This article presents batch experimental data describing the main batch adsorption operation parameters. Also the adsorption models (adsorption isotherm, adsorption kinetics and thermodynamic studies) of basic yellow dye on to the raw and treated kaolin adsorbents. Besides, instrumental analyses were recorded to characterize kaolin adsorbent. Such as, thermogravimetric analyzer, Fourier transformation infrared and scanning electron microscope with energy dispersion spectroscopy were used. UV–Visible spectrometer was used throughout the experimental study for the determination of absorbance. The effect of adsorption temperature (30 °C, 50 °C 70 °C), PH (3, 7, 9), initial dye concentration (20 mg/l, 40 mg/l, 60 mg/l), contact time (20 min, 40 min, 60 min, 80 min, 100 min) and adsorbent dosage (0.1, 0.5, 1, 1.5, 2 g/100ml) have been well determined. For adsorbent characteristics, we provide dataset regarding (i) thermogravimetry with differential scanning calorimetry, (ii) Fourier transform infrared spectral data before and after basic yellow dye adsorption process, (iii) scanning electron microscope with energy dispersion spectroscopy image at ×500 resolution, (iv) X-ray diffraction and, (v) batch adsorption experimental parameters records. Regarding scanning electron microscope with energy dispersion spectroscopy image, we provide data of three surface morphology image and three elemental distribution spectra for raw and treated kaolin adsorbent.

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1. Data

We report on several batch experimental study and adsorption models on the potential adsorption capacity of kaolin adsorbents datasets of three adsorbent at different operation parameters and model. Six kinds of data for basic yellow dye removal are reported: batch experiment datasets (sheet 1 from excel file), Optimization datasets (sheet 2 from excel file), Isotherm, kinetics and Thermodynamics dataset (sheet 3 from excel file), thermogravimetric with Differential Scanning Calorimetry (sheet 4 from excel file), Fourier transform infrared, before and after adsorption for basic yellow dye, dataset (sheet 5 from excel file), X-ray Diffraction (sheet 6 from excel file) and Scanning electron microscopy with energy dispersive spectroscopy dataset for beneficiated, calcined and raw kaolin adsorbents (images from three separate word file).

2. Experimental design, materials, and methods

2.1. Material and chemicals

Natural kaolin was collected from local area, Debre Tabor Town, Amhara Region, Ethiopia. Synthetic solution was prepared from Basic yellow dye. All laboratory grade reagents, sodium hydroxide (NaOH),
2.2. Preparation of adsorbent

Collected kaolin was crushed, milled and screened using jaw crusher, disc mill and Standard sieves, respectively. The size of kaolin powder was sieved to 75 μm. The powder of kaolin was calcined at 700°C using Muffle Furnace. Additionally, the powder of kaolin was beneficiated using distilled water in the conical flask of 1L capacity. Finally, three types of kaolin adsorbents were prepared from natural kaolin i.e. raw, beneficiated and calcined kaolin adsorbent in order to investigate their efficiency for dye adsorption from aqueous solution.

2.3. Preparation of stock dye solution

Basic yellow dye was taken from Bahir Dar Textile Share Company, Amhara Region, Ethiopia. The physical state of basic yellow dye is powdered solid. Basic yellow dye has the chemical formula; C_{21}H_{27}N_{3}O_{5}S as well as its molecular weight and maximum wave length are 433.52 g/mol and 438 nm, respectively. The stock solution (500 mg/L) of the dye was prepared by dissolving 0.5 g of basic yellow dye in 1 L of distilled water and required concentrations were obtained by dilution of the stock solution. The maximum wave length (438 nm) is obtained after scanning of the sample of dye using UV/VIS spectrometer (Lamda 35 Ferkin Elmer).

2.4. Experimental design and description

A measure amount of distilled water (100ml) was taken in 250 ml of conical flask for batch experiment. In conical flask calculated amount of initial dye concentration and adsorbent were added and agitated with magnetic stirrer on digital hot plate at 200 rpm. The initial pH of solution was adjusted with 1M HCl or 1M NaOH before adding the adsorbent. The batch adsorption experiments were performed for a wide range of initial dye concentration (20, 40 and 60 mg/L), temperature (30, 50 and 70°C), solution pH (3, 7 and 9), adsorbent dosage (0.1, 0.5, 1, 1.5, and 2 g) and contact time (20, 40, 60, 80 and 100 min). At the end of each experiment, small amount of the solutions was withdrawn at predetermined time and filtered. The absorbance value of a solution was measured after adsorption experiment for each run. The final dye concentration was calculated from calibration curve. The removal efficiency of the dye was calculated by Equation (1) [1]. The equilibrium state concentration (loading) of adsorbate in the solid phase (qe, mg/g) and concentration (loading) of adsorbate in the solid phase at any time (qt,mg/g) were determined by Equations (2) and (3), respectively, [2].

\[
\text{Removal Efficiency (\%)} = \left( \frac{C_0 - C_e}{C_0} \right) \times 100
\]

\[
q_e = \frac{V(C_0 - C_e)}{m}
\]  

\[
q_t = \frac{V(C_0 - C_t)}{m}
\]

Where, C_{0} is the initial dye concentration (mg/L), C_{e} is a solute (dye) concentration in the liquid phase at the equilibrium (mg/L), C_{t} is the dye concentration in liquid phase at any time (mg/L), m is the amount of adsorbent (g) and V is the volume of solution (L).

2.5. Analysis and characterization of kaolin adsorbents

The dye absorbance values were measured by UV/VIS spectrometer (Lamda 35 Ferkin Elmer) at a maximum wave length (438 nm). The thermogravimetric properties is important because metakaolin
is not a simple mixture of amorphous silica and alumina, but rather a complex amorphous structure that maintains some longer-range order due to the stacking of its hexagonal layers [3]. Mass losses and thermal property of kaolin adsorbent were analyzed by Thermogravimeter (SDT Q600) with liquid nitrogen from 20 to 1000°C temperature. The processed data of TGA-DSC is presented in Fig. 1. The powder of kaolin was calcined at 700°C using Muffle Furnace (Nabertherm B180). Fourier transform infrared (FTIR) spectra were obtained in the range of 400–4000 cm⁻¹ to analyze the surface function group and their percent transmittance by using a PerkinElmer Frontier Spectrometer (ILC38B6PD7) before and after adsorption. The processed data is presented in Fig. 2. The Qualitative and quantitative characteristic of the phases, its crystallinity and the number of phases that is present in were determined by X-ray diffractometer (M divine 3740) with a continuous scanning scan axis of 2θ/θ about a full scan of 6474 and scanning range from 4.99 to 90. The raw data is presented in mendeley data from excel file and the processed data is presented in Fig. 3. Surface morphology of kaolin adsorbents was analyzed by using Scanning Electron Microscopy (IT300 LA). The image of SEM with the corresponding EDS is presented in Mendeley Data of word file and also presented in Fig. 4 for the three samples.

2.6. Adsorption isotherm model

The raw data of isotherm was presented in Mendeley Data of Microsoft Excel in worksheet 3. Langmuir and Freundlich isotherm models were used to determine the relationship between dye ions adsorbed on the kaolin adsorbents surfaces and dye ions remaining in the solution. The Langmuir isotherm model assumes that sorption occurs in certain places and within the sorbent. In addition, the model assumes that sorption of dye ions occurs within homogeneous monolayers without any interactions between dye ions at the sorbent surface. The Freundlich isotherm model is an experimental model and assumes that the sorption of dye ions occurs at heterogeneous surfaces and active sites with different energies. The Langmuir and Freundlich model linear equation were presented in Eqs. (4) and (5), respectively [4,5].

![Fig. 1. Thermogravimetric analysis of kaolin adsorbent.](image)
Fig. 2. FTIR analysis of kaolin adsorbents before and after adsorption.

Fig. 3. XRD pattern for raw, beneficiated and calcined kaolin adsorbents.
Fig. 4. SEM/EDS image of a) raw b) beneficiated and c) calcined kaolin.
\begin{equation}
\frac{C_e}{q_e} = \frac{C_e}{q_m} + \frac{1}{q_m K_L}
\end{equation}

\begin{equation}
\log q_e = \log k_f + \frac{1}{n} \log C_e
\end{equation}

Where \( q_m \) is sorption capacity (mg/g), \( K_L \) is sorption energy (L/g), \( K_f \) and \( n \) are the Freundlich model constants and indicating the relationship between sorption capacity and sorption intensity, respectively. If \( n = 1, n > 1 \), and \( n < 1 \), then the sorption process would be the linear, physical, or chemical in its nature, respectively.

The calculated Langmuir and Freundlich constant parameters from raw data of Mendeley Data of Microsoft Excel in worksheet 3 were presented in Table 1.

### 2.7. Adsorption kinetic model

The raw data of kinetic was present in Mendeley Data of Microsoft Excel in worksheet 3. Kinetic model was used to know the information about experimental data of adsorption mechanism as a function of mixing time. The raw data of effect of mixing time on adsorption process was presented Mendeley Data of Microsoft Excel in worksheet 2. Pseudo first-order and pseudo second-order were used to analyze kinetic model. The linear equations for both models were presented in Eqs. (6) and (7), respectively [6].

\begin{equation}
\log\left(\frac{q_e}{C_0} - \frac{q_t}{C_0}\right) = \log q_e - \frac{k_1}{2.303} t
\end{equation}

\begin{equation}
\frac{t}{q_t} = \frac{1}{k_2 q_e^2} + \frac{1}{q_e} t
\end{equation}

The calculated Pseudo first-order and pseudo second-order constant parameters from raw data of Mendeley Data of Microsoft Excel in worksheet 3 were presented in Table 2.

### 2.8. Thermodynamic behavior

The raw data of thermodynamic was presented in Mendeley Data of Microsoft Excel in worksheet 3. The thermodynamic property was used to know the exothermic and endothermic of batch adsorption for the experimental data in terms of Gibb’s free energy, enthalpy and entropy a function of temperature. The raw data of effect of temperature on adsorption process was presented Mendeley Data of Microsoft Excel in worksheet 1. The values of standard change Gibbs free energy, enthalpy and entropy were obtained from according to the equations (8) and (9) [5].

| Types of kaolin adsorbents | Langmuir Isotherm Parameters | Freundlich Isotherm Parameters |
|---------------------------|-----------------------------|-------------------------------|
|                           | \( q_m \) (mg/g) | \( K_L \) (L/mg) | \( R^2 \) | \( K_f \) (mg/g) | \( n \) | \( R^2 \) |
| Beneficiated               | 2.174              | 2.190              | 0.988           | 1.309              | 3.571           | 0.999           |
| Raw                       | 1.818              | 2.594              | 0.999           | 1.236              | 2.994           | 0.974           |
| Calcinated                | 0.885              | 4.105              | 0.998           | 1.115              | 2.849           | 0.971           |
\[ \Delta G^0 = \Delta H^0 - T \Delta S^0 \]  

\[ \ln K_c = -\frac{\Delta G^0}{RT} = \frac{\Delta S^0}{R} - \frac{\Delta H^0}{RT} \]  

Where \( \Delta G^0 \) = Standard change free Gibbs energy (kJ mol\(^{-1}\)), \( \Delta H^0 \) = Standard change enthalpy (J mol\(^{-1}\)), \( \Delta S^0 \) = Standard change entropy (J mol\(^{-1}\)K\(^{-1}\)) and \( R \) = Universal gas constant (8.314 J mol\(^{-1}\)K\(^{-1}\)). \( K_c \), the equilibrium constant, represents the ability of the adsorbent to retain the adsorbate and extent of movement of the adsorbate within the solution. The \( K_c \) is the ratio of the equilibrium concentration of the dye (qe) attached to adsorbent compared to the Van't Hoff equation as equilibrium dye concentration in solution (Ce). The calculated values of standard change Gibbs free energy, enthalpy and entropy constant parameters from raw data of Mendeley Data of Microsoft Excel in worksheet 3 were presented in Table 3.

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**Conflict of interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**Appendix A. Supplementary data**

Supplementary data to this article can be found online at https://doi.org/10.1016/j.dib.2019.104504.
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