

Errors and inconsistencies in scientific reporting of aqueous phase adsorption of contaminants: A bibliometric study

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ABSTRACT

The errors and misconceptions associated with the published works on the removal of noxious waste from water based solutions, is a worrisome situation in relation to the potential propagation of the errors and misconceptions through citations. The insights provided are to eliminate this weakness and sustain adsorption processes as cleaner option for the remediation of contaminated matrixes. This study reviewed the errors, and elaborated the rectification of the observed inconsistencies. The use of VOSviewer 1.6.13 enabled the bibliometric analysis of the errors and misconceptions, using articles retrieved from Scopus and Web of Science. The results revealed that, the errors and misconceptions in the adsorption studies were largely associated with the inaccuracies in the approaches deployed to linearizing the models for adsorption. The wrong approaches yielded many incorrect adsorption model equations as reviewed in this study. This study reports the original (nonlinear) adsorption models, and corrects the expressions of the linearized forms of the isotherm models and adsorption kinetics. The bibliometric output displayed maps of clear visualizations of the existing connections of network data on the 100 articles retrieved from 1988 to 2022. Authors, institutional affiliations, journals, and countries were the factors that provide information on the quality and influence of the publications, using indicators such as the number of articles, total citations, subject area, and H-index. The findings indicate significant increase in the number of publications since 1988. China was the leading country in terms of publications related to inconsistencies in adsorption reports. From the bibliometric results, 50.0% of the publications were erratum while original research articles and letters to editor represent 23.0 and 12.0% respectively. Only 6.0% of the publications were review articles. The distribution of the retrieved documents according to institutional affiliation indicates that the University of Shanghai for Science and Technology with nine publications had the highest number of articles. The distribution of the articles by country/territory follow the trend China > Taiwan ≈ Iran > others. The co-authors that published collaborative research work on mistakes and inconsistencies regarding adsorption of contaminants from solution are from France, United States, Netherlands, Germany, Italy and Iran. There are four distinct clusters of co-authors representing the different issues discussed in the articles. Out of 2332, terms that occurred in the titles and abstracts of articles retrieved from the Scopus database, 509 terms occurred in the various titles retrieved. The network visualizations of the terms that occur in the abstracts show that the main themes of the various abstracts include the misconception that is associated with the conceptual approach to the adsorption system, with a highlight on the pseudo first order kinetic equation.

Introduction

Decontamination of water by adsorption technique is an efficient strategy for cleaner production. Unfortunately, errors and misleading impressions have been observed in publications of contaminants

removal from aqueous phase. Tran et al. (2017) and Obradovic, (2019) have reported the propagation of the errors and misleading impressions in scientific publications. Tran et al. (2017) has critically reviewed the inaccuracies related to the use of terms, and many problems relating to adsorption performance measurement. Numerous other errors involving

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the usage of pKa, adsorption isotherms, kinetics, thermodynamics and adsorption mechanism have been observed in published works. In order to apply adsorption thermodynamics and kinetics correctly, it is necessary to understand first, the concept of adsorption modeling and the correct transformation of adsorption models in order to make reliable judgments from adsorption data. The comments generated on Equilibrium constant (K_C) by Tran et al. (2017) raises another question from Kopinke et al. (2018) on the sorption constant K_C in the thermodynamic equation, $\ln K_C = -\frac{\Delta G^\circ}{RT} = -\frac{\Delta H^\circ}{RT} + \frac{\Delta S^\circ}{R}$ (Tran et al., 2017), which is normally used to obtain thermodynamic information from measured adsorption data. According to Kopinke et al. (2018), adsorption constants usually have a certain dimension, such as L/mmol in the case of Langmuir sorption constant K_L . With respect to the equation used by Tran (Tran et al., 2017), K_C should be dimensionless. Of course, using K -values with dimensions is mathematically incorrect because such K -values are likely to produce arbitrary values for ΔG° and ΔH° . As a strategy to provide solution to this drawback, Tran et al. (Tran et al., 2017) suggest,

$$K_C = \frac{SA}{S_V[A]} = e^{-\frac{\Delta G^\circ}{RT}} \quad (1)$$

wherein SA (in mmol/m²) are the adsorbate species bound to surface sites, S_V (in mmol/m²) are the vacant surface spots on the adsorbent, and [A] (in mg/L) is for concentration of the adsorbing specie A, in solution at equilibrium. According to Kopinke et al. (2018), with these definitions from Tran et al., the Tran et al. (2017), equation for K_C , which is written using SA, S_V and [A] is erroneous, because K_C will have the dimension of a reciprocal concentration instead of being dimensionless. Kopinke et al. (2018), therefore opined that this initial error from Tran et al. (2017), would not make it easy for the reader to comprehend all the subsequent thoughts and derivations in the article published by Tran et al. (2017). Kopinke et al. (2018), further argued that the attempt to deduce K_C from Freundlich isotherm constants K_F (in (mg/g)/(mg/L)ⁿ) is not consistent with the definition of the Freundlich equation, as published in the review. It is necessary to highlight that adsorption in heterogeneous systems has been generally described using the Freundlich adsorption isotherm. The slope of the isotherm takes the values between 0 and 1, which determine the intensity of the adsorption. The adsorption surface turns heterogeneous as the gradient tarnishes to zero. A gradient value that is not up to one has been associated with chemisorption procedure while 1/n value that is higher than one has been generally associated with the phenomenon of cooperative adsorption. Despite the successes associated with the Freundlich isotherm, arguments highlighting its lack of thermodynamic foundation are in Foo and Hameed, (2010).

Kopinke et al. (2018), pointed out that the attempt made by Tran et al. (2017) to obtain K_C that is dimensionless is also not correct because the process of multiplying a dimensional constant (K_L) by one or several numbers cannot convert the dimensional constant (K_L) into a dimensionless constant (K_C). Kopinke et al., explained that the Tran et al. equation containing the factor 55.5 and K_L should be written as Eq. (2) below,

$$K_C = 55,500 \frac{\text{mmol}}{\text{L}} \times K_L \text{ (for } K_L \text{ in L/mmol)} \quad (2)$$

Conventionally, the equilibrium constant, which has no dimension, is used to determine the standard Gibbs free energy and entropy. However, the idea to use the Langmuir equilibrium constant to calculate standard Gibbs free energy in adsorption experiments has been questioned extensively because the Langmuir constant has the unit of L/mole. For adsorption experiments in water solution, the theory of substitutional adsorption (Zhou & Zhou, 2014), through the exchange of water molecules from the solute-water system and the water molecules adsorbed on the surface of the adsorbent has been employed to pave the way for the transformation of equilibrium constant from thermodynamic system, to the Langmuir equilibrium constant that is dimensionless. Considering the activity (a) of water as being equal to its molar

concentration, the equilibrium constant from thermodynamic system, is transformed into the Langmuir constant by the molarity of water, thus forming the basis for the multiplication of the K_L by 55,500 $\frac{\text{mmol}}{\text{L}}$ as argued by Kopinke et al. (2018).

In one other study relating the removal of dyes from aqueous phase, using litchi peel biochar, which was originally published by Wu et al. (2020), Tran discussed analytically the errors and misconceptions that characterized the article as follows (Tran, 2020a), (i) that the results for the point of zero charge (pH_{PZC}) from the drift method, were determined from wrong positions on the graph and thereby produced lower values that consequently rendered the discussions in the published article invalid. The drift method provides for the interpolation of intercept of plot on the pH axis (x-axis) in order to generate the point of zero charge. At the position on the curve, where Wu et al. (2020) deduced the pH_{PZC} , there were two data points that were plotted below the x-axis. Of course, it is inconceivable scientifically, that two data points that are below the x-axis could join in any manner to produce acceptable maxima above x-axis, in order to achieve any acceptable intercept on x-axis. Wu et al. (2020), questionably produced a curve that generated maxima above the x-axis from the two data points which were plotted below the x-axis. This practice produced multiple intercepts and obviously introduced errors in the values of pH_{PZC} of the biochar. (ii) The reported excellent adsorption by biochar towards the dye contaminant as claimed by Wu et al. (2020), was analysed to be incorrect because, the maximum amount of the dye adsorbed could not have exceeded the original amount of dye that was dissolved (denoted as initial concentration, C_0). (iii) The adsorption mechanism purported to be chemical adsorption by Wu et al. (2020), relied only on the best fitting of experimental data to the pseudo-second-order model. This is speculative because other information possibly drawn from a number of analytical techniques including Fourier transform infra-red (FTIR), Scanning Electron Microscopy (SEM), nitrogen adsorption, Nuclear Magnetic Resonance (NMR) and X-Ray Diffraction (XRD), should substantiate the model data. The conclusion by Wu et al. (2020), that multi-layer adsorption was obtained with heterogeneity in surface, is erroneous because this information cannot be derived from the Freundlich model. The illustration of the hydrogen bonding for the adsorption mechanism is incorrect because the bond shown between the deprotonated oxygen on the biochar and the nitrogen atom of the dye is not a hydrogen bond. Tran (2020a) reiterated that the initial concentration of contaminant (C_0) plays an important role in the efforts to calculate accurately, the q_e value. This is because the experimental C_0 value is usually different from the theoretical C_0 value and this difference becomes very conspicuous when the C_0 value is very high, due to an extremely high dilution factor. All these issues stand to challenge the legitimacy of the results declared by Wu and the co-researchers.

Sumalinog et al. (2018), reported the adsorption of acetaminophen and methylene blue, on activated biochar prepared from community solid wastes. Huang, (2019a), has argued that the conclusion drawn by Sumalinog et al. (2018) from the kinetic studies is potentially affected by the incorrect pseudo-first order equation that was used by Sumalinog et al. (2018) which was incorrectly written as Eq. (3).

$$\frac{1}{q_t} = \frac{1}{q_e k_1 t} + \frac{1}{q_t} \quad (3)$$

Generally, the linearized Lagergren equation for pseudo-first order process is correctly written as Eq. (4).

$$\text{Log}(q_e - q_t) = \text{log}(q_e) - \frac{k_1 t}{2.303} \text{ or } \ln(q_e - q_t) = \ln q_e - k_1 t \quad (4)$$

It is instructive therefore, to explore the mathematical transformation of pseudo-first order rate equation that was published by Ho and McKay (1998) and Ho (2004), wherein, the pseudo-first order differential equation was integrated with subsequent application of the boundary conditions to obtain the linearized Lagergren equation for pseudo-first order process.

Mistakes in the use of pseudo-first-order kinetic model and improper citations of the models in the article published by Yu et al. (2018) have been reported by Huang (2019c). The many other comments of (Huang, 2018a; Huang, 2018b; Huang, 2019b; Huang, 2019c; Huang, 2019d; Huang, 2019e; Huang, 2019f; Huang, 2019g) on so many other articles with regard to the errors and inconsistencies in published articles that report adsorption studies, is a distress call on all adsorption experts/reviewers to be more vigilant in order to ensure that articles on adsorption research are thoroughly scrutinized to remove weaknesses before their publication.

Nekouei and Nekouei (2017), has also reported mistakes in the expression and application of pseudo-first order and the Brunauer-Emmette-Teller (BET) models for adsorption systems, especially with regard to the rectilinear plot of the BET isotherm. The correct linearized BET isotherm for adsorption systems is generally written as shown below.

$$\frac{C_e}{q_e(C_s - C_e)} = \frac{1}{q_s C_{BET}} + \frac{(C_{BET} - 1)}{q_s C_{BET}} \frac{C_e}{C_s} \quad (5)$$

The equation (5) is typically in the image of the traditional straight line equation, which is commonly written as $y = mx + c$. The expression $\frac{C_e}{q_e(C_s - C_e)}$ is for the ordinate axis (vertical) which is the y-axis in Cartesian coordinate, while the expression $\frac{C_e}{C_s}$ is for the abscissa, which is x-axis. The slope (m) of the straight line is equal to the expression, $\frac{(C_{BET}-1)}{q_s C_{BET}}$ and the expression, $\frac{1}{q_s C_{BET}}$ is intercept (c). This is the basis for describing the linearized expression of the BET equation. Unfortunately Wu et al. (2014), in their efforts to deduce the BET parameters for the removal of methylene blue dye using modified graphene oxide, plotted the expression $\frac{C_e}{q_e(C_s - C_e)}$ (y-axis) against C_e (x-axis) instead of $\frac{C_e}{C_s}$. This sort of error can potentially distort the correct application of BET model and may lead to incorrect deductions. This was the concern expressed by Nekouei and Nekouei (2017). Wu et al. (2017), consequently published the response, which contains the correct pseudo first-order kinetics equation. The response also contains the original forms of the BET isotherm and the pseudo-second-order kinetics.

Li et al. (2019), published the metoprolol adsorption onto montmorillonite, using several experimental conditions. Thiebault (2019) observed that regardless of the worth of the paper, the speciation plot of the metoprolol and numerous resulting interpretations reported in the article appeared to be inappropriate. According to Thiebault (2019), Metoprolol has a pK_a of 9.67 and another pK_a of 14.09 respectively, and further explained that metoprolol assumes neutrality if the pH of the equilibrium solution falls within 9.67 and 14.09, and that the metoprolol could not be a zwitter ion because the $pK_{a,(base)} < pK_{a,(acid)}$. As such, the plot to illustrate the influence of pH on speciation of metoprolol is incorrect and has negative imports on the evaluation of the capacity of montmorillonite to adsorb metoprolol.

Alagumuthu et al. (2010) commented on the errors observed in the Lagergren rate expression and Elovich linear equation as published by Sivasankar et al. (2010) and suggested, caution in writing the expressions for the kinetic and isotherm models in sorption science. The article published by Chairat et al. (2005) was also criticized by Ho (2007) for wrong citations and quotations. Observations have also been made on the error committed by Kim et al. (2004), in not citing Ho's original pseudo-second-order kinetic expression in their study, regarding removal of arsenic by mesoporous alumina, which was obtained by a templating method.

Ucun et al. (2002), originally published the chromium (VI) adsorption onto the cone of Scotch pine, *Pinus sylvestris* Linn, using varied factors, which includes solution pH, concentration and shaking speed. Aoyama (2003) reported mistakes in the explanation of the biosorption of Cr(VI) from aqueous solution, by cone biomass derived from *Pinus sylvestris* and highlighted that, there is the possibility of the chemical reduction of Cr(VI) to Cr(III) in acidic solutions. Unfortunately, Ucun

and co-workers did not consider very important, aqueous phase transformation in the oxidation state of Cr(VI) in their studies and based the adsorption denseness on the changes between the initial and final concentrations of Cr(VI) only, without consideration for the fate of the Cr (III). As a correction for the oversight, Aoyama (2003) recommended that the denseness of biosorption should be derived from the changes between the original concentration (initial Cr (VI)) and the final total Cr concentrations including both the Cr(VI) and Cr(III). This would enable equity in the mass transfer that is involved in the process of adsorption.

Tran et al. (2019) has also highlighted errors in the binding energies of Cr (III) and Cr(VI) in the Cr 2p spectra of adsorbent samples following the adsorption of Cr(VI). Tran et al. further reiterated that because of the electrophilicity of chromium in + 6 oxidation state, it has higher binding energies than chromium in + 3 state. The researchers on grounds of the misconception concerning the Weber and Morris intra-particle diffusion model, the inconsistency associated with the experimental result and the Thomas adsorption rate constants, have also criticized Fan et al. (2019). The criticism premises on the Weber-Morris intra-particle diffusion curve, which should have an intercept and not be forced through the origin of the curve. This argument is corroborated by the explanations of the Weber-Morris particle diffusion model.

The intra-particle diffusion model of Weber and Morris (1963), describes the journey of the adsorbate molecule through the pores of the adsorbent as it transits from the surface of the adsorbent. This kinetics model fits adsorption data to provide insights into the stepwise migration of molecules through the adsorbents in heterogeneous solid-liquid adsorption processes in which the series of diffusion describes the migration of adsorbate molecule. The first phase involves the mobility of the molecule through the solution as soon as the adsorbent is introduced into the solution. The migration of the molecules from the bulk solution to the surface of the adsorbent follows the first phase. The next phase involves the molecule's diffusion from the adsorbent's surface and gradually fills the adsorbent pores, along the surfaces of the walls of the pores. This intra-particle diffusion occurs slowly and, Weber and Morris (1963) described it using the equation below.

$$q_t = K_{ip} t^{1/2} + C \quad (6)$$

Where q_t in mg/g is the amount of the molecules adsorbed at time (t) in minutes. The intra-particle diffusion, adsorption rate constant is $K_{ip}(mg/g) \times min^{1/2}$. The rate constant for diffusion is determined from the slope of the linear plot. The intercept on the q_t axis is C (mg/g). This intercept is a constant, which defines the thickness of the boundary layer. The intra-particle diffusion becomes the only rate-determining step if the graph of q_t versus $t^{1/2}$ is a straight line through the origin. If the curve is unable to pass through the origin, it suggests intra-particle diffusion process in association with other forms of mechanism and thereby indicates that intra particle diffusion cannot be the exclusive rate-determining step (Rahman and Haseen, 2014). If the graph is multi-linear, it indicates many steps are involved in the process of adsorption. This explains why the Weber-Morris model is applied to investigation of adsorption mechanism. El-Khaiary and Malash (2011) highlighted the disregard for segments and mismanagement of segmented data, in the usage of Weber's pore-diffusion model in batch adsorption studies. This certainly, has implications for deduced slopes, and the resulting K_{ip} values. El-Khaiary and Malash, (2011) reported that a distorted version of Boyd's pore-diffusion model, as shown below, is wide spread in the literature.

$$ForallFvaluesBt = -0.4977 - \ln(1 - F)$$

Using this distorted model leads to wrong estimates of Bt and wrong conclusions about the rate-limiting step. In comments by Tran (2020b), Tran discouraged the attempt by Zhang et al. (2020) to determine chemisorption mechanism by fitting time-dependent adsorption data to pseudo-second-order model, with the calculation of thermodynamic parameters of liquid-solid adsorption process from equilibrium

Table 1
List of correct expressions of the adsorption isotherm models and adsorption kinetics.

S/ N	Isotherm model / Kinetics	Nonlinear form	Linear form	Reference
1.	Langmuir	$q_e = \frac{Q_0 b C_e}{1 + b C_e}$	$\frac{C_e}{q_e} = \frac{1}{b Q_0} + \frac{C_e}{Q_0}$ $\frac{1}{q_e} = \frac{1}{Q_0} + \frac{1}{b Q_0 C_e}$ $q_e = Q_0 - \frac{q_e}{b C_e}$ $\frac{q_e}{C_e} = b Q_0 - b q_e$	Langmuir (1918)
2.	Freundlich	$q_e = K_F C_e^{1/n}$	$\log q_e = \log K_F + \frac{1}{n} \log C_e$	Freundlich (1906)
3.	Brunauer-Emmett-Teller (BET)	$\frac{q_s C_{BET} C_e}{C_s - C_e [1 + (C_{BET} - 1)(C_e / C_s)]}$	$\frac{C_e}{q_e (C_s - C_e)} = \frac{1}{q_s C_{BET}} + \frac{(C_{BET} - 1) C_e}{q_s C_{BET} C_s}$	Brunauer, Emmett & Teller (1938)
4.	Dubinin-Radushkevich	$q_e = (q_s) \exp(-k_{ad} \varepsilon^2)$	$\ln(q_e) = \ln(q_s) - k_{ad} \varepsilon^2$	Dubinin & Radushkevich (1947)
5.	Lagergren [Pseudo – first – order equation]	$q_t = q_e (1 - e^{-k_1 t})$	$\log(q_e - q_t) = \log(q_e) - \frac{k_1 t}{2.303} - \ln(q_e - q_t) = \ln q_e - k_1 t$	Lagergren (1898)
6.	Blanchard et al.(1984) [Pseudo – second – order equation]	$q_t = \frac{q_e^2 k_2 t}{1 + k_2 q_e t}$	$\frac{t}{q_t} = \left(\frac{1}{q_e}\right) t + \frac{1}{k_2 q_e^2} \frac{1}{q_t} = \left(\frac{1}{k_2 q_e^2}\right) \frac{1}{t} + \frac{1}{q_e} q_t = -\left(\frac{1}{k_2 q_e}\right) \frac{q_t}{t} + q_e \frac{q_t}{t} = -(k_2 q_e) q_t + k_2 q_e^2$	Blanchard et al.(1984)
7.	Redlich-Peterson equation	$q_e = \frac{K_R C_e}{1 + a_R C_e^b}$	$\ln\left(K_R \frac{C_e}{q_e} - 1\right) = g \ln(C_e) + \ln(a_R)$	Redlich & Peterson (1959)
8.	Flory-Huggins	$\frac{\theta}{C_o} = K_{FH} (1 - \theta)^{n_{FH}}$	$\log\left(\frac{\theta}{C_o}\right) = \log(K_{FH}) + n_{FH} \log(1 - \theta)$	John & Roger (1969)
9.	Temkin	$q_e = \frac{RT}{b_T} \ln A_T C_e$	$q_e = \frac{RT}{b_T} \ln A_T + \left(\frac{RT}{b_T}\right) \ln C_e$	Temkin & Pyzhev (1940)
10.	Elovich	$q_t = \frac{1}{\beta} \ln(1 + \alpha \beta t)$	$q_t = \frac{1}{\beta} \ln(t) + \frac{1}{\beta} \ln(\alpha \beta)$	Low (1960)
11.	Weber-Morris equation	$q_t = K_p t^{1/2} + C$		Weber & Morris (1963)

constant derived from the Redlich–Peterson constant.

Tran (2017a) criticized the Ben-Ali et al. (2017)'s findings on the removal of copper by biosorbent derived from raw pomegranate peel. Tran (2017a) reported that Ben-Ali et al.'s paper had numerous incorrect computations, erroneous data analyses, and unacceptable conclusions. Tran therefore published comments on (i) wrong determination of surface area from iodine number (ii) inappropriate interpretation of Fourier-transform infrared (FTIR) data, (iii) wrong statements on pKa, (iv) invalid explanations on mechanisms of adsorption, (v) wrong calculations of energy from the Dubinin-Radushkevich equation, (vi) improper representation of the intra particle diffusion and Elovich model and (vii) errors in calculating thermodynamic parameters. It is important to note, that the Dubinin-Radushkevich equation for the effect of the porosity of adsorbent during the process of adsorption, contains several parameters and must be correct to avoid inadvertent errors in calculations. The correct expressions of the nonlinear and linear forms of the Dubinin-Radushkevich equation are presented in Table 1.

Mistakes in the expressions of the kinetic equation, that was applied by Li et al. (2014), to the removal of Hg(II) and Cr(VI) in aqueous forms, has been reported by Ho (2016). In previous studies reported by Ho (2014), it had been made clear that, to prevent the propagation of incorrect kinetic expressions, it is better to cite the publication in which the original kinetic model was published. This will definitely ensure better accuracy and provide the necessary details on the kinetic model.

In their publication, Hsu et al. (1997) emphasized on the severe error created in adsorption isotherm when isotherm is solely centering on the limited values of equilibrium surface tension data.

Remarking on the article published by Baskir et al. (1987), which described the influence of phase-forming polymers in the separation of biomaterials, Van der Schoot and Leermakers (1988) argued that although the research article was of considerable interest, the Schuettjens and Fleer's theory was incorrectly expressed in the study. Baskir et al. (1988) subsequently agreed with Van der Schoot and Leermakers, and published a reply that captured recalculated values of the various parameters while adapting the correct geometrical weighting factors (λ_i) with respect to the treatment of curvature in the liquid lattice model. The authors had earlier, in their original article assumed an approximated λ_i to enable inversion symmetry and this led to the attenuation of the effect of the factors that describe the arrangement of the polymer chains and the solvent molecules in the liquid lattice.

Other areas that have been in debate for inaccuracy include the utilization of methylene blue (MB) adsorption for surface area measurement. The determination of the specific surface area of spongy materials such as graphene oxide has been accomplished by the MB-spot test and has been associated with simplicity when contrasted to the BET test by nitrogen adsorption. However, Ma et al. (2019) has disputed the test and argued it to be vulnerable to some factors, and may not accurately determine the precise surface area of carbonaceous materials. In a rejoinder, Yousefi and Tufenkji (2020) defended their methodology and highlighted the hydrophilic nature of graphene oxide as a critical limitation in the N₂ adsorption tests because the surface area determined from N₂ adsorption methods would be affected if the porous material adsorbed water.

In 2010, Milonjić (2010) engaged in trading comments with Smičiklas et al. (2009), who responded to the condemning remarks about

their article, on the utilization of hydroxyapatite for the elimination of divalent cations, in relation to the factors that affect cation removal. Following a thorough review of the authors' rebuttal of observations made regarding the inconsistencies in their experimental methods, Milonjić insisted that the identified inconsistencies were not academically addressed and so reiterated that the results obtained, and their interpretations, remained doubtful (Milonjić, 2010). These types of situations may generate confusion if Editors do not view the arguments seriously and subject such articles to post publication review by reputable authorities to evaluate the veracity of claims. Milonjić tried to explain that during the sorption process, the investigated system spontaneously tends to reach equilibrium state which depends on certain initial parameters including concentration, pH, and temperature, therefore, in order as to examine the sorption process in relation to various equilibrium pH it is necessary to add a certain quantity of acid or alkali to the studied solution, while maintaining the quantity of sorbate in the investigated solution and the ionic strength of the solution as constant. In response, Smičiklas et al. argued that the addition of certain amounts of either acid or base solutions to the investigated solution can alter the volume, composition and consequently the concentration of the solution. Milonjić concluded that Smičiklas et al.'s claim on the concerns raised was not true and confirmed the authors' misunderstanding of the basic principle of sorption processes. To resolve this quandary between researchers, it is recommended that experts in sorption subject disputed information to post-publication peer reviews. This will provide authoritative explanations and make for well-informed decisions on the issue, thus warding off the looming confusion on the vital role of pH in adsorption studies.

Counter reactions by Arica (2003) have been published on perceived inconsistencies in adsorptive removal of lysozyme in relation to disputed citations and issues on biosorption kinetics and thermodynamics published by Liu and Liu (2008). Borisover and Graber (1997), have raised concerns about the inconsistency in the work on sorption of atrazine and other organic substances in earthy matrix and model sorbents, published by Xing et al. (1996). Bui and Choi (2010) published observations on the errors created by data swap in the adsorption and desorption of an antibacterial and anticonvulsant medicine by the multiwalled nanotubes of carbon (Oleszczuk et al., 2009). Although the error was largely editorial, recalculations revealed an incorrect value claimed for the pKa of the anticonvulsant resulting from the swapped data. Canzano et al. (2012) also criticized the inconsistencies in the thermodynamic and kinetic studies reported by Dawood and Sen (2012) on the adsorption of congo red from solution by pine powder adsorbent, especially in relation to the utilization of the Van't Hoff equation for the computation of the enthalpy and entropy of adsorption. The attempt to use the logarithmic expression of the quotient, dye adsorbed by unit mass of adsorbent and the equilibrium concentration, is being contested in realization of the need for dimensionless quantity that is often advised for log transforms. Tran (2017b) reported another major adsorption inconsistency, which reacted to Senthil Kumar et al. (2014) and discussed, the erroneous perception of the Freundlich exponent, n . When applying the Freundlich equation, it should be noted that n is dimensionless and describes the thrust force of the adsorption and its magnitude. This dimensionless quantity cannot be applied to deduce the pathway of adsorption to describe it as either physical or chemical as claimed by some authors. The Freundlich adsorption theory only labels the isotherm as linear if $n = 1$, favorable if $n < 1$, and not favorable if $n > 1$. Errors relating the calculation of the thermodynamic parameters, the uninformed deductions regarding the Langmuir separation factor, the inconsistencies relating to adsorption equilibrium figures and the thermodynamic parameters have been observed. Tran (2017b) thus argued that adsorption progression could not have achieved equilibrium with the low initial concentrations of the Methylene dye, in the range of 50 to 250 mg/L at the solid to liquid ratio of 4 g/L, and this consequently resulted in invalid discussions and deductions regarding the isotherm published by Senthil et al.

For proper insight into the utilization of adsorption models, it is worthy to note that the original forms of the models are usually nonlinear. Therefore, for meaningful interpretation in a generally acceptable manner, curves are fitted to illustrate the data from experiments. The fitting of curves depicts the experimental data in the linear mathematical equation expressed as, $y = mx + c$, with y depending on x . The y and x are conventionally, parameters that are associated with the adsorption data. The extent of linear relation in the graph of y versus x describes the fitness of the data for adsorption. The adsorption models therefore linearize to determine this fitness and derive meaningful interpretation from adsorption data. However, El-Khaiary and Malash (2017) earlier highlighted spurious correlations due to the reversal of relative weights of data points in the linearization of nonlinear adsorption model equations and advised of the inappropriateness linearizing nonlinear adsorption models in the absence of data about the error-structure in the adsorption studies. Rather, it is necessary to compute Akaike's Criterion for comparing such models. A suitable statistical method for ranking adsorption isotherm models is the Small-Sample corrected Akaike Information Criterion (AICc). Because it is more sensitive to model deviations and takes into account the number of parameters in an equilibrium isotherm model, the AICc ranks adsorption isotherm models better than error functions.

The AICc is more robust in resolving very close adsorption isotherm performance. When fitting more than one model to experimental data and screening of the candidate models is critical to the research work's objectives, Akaike's AICc provides a tool for model selection. The broad approach used by Akaike not only allows for the identification of the best model, but also for the ranking of the other models under consideration. The Relative Akaike Weight (RAW) (λ), is used to rank the isotherm equations, and the values of λ clearly identify the appropriateness of the model isotherm equations.

Giancarla et al. (2012) also reviewed extensively, the modeling of sorption phenomena beyond the discovery of new adsorbents and highlighted the deficiencies of linearizing nonlinear adsorption models in relation to wrong expressions and goodness of fit. The exponential expression of the Bohart-Adams model (Jang and Lee, 2019), has been described as incompatible with the S-shaped breakthrough curves commonly associated with adsorption studies on fixed bed. The generalized Bohart-Adams model (logistic function) is however recommended to fit breakthrough curves that are S-shaped (Chu, 2020a). The Bed Depth-Service Time (BDST) equation used by Ang and co-workers (2020a), was incorrect and produced undesirable results in the study on fixed bed modeling (Chu, 2020b). Bollinger (2020) has also commented on the inadequacy of linearized models when applied, to obtain parameters of kinetic and isotherm models in adsorption processes. Zhou (2020a) has observed the misapplication of Polanyi potential. The reported errors have been linked to incorrect expression of the Polanyi potential equation and its dimensional problem in relation to units of the equilibrium concentration of solute (C_e). Tran and Limac (2021) have also highlighted the influence of species of chromium in wastewater treated with adsorbent. The errors committed by Oumani et al. (2019) in the use of Redlich-Peterson constant (K_{RP}) for calculating the thermodynamic parameters (ΔG° , ΔH° , and ΔS°) of the adsorption process have again been highlighted by Tran and Limac (2021). According to Zhou, (2020b), Huang et al. (2019) published an article with mistakes in the mathematical notation and dimensions used in the computation of Gibbs free energy in the studies on the adsorption of divalent manganese by layered double hydroxides with diethylenetriaminepentaacetic acid intercalate (Zhou, 2020b). It is however encouraging, observing the regret expressed by the Huang et al. (2020) and the relevant corrections provided for their misinterpretation of the equilibrium constant, which resulted in the incorrect computation of the entropy, enthalpy and Gibbs energy as published in their original article. The willingness of authors to publish Corrigendum on observed inconsistencies is an important step towards the elimination of any potential propagation of published errors in adsorption studies. In 2019, Tran (2019) also observed the incorrect

determination of the binding energies of Chromium (III) and Chromium (VI) in Cr 2p spectra of a laden adsorbent, in studies involving the simultaneous removal of Chromium (VI) and methyl orange on layered double hydroxides decorated carbon adsorbent, which were published by [Chen et al. \(2018\)](#). It is imperative to reiterate that because Cr(VI) has more electron seeking ability than Cr(III), higher binding energies are commonly associated with Cr(VI) in x-ray photoelectron bands of chromium species. [Chen et al. \(2019\)](#) however accepted the errors and published a Corrigendum to the article in which the authors expressed appreciation to Tran for raising the issues and the insights it provided. In another comment by [Tran \(2020c\)](#), huge errors were reported in the published works on Puffed Rice Carbon for removal of mercury in aqueous phase ([Fang et al., 2020](#)). Tran highlighted the common error that is exhibited when equilibrium constant forms the basis for the calculation of thermodynamic parameters and presented a good argument on the need to adopt pH_{PZC} or pH_{IEP} to verify discussions on electrical charges on adsorbent surfaces. [Wang and Giammar \(2019\)](#) criticized the conventional approach to evaluation of new adsorbents and argued for the homogeneous surface diffusion model (HSDM), which can “yield adsorption rates that have a similar appearance to a PSO reaction without assuming the chemical sorption mechanism”. Zimeng and Daniel equally argued that surface complexation modeling (SCM) could enable the predictions of adsorption equilibrium over an array of chemical conditions in studying new sorbents.

The influence of inconsistencies on scientific research is evident in the propagation of the proclaimed deficiency in the Bohart-Adams model (B-A model) as identified by many investigators. The B-A model, along with its derivative, the bed depth-service time (BDST) equation, is the foundation of adsorber design and analysis for fixed bed experiments ([Chu, 2020c](#)). [Ang and co-workers \(2020b\)](#) commended Chu's insightful commentary on the different versions of the Bohart-Adams model (exponential and logistic versions). Chu argued that the B-A, Thomas, and Yoon-Nelson models are equivalent when they are presented using the logistic growth function that has two general parameters. The general parameters can be determined, by fitting the logistic equation to the breakthrough data. Thus, the respective parameters of the models can be computed ([Chu, 2020c](#)). According to Chu, the oversimplification by [Ang et al. \(2020\)](#) in deriving the B-A model is the reason for the erroneous proclamation of deficiency in the B-A model. [Salvestrini et al. \(2014\)](#) comparatively analysed the common approaches for deriving sorption thermodynamic parameters from temperature dependent sorption isotherms and highlighted that standard and isosteric thermodynamic parameters are different in meaning. The researchers showed how the sorption model influences the standard state and consequently the values of ΔG and ΔS , and argued that the arbitrary choice of standard states in sorption studies leads to distorted interpretations of results. They therefore recommended the well-known standard states for the comparison of thermodynamic parameters that are obtained from various sources. [Thue and co-workers \(Thue et al., 2020\)](#) have also argued that beside the molecular size used as a criterion of maximal sorption capacity, equilibrium constant is another critical factor, because high equilibrium constants links to the adsorbing specie and adsorbent's inclination to interact.

As shown in this bibliometric study, the observed errors and discrepancies in adsorption report are majorly linked to inaccuracies in the approach to linearizing the adsorption equations. The wrong approaches have in turn, yielded many incorrect adsorption model equations as also reviewed in this study. Therefore, this study attempts to compile the original (nonlinear) and correct expressions of the linearized forms of the models of adsorption isotherm and adsorption kinetics ([Table 1](#)) to serve as good reference material. Some of the nonlinear adsorption models are in [Ece and Kutluay \(2022\)](#), [Kutluay \(2021\)](#), [Kutluay et al. \(2020\)](#) and [Kutluay et al. \(2019\)](#).

Despite a series of comments by various authors on errors and misunderstandings in various reports of adsorption studies, errors and misinterpretations continue to spread. Tran's recent comment shows

Table 2

The latest inconsistencies within adsorption studies developed in the last 5 years (2018–2022).

S/ N	Authors	Year	Journal	Observed inconsistency
1	Wu et al.	(2020)	<i>Chemosphere</i> , 246, 125,734	i. Point of Zero Charge (pH_{PZC}) from the drift method, were determined from wrong positions on the graph ii. Maximum amount of the dye adsorbed iii. Wrong Prediction of adsorption mechanism iv. Incorrect illustration of hydrogen bonding in adsorption mechanism Incorrect pseudo-first order equation
2	Sumalinog et al.	(2018)	<i>Journal of Environment Management</i> , 210, 255–262.	
3	Yu et al.	(2018)	<i>Chemosphere</i> , 195, 632–640.	Mistakes in the use of pseudo-first-order kinetic model
4	Li et al.	(2019)	<i>Chemical Engineering Journal</i> , 360, 325–333.	incorrect speciation plot with wrong interpretations
5	Fan et al.	(2019)	<i>Chemosphere</i> , 217, 85–94.	Wrong Weber-Morris intra-particle diffusion curve chemisorption mechanism determined by fitting time-dependent adsorption data to pseudo-second-order model and the calculation of thermodynamic-parameters of liquid–solid adsorption process from equilibrium constant derived from the Redlich–Peterson constant
6	Zhang,	2020	<i>Sci. Total Environ.</i> 727, 138,701	Incorrect Bed Depth-Service Time (BDST) equation
7	Ang and co-workers	(2020)	<i>Chemosphere</i> 239, 124,839	The wrong use of Redlich–Peterson constant (K_{RP}) for calculating the thermodynamic parameters (ΔG° , ΔH° , and ΔS°) of adsorption process
8	Oumani et al.	(2019)	<i>J. Hazard. Mater.</i> 378, 120,718	mistakes in the mathematical notation and dimensions used in the computation of Gibbs free energy.
9	Huang et al.	(2019)	<i>J. Environ. Sci.</i> 85, 56–65.	incorrect determination of the binding energies of chromium (III) and Chromium (VI) in Cr 2p spectra of a laden adsorbent
10	Chen et al.	(2018)	<i>Chemical Engineering Journal</i> , 352 306–315	error that is exhibited when equilibrium constant forms the basis for the calculation of thermodynamic parameters
11	Fang et al.,	2020	<i>Environ. Sci. Technol.</i> 54(4), 2539	

that the issue is at the emerging phase and there is no bibliometric survey of these errors and misunderstandings to highlight the global spread of this concern. [Salvestrini et al. \(2022\)](#) recently reviewed and published a couple of errors in the calculation of ΔH and ΔS in addition to parameters that were determined without error estimates. The authors reported a mismatch between selected isotherm models and isosteric heat of adsorption with misleading interpretation of process spontaneity, and interchangeability of ΔG° and ΔG . The authors recommend graphical method for assessing data reliability and the applicability of the van't Hoff equation.

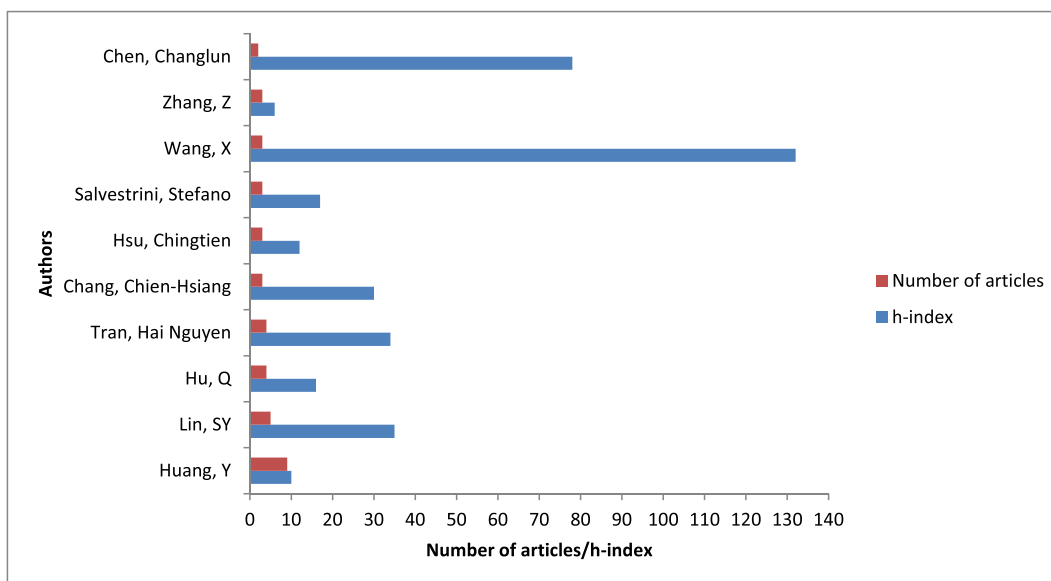


Fig. 1. Articles Contributed by Authors.

To publicize further these phenomena, which are threatening the trustworthiness of the application of adsorption technique to water treatment, a bibliometric investigation of mistakes and inconsistencies in numerous reports of adsorption of pollutants from solutions is required. Given the growing concerns about industry-produced dye and other pollutants, it is critical to limit the spread of theoretical inconsistencies and errors through citations. The diverse application of adsorption–desorption science enabled the investigation of the catalytic activity of the metal–organic frameworks studied by Lee et al. (2022), using isotherm. Hubbe (2021) provided insights to the correct approaches that produce meaningful results from adsorption studies and referred to the segmentation of data in Weber-Morris intraparticle diffusion model as incorrect due to its suggestion of more than one adsorption mechanism.

The paucity of bibliometric data on the subject inspired the authors’ interest in collating the mistakes. After which a bibliometry was performed to evaluate the comment trends and scholarly networks in the different responses of authors to the mistakes and misconceptions in adsorption studies. This type of analysis can provide guidance to young and budding researchers in adsorption science and forestall the propagation of the errors and misconceptions in future studies. Table 2 shows the latest inconsistencies within adsorption studies developed in the last 5 years (2018–2022).

Methodology.

VOSviewer (version 1.6.13) software performed the bibliometric analysis, using articles retrieved from the Scopus database. The exploration of the Web of Science (WoS) also retrieved the same content as those retrieved from the Scopus database. The search strings are, adsorption, AND mistake. These were typed and searched through all documents in the Article title, Abstract, Keywords search bar with limit showing all years publication until 31st March 2022. The data for this study consists of English articles published in the Scopus database. The examination of the title, abstract, author keywords, and contents of all documents ensured, the retrieved documents address the subject and focus of the study. The data was exported using Microsoft excel Comma Separated Values file (CSV) for the VOSviewer analysis. The search results were also analysed using the analysis software on Scopus to generate descriptive charts for the focused items for the study, in addition to the VOSviewer images.

The VOSviewer is a tool for carrying out data analysis and generates the graphics of the items that occur in clusters and create explanatory graphics in the form of maps. This operative instrument has the capacity

Table 3
Number of articles published per year.

Year	Articles
2022	6
2021	6
2020	18
2019	31
2018	12
2017	4
2016	4
2015	1
2014	2
2013	1
2012	1
2011	1
2010	1
2007	1
2006	1
2004	1
2001	1
2000	1
1999	1
1997	1
1994	2
1993	1
1990	1
1988	1

to distinguish the group level of the intensity of the occurrence of keyword in a document (Van Eck and Waltman, 2013). The VOSviewer software can create visuals, and enables the exploration of maps that are obtained from bibliometric network data (Van Eck and Waltman, 2013). The results are in clusters that interpret to explain any connections that may exist in the data. In this study, co-authorship, co-occurrence, and citation analyses generated the network maps that show the co-occurrence of keywords, co-authorship among the researchers, countries of affiliation, and the cited academic journals. The nodes contained in the network map have sizes that are determined by the strength of the total link. The study highlights the country of origin of the researchers who have published their observations and comments regarding the mistakes and inconsistencies in the published works on adsorption of contaminants from solutions. This is to provide literature and the insights on the concern and spread of the subject matter across the globe.

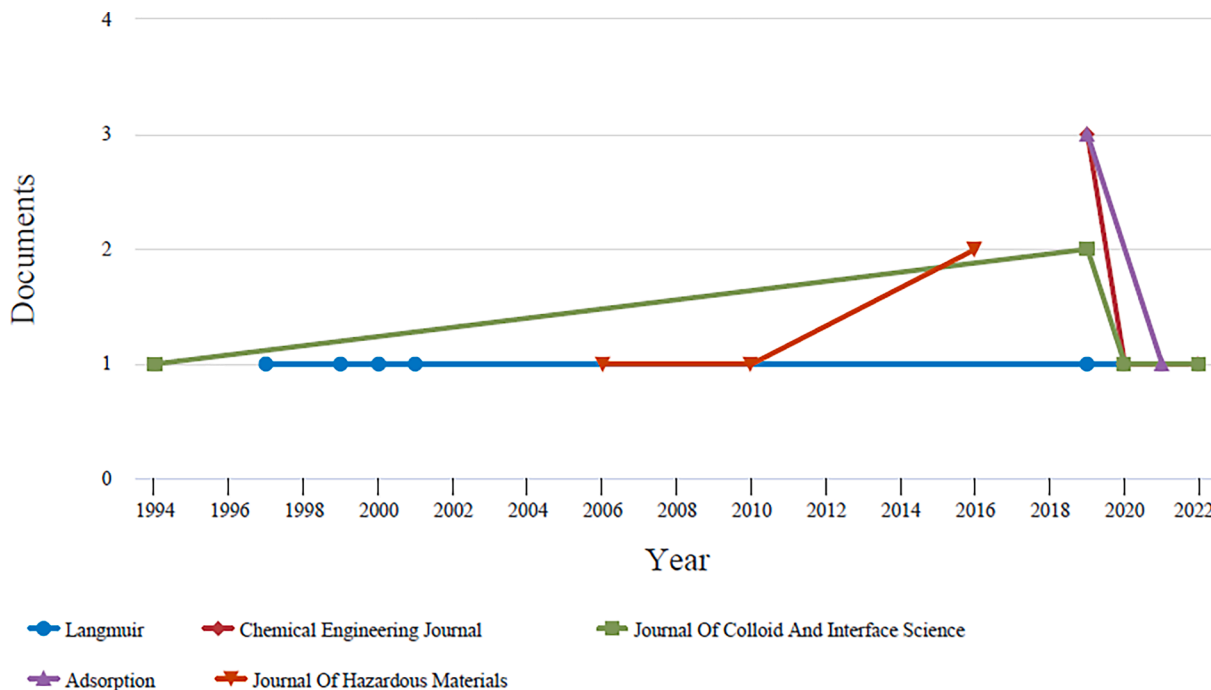


Fig. 2. Articles published per year by source.

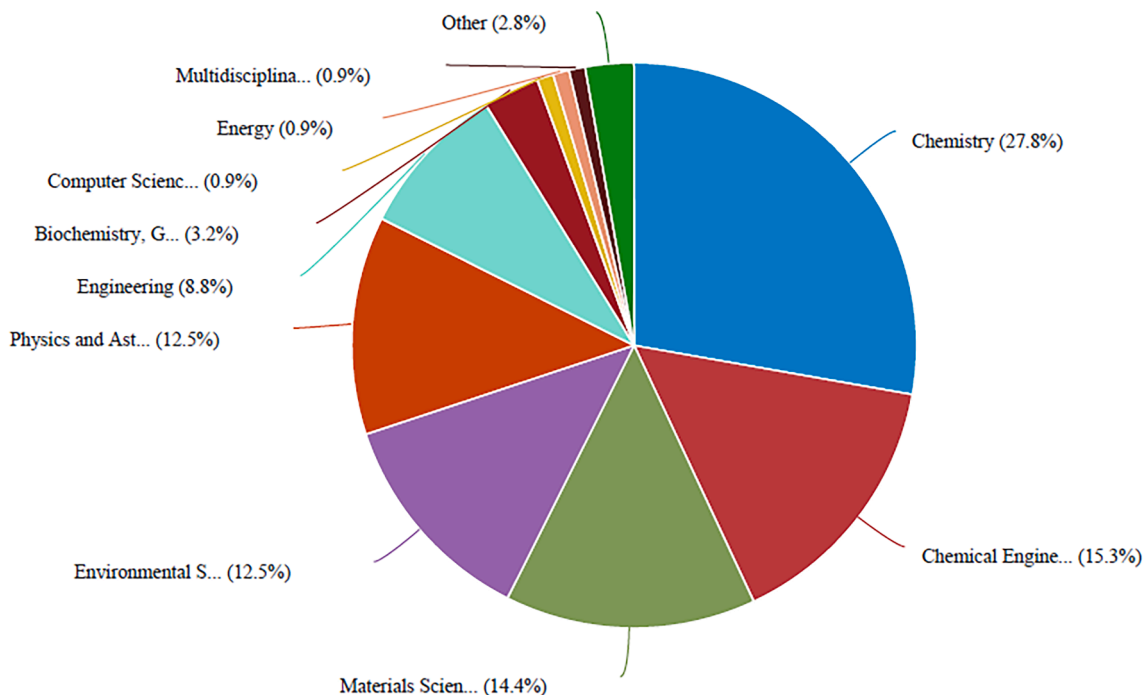


Fig. 3. The distribution of the retrieved articles by subject area.

Results and discussion

This study conducted a search through the metric literature on the Scopus and Web of Science database, regarding researchers’ comments on mistakes and inconsistencies in reporting adsorption of contaminants from solutions. The retrieved articles are scanty, as the search returned only 100 items covering the period 1988 to 2022. All the 100 articles are relevant to the subject and thus reviewed in this study. Fig. 1 presents the academic impacts of the top 10 most productive authors with their h-indexes. Wang produced the highest impact with H-index of 132. The

highest number of research articles was published on the subject in 2019 with 31 articles (Table 3). Fig. 2 shows the published articles per year by source with Chemical Engineering and Adsorption Journals dominating with three articles each. Other sources produced either one or 2 articles each. The distribution of the retrieved articles by subject area is in Fig. 3. The contribution of Chemistry alone was 27.8% while Chemical Engineering and Material Science contributed 15.3 and 14.4% respectively. The total contribution from other Engineering areas was 8.8%. The temporal trend of the publications on the subject is presented in Figure S1 (Supplementary Materials), showing an exponential increase

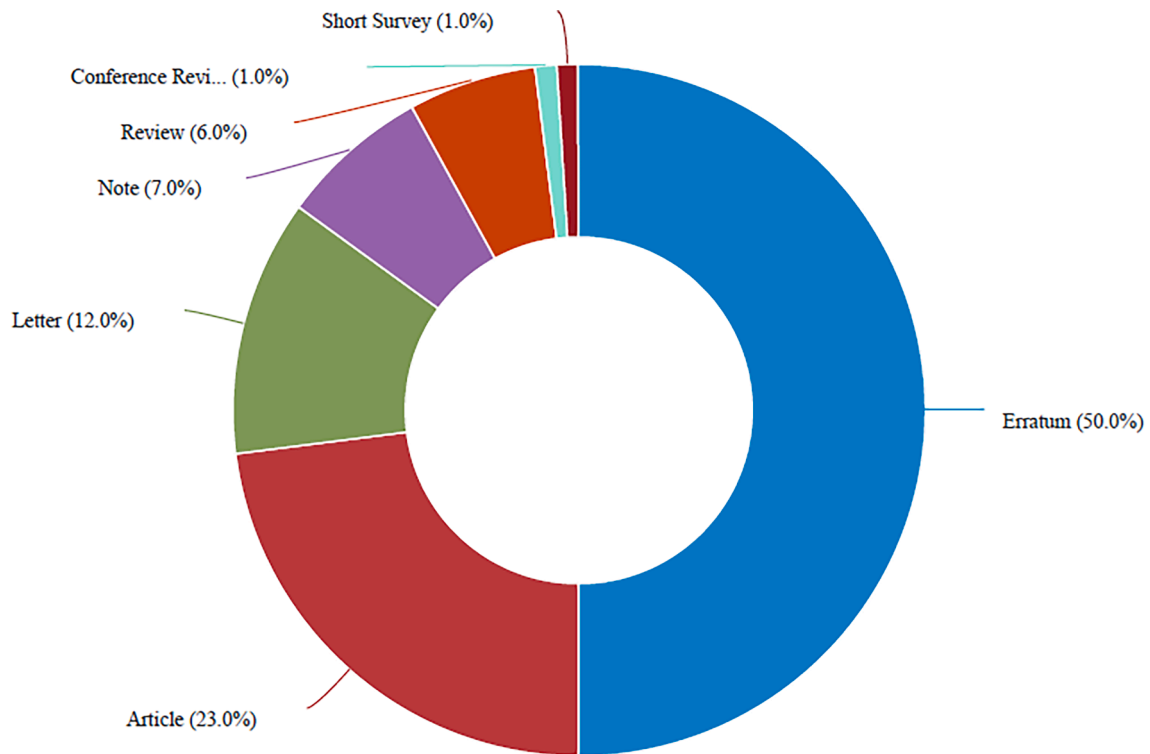


Fig. 4. The distribution of the different types of articles retrieved.

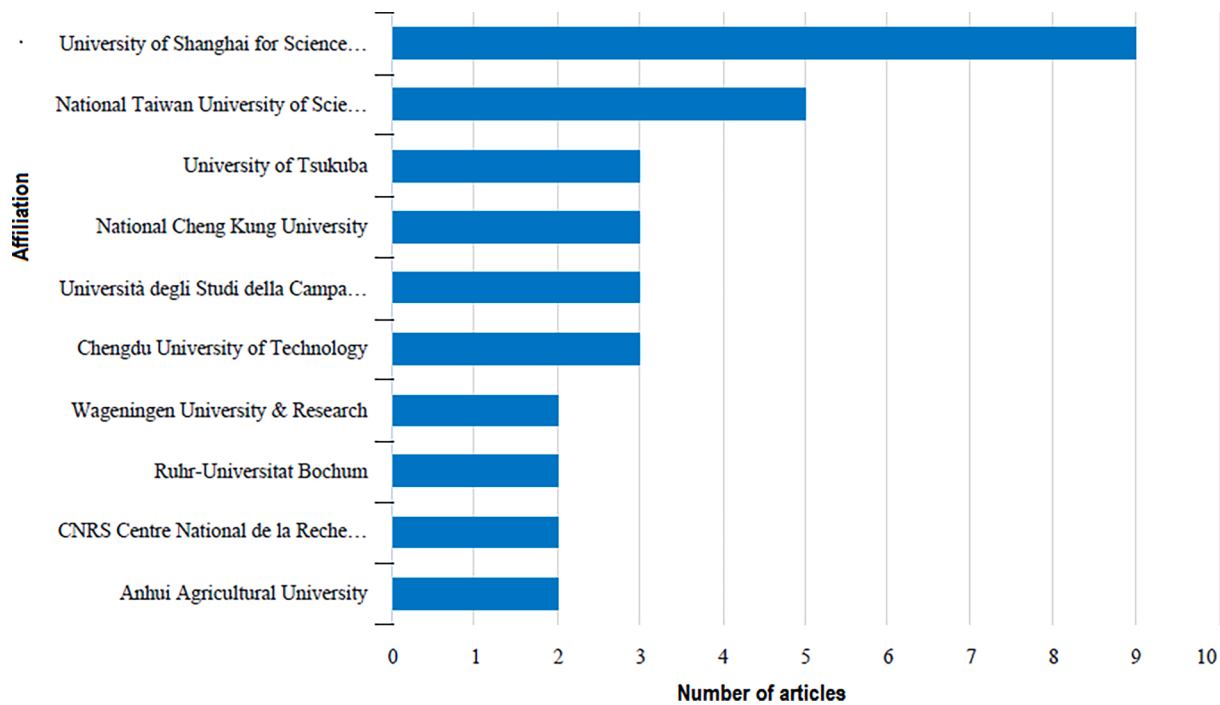


Fig. 5. The distribution of the retrieved articles according to institutional affiliation.

in articles published in 2019.

Fig. 4 shows that 50.0% of the publications were erratum while original research articles and letters to editor represent 23.0 and 12.0% respectively. Only 6.0% of the publications were review articles. The distribution of the retrieved documents according to institutional affiliation indicates that the University of Shanghai for Science and Technology with nine publications had the highest number of articles

(Fig. 5).

The distribution of the articles by country/territory follow the trend China > Taiwan ≈ Iran > others (Fig. 6). Advances in international and intercontinental research collaborations should enhance the transfer/share of knowledge and technology across nations. Fig. 7 shows only the six countries (France, United States, Netherlands, Germany, Italy and Iran) of co-authors that published collaborative research work on

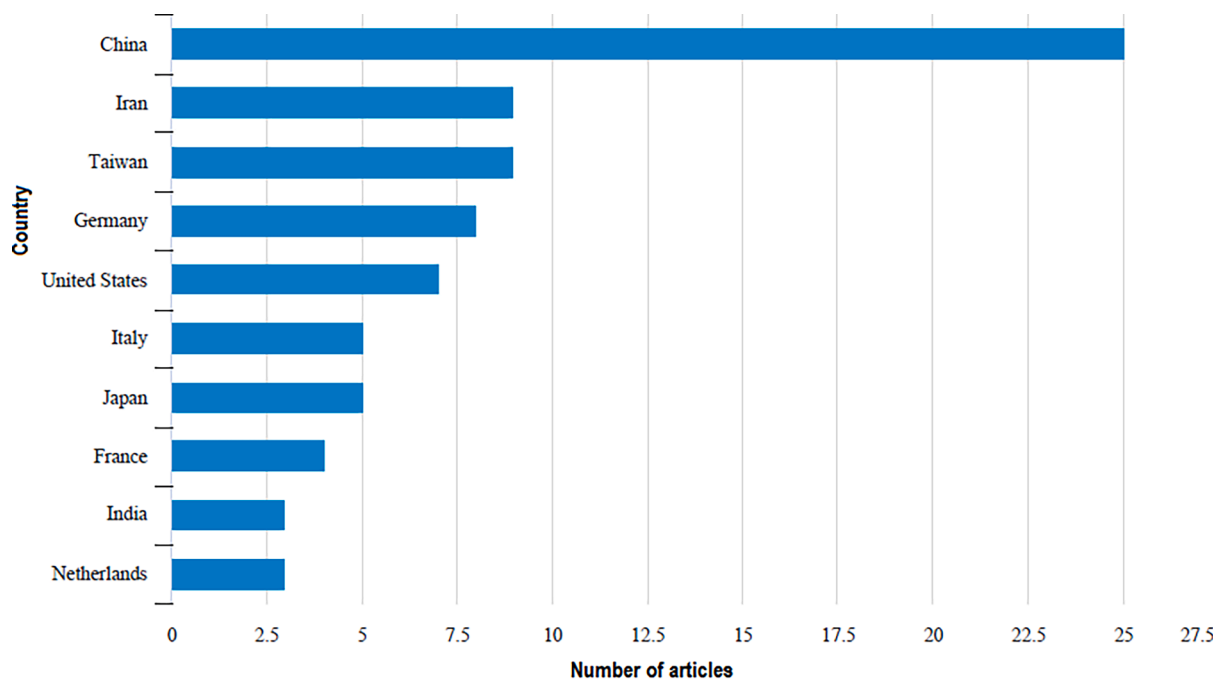


Fig. 6. The distribution of the articles by country.

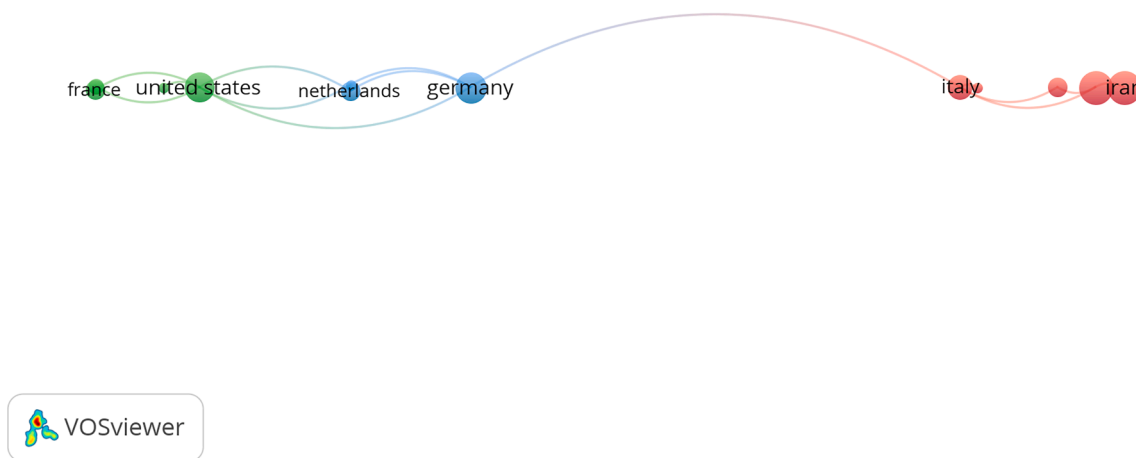
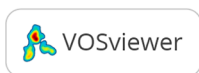


Fig. 7. Network visualization of countries of co-authors with link.



mistakes and inconsistencies regarding adsorption of contaminants from solution. The other countries are, United Kingdom, Spain, Saudi Arabia, Portugal, Latvia, Hungary, Brazil, Australia, Serbia, Poland, Malaysia, Canada, Vietnam, South Korea, Russia, India, Japan, Taiwan and China, and their contributions are none collaborative. The absence of other countries particularly, the African countries, from the list of the contributors to the subject perhaps indicates the limited awareness on the issue. There is therefore, the danger of the propagations of the errors and misconceptions in journals. The major funding agents of the retrieved articles include China scholarship council, Australian research council, European commission, European social fund, Basic energy sciences (USA), Deutsche Forschungsgemeinschaft and Budapesti Muszaki es Gazdasagtudomanyi Egyetem (Fig. 8).

Clusters of terms and the researchers that strongly relate to each other in their comments are in different colours. Term co-occurrence maps based on text data are in Figures S2-S4 (Supplementary Materials). The density visualization is in Figure S2, while the network and overlay maps are in Figure S3 and Figure S4 respectively. Figure S2 displays the terms in the literature, which defined the discussions on the

mistakes and inconsistencies in reporting adsorption of contaminants from solutions. This academic discuss were associated majorly with comments reported on adsorption from aqueous solutions with special highlights on kinetic parameters, adsorption kinetic model, area and classic BET test. Uptake of contaminants with respect to adsorption capacity of adsorbents was also in focus. Figure S3 indicates the link and similarity of the contents discussed by the researchers. The overlay map in Figure S4 shows that typically, the discussions of mistakes and inconsistencies in reporting adsorption from solutions were “Science Communications” on the original articles.

The bibliographic data produced the density and network maps of co-authorship shown in Figures S5 and S6 (Supplementary Materials), respectively. Figure S5 shows the distribution of authors indicating that Zhang J., Zhang Z., and Hu Q., with their co-authors were the prominent contributors among the scholars. Among the array of issues generated on the mistakes and inconsistencies in adsorption reporting, Zhang J., Huang I., Zhang Q., Xiong Y., Yan Y., Tan S and Li C made their comments on related issues (Figure S6). Zhang Z., Xie Y., Feng C., Hu Q., and Pang S clustered on the same comment while Yu F., Ma J., Lin Y., Li Z.,

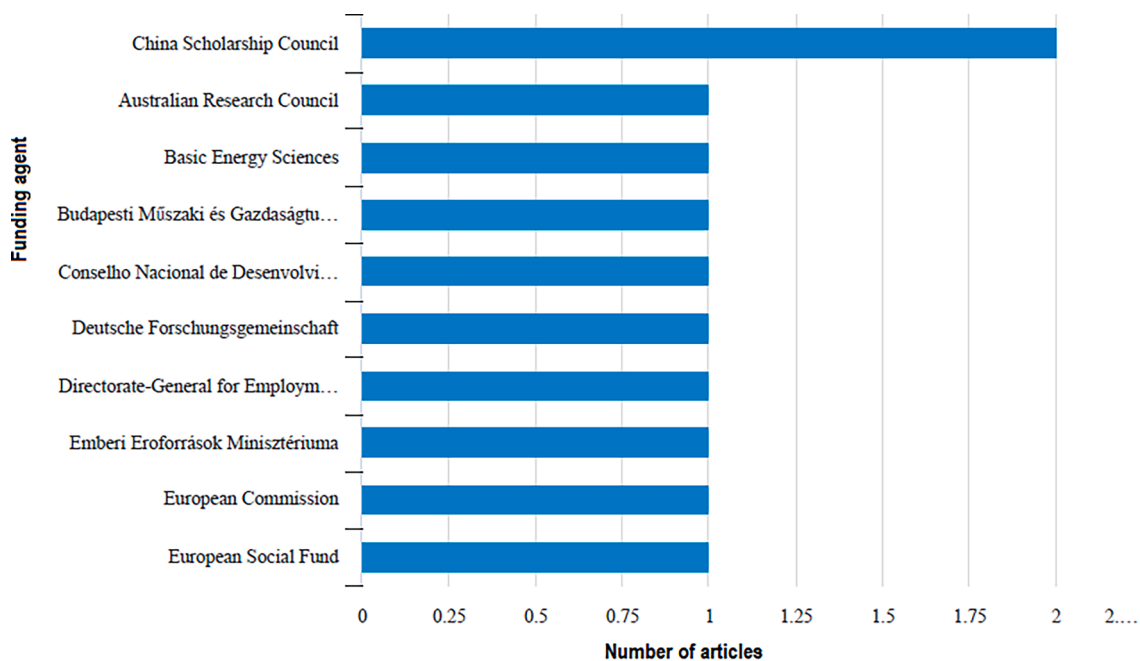


Fig. 8. The distribution of the articles by Funding agent.

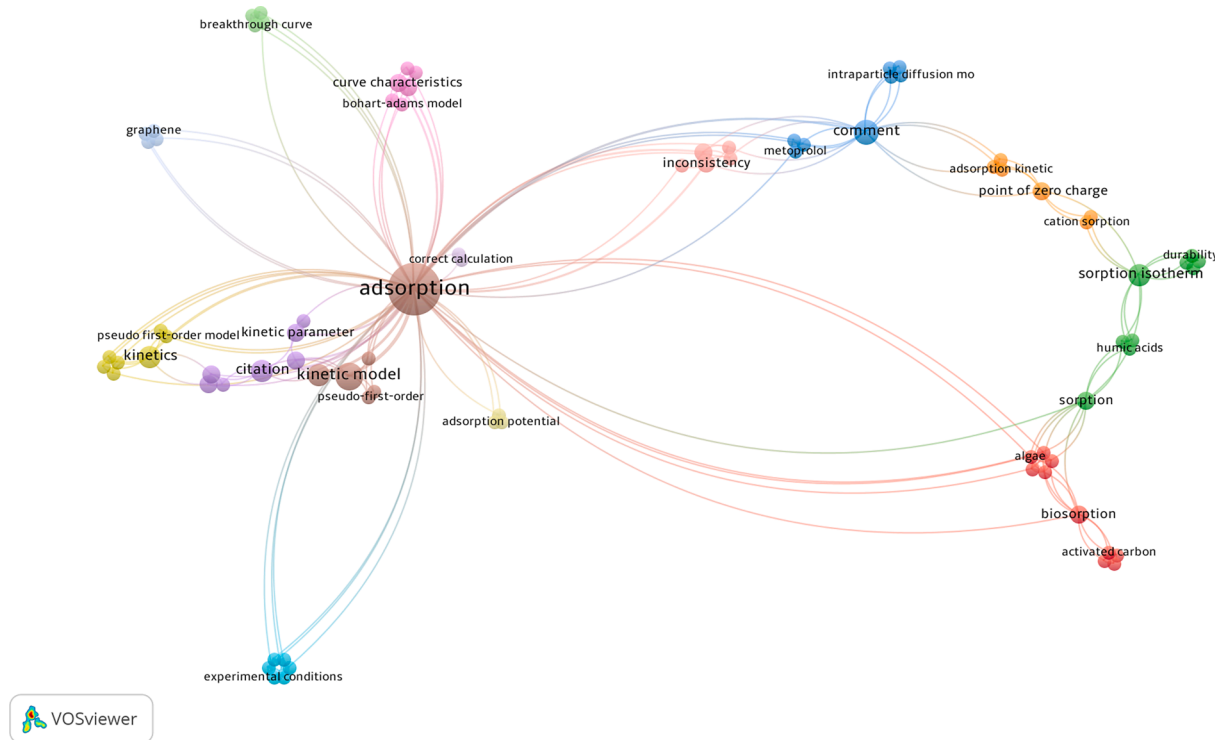


Fig. 9. Co-occurrence analysis of the keywords.

Liu W., and He K., focused on a different issue. There are four distinct clusters of co-authors representing the different issues, as shown in Figure S6. Co-authors within the clusters were more than five in the clusters.

Considering the title and abstract fields concurrently, 2332 different terms occurred in the database, with all the 2332 terms in both the titles and abstract meeting the threshold with minimum of one link (Figure S7, Supplementary Materials). Out of 2332 terms, only 509 terms occurred in the various titles retrieved from the Scopus database.

The network visualizations of the terms that occur in the abstracts show that the main themes of the various abstracts include the misconception that is associated with the conceptual approach to the adsorption system, with a highlight on the pseudo first order kinetic equation (Figure S8, Supplementary Materials). The inappropriate description of the adsorption process and its kinetics in association with the isotherms were largely responsible for the mistakes observed in the published adsorption works. The terms that connect in the titles are in the density visualizations of the terms in Figure S9 (Supplementary Materials). In all

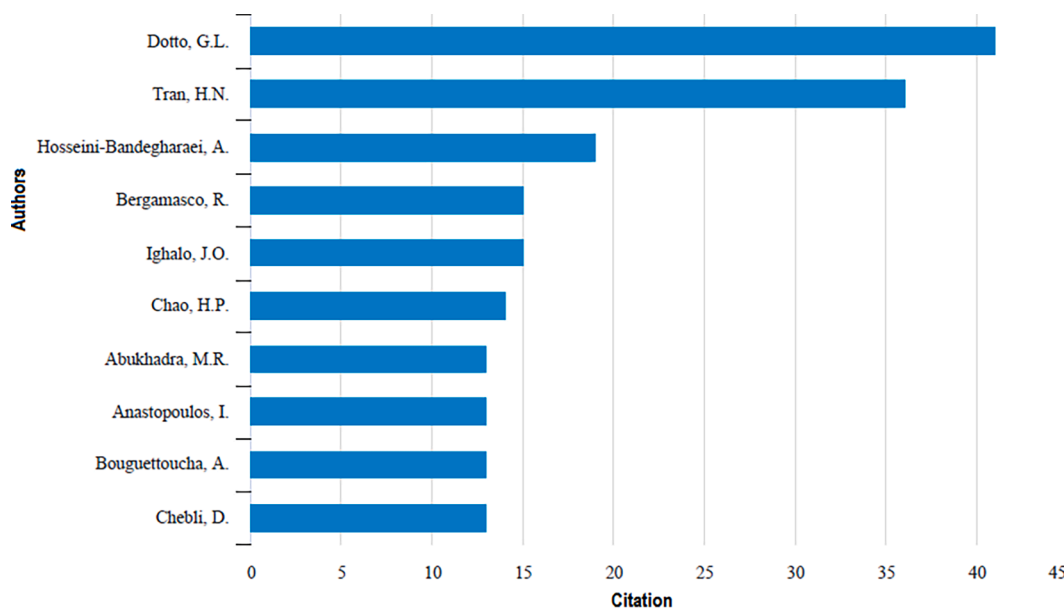


Fig. 10. Citation index of articles on inconsistencies in adsorption reporting.

the discussions, the comment published by Tran et al on the adsorption inconsistencies featured prominently. Many discussions centered on mistakes committed by authors in their transformation of the celebrity isotherms without recourse to the original ideas in the original articles in which the isotherms were first reported. The bibliometric study revealed the term ‘comment’ (Fig. 9) as a key terminology in discussion of the inconsistencies in reporting adsorption of contaminants from solutions. The term ‘mistake’ was however, mostly used in the abstracts of the work published on mistakes and inconsistencies in reporting adsorption of contaminants from solutions. Fig. 9 shows the co-occurrence analysis of the keywords. The results indicate that the dominant keyword is ‘adsorption’ and it is the most widely discussed keyword regarding mistakes and inconsistencies in reporting removal of contaminants from solutions. Other keywords that were also used to render contribution by various authors include, sorption, kinetic model, aqueous solution, citation, water treatment, dye, pseudo first-order and pseudo second-order equations. The source dynamics of the publications (Figure S10) (Supplementary Materials) shows the retrieved sources of the various titles that cited the bibliometric articles retrieved from the Scopus database. The top ten authors that cited the 100 retrieved articles are in Fig. 10 with Dotto, G.L and Tran et al. having the highest citation index.

Conclusion

The unfortunate mistakes and misconceptions that have been associated with the adsorption of contaminants from aqueous solutions is a worrisome development with respect to their potential propagation through citations. This study reviewed the errors, and elaborated the corrections of the observed inconsistencies. The analysis revealed that, the mistakes and inconsistencies in the adsorption studies were largely associated with the errors in the approaches deployed to linearizing the adsorption models. The wrong approaches yielded many incorrect adsorption model equations as reviewed and corrected in this study. This study therefore reports the original (nonlinear) adsorption models, and corrects the expressions of the linearized forms of the isotherm models and adsorption kinetics. The computation of thermodynamic adsorption parameters from the Langmuir Equation is associated with unit Problem. It is important to note that:

(i) ΔG° is not to be calculated from the equilibrium constant (K) in the Langmuir equation because (K) has dimension. The equilibrium constant that is suitable for the computation of thermodynamic

parameter must be dimensionless.

(ii) The very important step in the correct calculation of thermodynamic parameters is the correct computation of the standard equilibrium constant (K°) from the transform of the Langmuir equation.

(iii) The transforms of Langmuir equation are either from the chemical potential or substitutional adsorption.

(iv) Because the modified Langmuir equation from the chemical potential, does not account for exchange adsorption, it is only suitable for describing adsorption of an adsorbate on a clean solid surface.

(v) Because the vacant sites on the surface of the adsorbent have been occupied by solvent molecules before the adsorption of the solute, the modified Langmuir equation from the substitutional adsorption process conforms to the actual situation of liquid–solid adsorption, as a result, it can be used to calculate K° .

(vi) The ability to correctly calculate the polanyi potential is critical to the success of the Dubinin-Radushkevitch (D–R) adsorption isotherm. It is critical to remove the dimension of solute concentration and replace it with the solution’s standard concentration value.

This study presents bibliometric maps of clear visualizations of connections from network data on 100 articles retrieved from 1988 to 2022 and demonstrate the capabilities of VOSviewer for clustering and mapping publications from bibliometric survey on the subject. The findings indicate remarkable increase in the number of publications since 1988. China was the leading country in terms of publications related to inconsistencies in adsorption reports. The bibliometric results indicate 50.0% of the publications were erratum whereas the original research articles and letters to editor represent 23.0 and 12.0% respectively. 6.0% of the publications were review articles. The distribution of the retrieved documents according to institutional affiliation indicates that the most productive institution is University of Shanghai for Science and Technology with nine publications. The contribution of the various countries/territories follow the trend China > Taiwan \approx Iran > others. The co-authors that published collaborative research work on mistakes and inconsistencies regarding adsorption of contaminants from solution were from France, United States, Netherlands, Germany, Italy and Iran. The four distinct bibliometric clusters of co-authors indicate that there are four different and related issues discussed in the articles. Out of 2332, terms that occurred in the titles and abstracts of articles retrieved from the Scopus database, 509 terms occurred in the various titles retrieved. The network visualizations of the terms that occur in the abstracts show that the main themes of the various abstracts include the

misconception that is associated with the conceptual approach to the adsorption system, with a highlight on the pseudo first order kinetic equation. The presentation of the misconceptions and mistakes as compiled in this study, with the discussions on the correct approaches can prevent their proliferation into the adsorption science database.

Declaration of Competing 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.clema.2022.100100>.

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