidation process basically works to remove iron or manganese content from the water, and the processing method must be adjusted to the specific iron and manganese compounds present in the water to be treated. The process of removing iron and manganese from water through oxidation can be done in three ways, i.e., oxidation with air or aeration, oxidation with chlorine (chlorination) and oxidation with potassium permanganate (Mardiansyah et al., 2021) The coagulation process is the process of adding chemicals to water so that impurities in the water in the form of suspended solids, for example organic dyes, fine mud, bacteria, etc., can coagulate and settle to the bottom quickly. There are a number of coagulant materials that can be used, including lime, alum, local clay, and moringa seed flour (Rahmi, 2022). The next step is the floc growth process, wherein the impurities are slowly stirred in the flocculator to coagulate and become stable, this process is called flocculation (Mardiansyah et al., 2021). Moreover, peat water can also be treated using the adsorption method. Adsorption is a separation process in which components move from a liquid or gaseous phase onto the surface of a solid that absorbs them (adsorbent). Typically, small particles of adsorbent materials are released in a chemical adsorption process which form a strong bond between the adsorbent and the adsorbed substance so that a reversible process is not possible. In adsorption, we use the terms adsorbate and adsorbent, wherein adsorbate refers to the substance that is adsorbed or the substance that will be separated from the solvent, while the adsorbent is the medium (Sahan et al., 2012).

Based on the explanation above, we can learn that colored water (peat water) can treated by the adsorption process. This study uses adsorption to reduce color concentration in peat water and activated chicken bone powder as the adsorbent. It is necessary to reduce the color concentration in peat water so that it meets the clean water standards so the water can be used. This research needs to be carried out to obtain the optimum mass and contact time of activated chicken bone powder adsorbent in color concentration reduction in peat water using the adsorption method.

Method

Preparing Chicken Bones Powder as an Adsorbent

The preparation of raw material for the test involved several steps. First, the chicken bones were separated from the cartilage, and any meat still attached to them was cleaned. After that, the chicken bones were broken down to remove the marrow and then thoroughly cleaned with water. Subsequently, the cleaned bones were left to sun-dry for one day. Next, the dried bones were crushed using a crusher and grinding tool, and then they were sieved using a 70-mesh size sieve.

Chicken bones that had been mashed into powder were activated by immersing them in 4% NaOH solution with a ratio of 1:2 for 24 hours. The process was followed by rinsing the bones powder with distilled water until the pH of the filtrate was neutral. Afterward, the chicken bones powder was oven-dried at 105^{o} C, and then sifted again with a 70-mesh size sieve. Lastly, the bones powder was baked in the oven for 45 to 60 minutes before use.

The Process of Reducing Color Concentration in Peat Water

The color concentration of peat water is measured based on the Pt-Co concentration, which is measured by achieving the same color as the standard solution on the Pt-Co color scale (Rahmawati, 2018)

The Effect of Activated Chicken Bones Powder Mass

The adsorption process to reduce color concentration in peat water using activated chicken bones powder as an adsorbent was carried out using the de-batch method as follows: activated chicken bones powder with varying masses (0.1, 0.2, 0.3, 0.4, 0.5, 1.0, 1.5 and 2.0 grams) was added into 50 mL of peat water. The mixture of chicken bones powder with these different compositions was stirred using a magnetic stirrer at room temperature for 30 minutes. The stirring function on the hot plate makes the carbon surface effectively contact with the activator solution so that all particles are completely activated (Sumila et al., 2023) Next, the mixture was decanted for 1 day. The absorbance of each mixture was measured using a visible spectrophotometer (uv-vis) at a wavelength of 360 nm.

The Effect of Contact Time

The mass of activated chicken bones powder used was 0.5 grams, and it was mixed with an optimum volume of peat water at 50 mL. To observe the effect of contact time, 0.5 gram of activated chicken bones powder as added to 50 mL of peat water (ratio of chicken bones powder to peat water 1: 100). The mixture was stirred using a magnetic stirrer at room temperature. Stirring was carried out at various contact times (20, 30, 40, 50 and 60 minutes). The mixture was left to settle for 1 day and then decanted. The absorbance of each mixture was measured using a visible spectrophotometer (uv-vis) at a wavelength of 360 nm.

Result and Discussion

Adsorption involves a process of mass transfer and results in an equilibrium in the distribution of one or more solutions between the liquid phase and the particles. The separation of a single solution between the liquid and the adsorbed phase makes it possible to separate the solution from the bulk liquid phase. The absorbing phase is referred to as the adsorbent. The surface of adsorbent medium physically or chemically is mostly heterogeneous and it is quite possible that the energy that bounds these substances may vary from one point to another. In principle, during the treatment of peat water with the adsorption method, humus acid molecules are attracted to the surface of an adsorbent. The adsorption process on heavy metals from liquid waste using adsorbent made from chicken bones is physical adsorption (Hasanah et al., 2021). Physical adsorption occurs due to an imbalance in the surface of the adsorbent that tends to be porous, so that it tends to attract adsorbate to the surface of the adsorbent (Hasanah et al., 2021).

The objective of this study is to reduce color concentration in peat water using chicken bones powder as an adsorbent. The color of peat water is attributed to the presence of particles from decomposed organic matter, natural metal ions (iron and manganese), plankton, humus, industrial waste, and aquatic plants (Hasrianti, 2015). Moreover, humic acid, a product of lignin decomposition, along with iron in the form of ferric humate chelate, is responsible for the color of peat water. In general, it can be said that the color of peat water is caused by the cations of Ca, Mg, Fe, and Mn. Iron oxide causes the water to have a reddish color, manganese oxide causes the water to turn blackish-brown, and calcium carbonate is responsible for the greenish tint (Suprapto et al., 2019). Additionally, organic materials, such as tannins, lignin, and humus acid, which come from the decomposition of dead plants, contribute to the brownish color (Hasrianti, 2015). The study has yielded the following data in Table 1, which were then analyzed to obtain the optimum result.

Table 1. Peat water analysis data before and after processing

Parameter(s)	Clean water standards	Before	After (optimum)	Unit
pH	6.5–8.5	2.68	6.85	-
Turbidity	5	180	13	FTU
Color	15	337,816	14,892	Pt-Co
Iron (Fe)	0.3	3.50	0.1255	mg/l
Manganese (Mn)	0.1	0.22	-0.0104 (ND)	mg/l
Organic substances	10	61.94	43,92	mg/l
Hardness	500	232.44	274.88	mg/l
Chloride (Cl)	250	9,92	5,61	mg/l
Conductivity	225	260	158	µs/cm
E-coli	Negative	Negative	Negative	-

*ND (Not Detected) = 0 mg/l

The Effect of Activated Chicken Bones Powder Mass

Differences in chicken bones powder before and after activation can be seen from Figure 1.

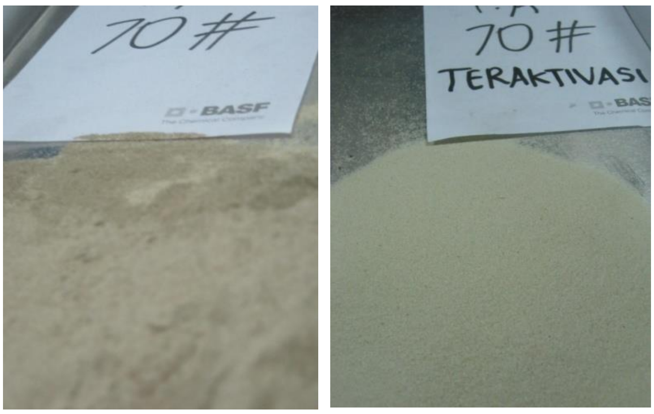

Figure 1. (a) Inactivated chicken bones powder, (b) activated chicken bones powder

The chicken bones powder which had been activated using 4% NaOH was quite different from the chicken bones powder that had not been activated. This was clearly apparent in the color of the powder, the water content, as well as the amount of calcium and iodine. Figure 1 illustrates the difference in the colors; the inactivated chicken bones powder is brown, whereas the activated chicken bones powder is white.

Water content of the inactivated chicken bones powder was 11.2%, while the activated one was 9.325%. The amount of iodine in the inactivated chicken bones powder was 104.2371 mg/g, and that of the activated one was 175.239 mg/g. Likewise, the percentage of calcium in the inactivated chicken bones powder was 17.17% and the amount in activated one was 17.57%.

The effect of the amount of adsorbent is an important parameter because it can determine the capacity of the adsorbent at the initial adsorbate concentration (Anjani & Koestiari, 2014). In this study, we applied the same treatment with different mass composition, and the treatment of chicken bones powder varied. We mixed 0.1, 0.2, 0.3, 0.4, 0.5, 1, 1.5 and 2 grams of activated chicken bones powder into 50 mL of peat water. Each solution was then stirred with a magnetic stirrer for 30 minutes. The concentration of each sample was determined by converting the absorbance of the sample to the prevailing standard curve, and the concentration value is expressed in Pt-Co units. The experiment showed that even with a small amount of mass, the concentration of Pt-Co can be close to the standard set for clean water, i.e., 50 Pt-Co. The graph showing the result of reduction of color concentration in peat water is shown in Figure 2.

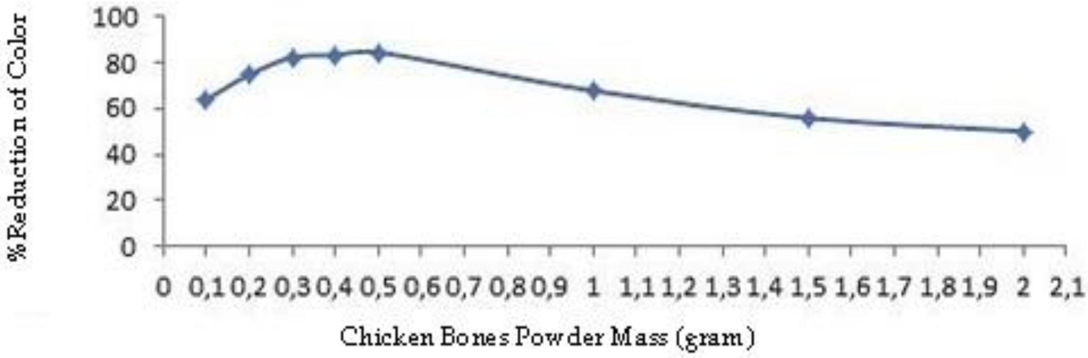

Figure 2. The effect of adsorbent mass on the % reduction of color concentration in peat water

From the graph it can be seen that the initial color concentration of peat water sample at 337.816 Pt-Co was reduced. The optimum mass of activated chicken powder to reduce the color concentration of peat water was found to be 0.5 grams, which lowered the color concentration to 52.108 Pt-Co or a drop of 84.57%. However, when 1 gram of chicken bones powder was added, the color concentration only dropped to 108.796 Pt-Co, a decrease of 67.79%. (Utama et al., 2020) uses kaolin-based geopolymer as an adsorbent to obtain a reduction in the color of peat water from 425 PtCo to 0 PtCo, so it can be said that the percentage of color reduction obtained is 100%. (Pramuni Oktaviani Sitanggang et al., 2022) obtained a percentage reduction in peat watercolor of 52.26% with bintaro fruit cells activated carbon. (Elystia et al., 2022) obtained a watercolor adsorption percentage of 68.703% with the Biosolid Land Application Waste Palm Oil Industry adsorbent in 90 minutes at a stirring rate of 150 rpm.

Previous research conducted by (Rahmawati, 2018) showed that a higher mass of adsorbents leads to a finer-sized adsorbent, making the solution more opaque and affecting the results of color reduction experiment in peat water. The results of (Rahmawati, 2018) research revealed that the treated peat water in the experiment failed to meet the existing standard of quality; however, the adsorption process itself yielded a good result, i.e., it managed to reduce the level of organic matter from 184 mg/L to 151 mg/L. (Anggriawan et al., 2015) Istighfarini, et al., (2017) also stated that mass variations affect the decrease in color intensity, and it caused the more the dose of adsorbent, the more surface area will increase so that the availability of active sites in the pores of the adsorbent increases, thus allowing for increased absorption. This is different from the research results obtained by Suziyana, et al., (2017), which stated that the greater the mass of the adsorbent, the more surface area of the adsorbent available, resulting in the active area of the adsorbent increasing. In the other hand, research results by (Era et al., 2016) showed that the optimum mass for adsorption was 1.75 grams with an efficiency value of 91.01%, and also explained that the more adsorbent mass used in adsorption, the more the absorption efficiency would decrease. The dye removal efficiency was 57.16% for an adsorbent mass of 3 gr with a contact time of 60 minutes obtained by (Puspita & Sopandi, 2019)

The Effect of Contact Time

The contact time in the adsorption process is related to the opportunity given to the organic material contained in the peat water to interact with the active carbon surface (Arisna, et al., 2016). To learn the effect of contact time in reducing the color concentration in peat water, we varied the contact time between 0.5 grams of activated chicken bones powder with 50 mL of peat water starting from 20, 30, 40, 50, and 60 minutes. From these series of contact times, the reduction of color concentration peaked at 40 minutes with 95.59% reduction in color concentration, while the lowest occurred at 20 minutes, which yielded a 91.01% reduction. The effect of contact time on the % reduction of color concentration in peat water in the following Figure 3.

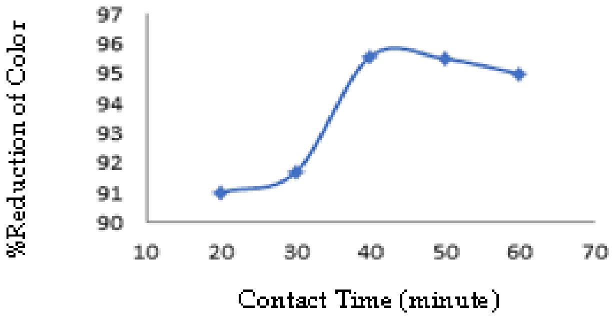

Figure 3. The effect of contact time on the % reduction of color concentration in peat water

The graph clearly shows that contact time by activated chicken bones powder affects the absorption of color. In this study, the amount of color absorbed increased steadily up to the optimum peak time of 40 minutes, resulting in a reduction of 95.59% or 14.89 Pt-Co, which is in line with the standard color for clean water specified in Regulation by the Minister of Health of the Republic of Indonesia No. 492/MENKES/PER/IV/2010, stating the standard color for clean water is 15 Pt-Co. In addition, the measurements of iron and manganese particles also demonstrated a lower figure. The initial iron content in peat water was 0.9316 mg/l, and it dropped to 0.1255 mg/l, while the level of manganese content, which initially was 0.22 mg/l, dropped to -0.0104 mg/l. (Fahmijal et al., 2023)obtained results reducing the color of peat water by 97.5% by using coconut fiber adsorbent activated with H_3PO_4. The result of research by (Mulyadi et al., 2020) shows that iron and manganese decreased as 98.6% for iron and 100% for manganese, while color decreased by 99.6%.

Between the duration of 20 to 40 minutes contact time, there was an increase in the amount of color absorbed by the activated chicken bones powder. This is due to the chemical reaction between the humus compounds and the material contained in the chicken bones powder and the expansion of the pores due to the activation process, which was relatively effective. On the other hand, from the 40 minutes up to the 60 minutes contact time, the increase in color absorption was relatively stable and tended to decrease. This is likely because some organic materials were detached from the activated chicken bones powder due to extended contact time.

According to Yoseva (2015), adsorption efficiency is due to the desorption process or the release of adsorbate again during stirring. Desorption occurs due to the surface of the adsorbent being saturated. In the saturated state, the adsorption rate decreases so that the contact time no longer has an effect. (Elystia et al., 2022) got the best results when varying the mixing time, which was 30 minutes, which could work optimally by increasing removal efficiency, but at 60 minutes to 90 minutes, the desorption process occurred, resulting in decreased efficiency.

On the other hand, Qurbaniah's research (2017), which examined the treatment of peat water using kepok banana peel activated with NaOH as adsorbent, with contact time ranging from 10 minutes to 60 minutes, showed that the decrease in absorbance is the highest. Therefore, it can be concluded that the longer the contact time, the more organic matter is absorbed by the adsorbent. Zulfikar et al., 2014 in their research using Chitosan-Silica Composite as an adsorbent, obtained the equilibrium sorption within a contact time of 90 minutes. (Zulfikar et al., 2014) stated that the adsorption percentage increased with increasing stirring time and reached a constant value with increasing contact time due to the increasing of empty surface locations number. In line with research results obtained by (Suhendra et al., 2016), they stated that the longer the contact time between peat water and activated carbon, the less active carbon's ability to absorb water color will be. Visually the reduction in color concentration in this study is shown in Figure 4.

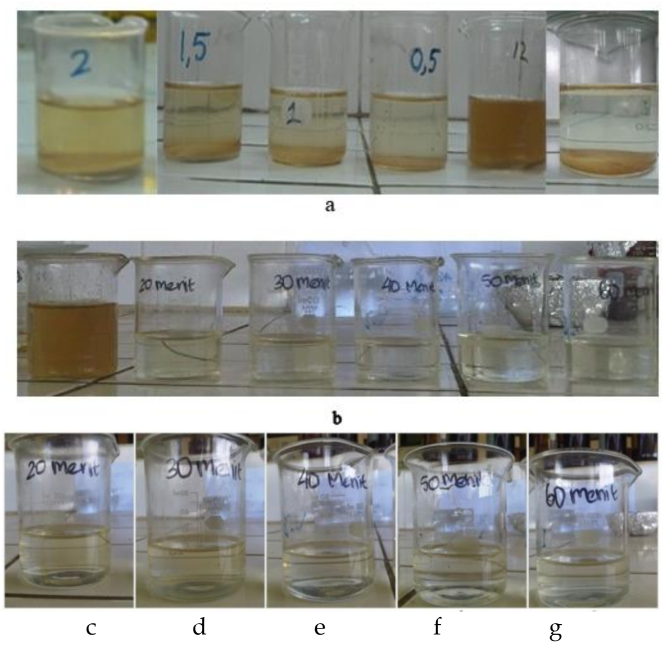

Figure 4. Comparison of the results of mass variations and contact time variations:
a. Comparison of peat water and results of the different mass of activated chicken bones powder.
b, c, d, e, f, and g. Comparison of peat water and results of variations in stirring time at 20, 30, 40, 50 and 60 minutes.

A research conducted by (Eprie et al., 2022) reperted that there was no absorption of color in peat water treated with NaOH activated charcoal. However, in this study, it was found that the chicken bones powder adsorbent, which was activated using NaOH could effectively absorb the color up to 95.59%. This significant percentage of the reduction in color concentration indicated that almost all of the dye was absorbed by the chicken bones powder adsorbent.

Conclusion

From this study, we can conclude that the optimum yield was obtained when the mass and contact time were at 0.5 grams and 40 minutes, resulting in the reduction percentage of 95.59%. The initial color concentration of peat water of 337.816 was successfully reduced to 14.89 Pt-Co, which is in line with the standard color for clean water as specified in the Regulation by the Minister of Health of the Republic of Indonesia No. 492/MENKES/PER/IV/2010, which states that the standard color for clean water is 15 Pt-Co.

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Author Contributions
The authors in this study have made maximum contributions in their respective roles according to their areas of expertise. LK contributed to the development of the research concept, research methodology and article finalization. AB contributed to the analysis and validation of the research results and library resources. YH contributed to the water quality measurement tool. SRS contributes to the data collection and journal editing processes all authors have read and agreed to publish this article.

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Conflicts of Interest
All authors declare that they have no conflicts of interest.

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