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ORIGINAL RESEARCH PAPER

Optimized removal of trivalent arsenic from aquatic environments using *Prosopis juliflora* seed biomass

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ABSTRACT

BACKGROUND AND OBJECTIVES: With urban populations struggling with wastewater and water sources contaminated by metalloids, the demand for sustainable and effective methods for removing heavy metals is growing ever more urgent. Arsenic contamination in wastewater and water supplies is a critical environmental concern worldwide, posing severe health risks and demanding effective mitigation strategies. With numerous regions contending with increased arsenic levels, it is crucial to explore various removal strategies to maintain water quality and safeguard public health. Employing biomass obtained from waste materials offers an affordable and uncomplicated strategy for the removal of environmental pollutants. The study objectives were to evaluate the ability of biomass derived from *Prosopis juliflora* fruit to uptake arsenic from wastewater..

METHODS: Following the drying process, the harvested biosorbent was processed into a fine powder through grinding. All tests utilized the biomass that had been refined to powder sizes of less than 45 micrometers. An assessment of arsenic adsorption was conducted using response surface methodology, focusing on the effects of several operational parameters, including the biosorbent to arsenic ratio, solution potential of hydrogen, and the contact time between the biomass and the analyte. Additionally, the optimal conditions for maximizing arsenic removal by the biomass of *Prosopis juliflora* were determined through the Box-Behnken approach. Kinetic studies were conducted to statistically analyze the trivalent arsenic adsorption process.

FINDINGS: The effectiveness of the proposed model in identifying the optimal conditions for the trivalent arsenic uptake process was validated through testing. The analysis of experimental data revealed the coefficient of determination, adjusted coefficient, and predicted coefficient values to be 0.9936, 0.9820, and 0.9053, respectively. According to the results, the highest adsorption of arsenic ions by the biomass was achieved at 91.11 percentage, with *Prosopis juliflora* fruit biomass to-arsenic ratio of 8:1, potential of hydrogen of 7.5, and a contact time of 90 minutes.

CONCLUSION: The findings of this study indicate that the biomass of *Prosopis juliflora* fruit serves as an efficient sorbent for the removal of trivalent arsenic from water under optimal conditions. The adsorption data aligned with pseudo-second-order kinetics, with a maximum capacity of 114.94 milligrams per gram, suggesting that the adsorption of trivalent arsenic onto the *Prosopis juliflora* occurs in monolayers.

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NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
61	4	4

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INTRODUCTION

High concentrations of toxic metals, including cadmium, chromium, mercury, arsenic, lead, and zinc, are commonly found in industrial effluents, often exceeding the permissible limits in treated wastewater (Asadullah *et al*., 2022; Hawrami and Baset, 2024; Samimi and Shahriari Moghadam, 2024). Wastewater contamination poses a multifaceted challenge to public health and environmental sustainability (Mohadesi *et al*., 2024a; Samimi and Moghadam, 2024a). The water sources that serve urban areas, crucial for maintaining population health, are increasingly at risk of contamination from both anthropogenic influences and natural occurrences (Al-Azzawi and Saleh, 2023; Samimi and Validov, 2018). The detrimental impact of contaminated wastewater on public health necessitates a thorough investigation into the sources and potential remediation strategies (Samimi and Shahriari Moghadam, 2020; Ehzari *et al*., 2022). Water supplies are vulnerable to a diverse array of contaminants, ranging from microbial pathogens to chemical pollutants. The presence of pathogenic microorganisms, such as bacteria and viruses, raises concerns about waterborne diseases (Erdag *et al*., 2023). Moreover, the complexity of water and wastewater quality issues is exacerbated by the presence of heavy metals, industrial byproducts, and emerging contaminants, which include pharmaceuticals and personal care products (Sulistyowati *et al*., 2023; Sabilillah *et al*., 2023; Cheraghipoor *et al*., 2024). Advanced treatment technologies, including membrane filtration, activated carbon adsorption, and ultraviolet disinfection, offer effective means of removing diverse contaminants (Handayani *et al*., 2024; Abdallat *et al*., 2024; Fatima *et al*., 2024). Additionally, the implementation of green infrastructure, sustainable urban design, and community-focused programs can significantly aid in addressing contamination at its source (Douglas, 2018). The burgeoning demands of growing cities, coupled with the escalating threats of waterborne contaminants, necessitate continuous advancements in wastewater treatment methodologies (Mohadesi *et al*., 2024b). Arsenic, classified as a metalloid, consistently raises concerns regarding its presence in both water and wastewater. The main environmentally relevant forms include arsenite (As(III)), arsenate (As(V)), monomethylarsenate, and dimethylarsenate. Trivalent arsenic is typically more toxic than pentavalent arsenic. Arsenic contamination in water and wastewater sources is a significant worldwide challenge, endangering public health and demanding specific actions for successful removal (Samimi *et al*., 2023a). Arsenic, a naturally occurring element, often finds its way into water supplies through geological processes or human activities such as mining and industrial discharges (Hammond *et al*., 2018; Abubakar *et al*., 2023). Arsenic contamination, commonly stemming from natural geological formations or human-induced activities, emphasizes the essential demand for innovative technologies in water and wastewater treatment. Arsenic removal from water and wastewater due to toxicity and carcinogenicity is paramount (Younas *et al*., 2024). Municipal water systems, prone to arsenic infiltration due to geological conditions or industrial discharges, must implement effective arsenic removal techniques to satisfy demanding water quality criteria. The recognition of arsenic as a silent threat to public health has prompted a renewed focus on developing sustainable and efficient treatment methodologies (Phewnil *et al*., 2024). Copper smelting wastewater can contain high levels of arsenic, often in the form of As(III) (Luo *et al*., 2010). Paper mill industries can generate wastewater that contains arsenic (Zodi *et al*., 2011). Various treatment methods have been investigated for arsenic removal, including electrocoagulation using iron electrodes, which has shown effectiveness in treating both organic matter and arsenic salts in paper mill wastewaters (Balasubramanian and Madhavan, 2001). The challenge of arsenic removal stems from the presence of various oxidation states and the necessity for selective extraction to comply with strict regulatory standards (Nicomel *et al*., 2016). Conventional treatment methods, such as coagulation-flocculation, precipitation, and activated alumina adsorption, have shown efficacy, yet challenges persist in terms of cost-effectiveness and operational sustainability (Elhadeuf *et al*., 2023). Various biomass sources, including oil palm waste, algae, fungi, bacteria, and agricultural by-products, have demonstrated usage to produce biofuel (Osipova and Gladkov, 2024), usage to design and prepare stable catalysts (Goudarziafshar *et al*., 2024) and excellent adsorption capabilities for contaminants such as dyes, heavy metals, phenolic compounds, and petroleum pollutants (Vahabisani and An, 2021; Samimi and Nouri, 2023; Bakar *et*

al., 2024; Samimi and Shahriari-Moghadam, 2025). *Prosopis Juliflora* is a tree in the family Fabaceae. Found in semi-arid and arid regions worldwide, *Prosopis juliflora* is recognized as an invasive tree species (Yadav and Rana, 2020). It is a species of mesquite planted in most of the dry and hot regions of Africa, Australia, Asia (Eshetu *et al*., 2024; Rembold *et al*., 2015) and Ethiopia's Middle Awash area (Mehari, 2015). his plant reproduces through seeds and is cultivated in select regions to promote urban greening, stabilize loose sand, combat soil erosion, and function as a source of fuel and fodder, owing to its unique characteristics (Oliver Paul Nayagam and Prasanna, 2023; Gebrehiwot and Steger, 2024). *Prosopis juliflora* bears bean-shaped fruit in the summer which is not edible. Despite the extensive research conducted on the removal of arsenic using biosorbents, there has been no investigation into the effectiveness of *Prosopis juliflora* fruit biomass (PJB) in absorbing arsenic from wastewater. This study was performed to evaluate the ability of biomass obtained from *Prosopis juliflora* fruit for the arsenic uptake from wastewater. The operational factors in arsenic removal by PJB were also investigated and optimized. The current investigation has been performed in Kermanshah, Iran in 2024.

MATERIALS AND METHODS

Preparation of PJB biosorbent

The *Prosopis juliflora* fruit was collected from southern cities of Iran. The method of preparing biomass was executed based on research conducted by Samimi (2024). The collected biosorbents were washed using deionized water to eliminate surface impurities from the *Prosopis juliflora*. Subsequently, they were dried in an oven at a temperature of 32 degrees Celsius (°C) for a duration of 72 hours. After the drying stage, the adsorbent was pulverized into a fine powder and then subjected to sieving. The final PJB product, with particle sizes below 45 micrometers (µm), was applied in subsequent research endeavors.

Stock solution and batch biosorption

The As(III) stock solution (200 milligram per liter (mg/L)) was prepared by dissolving a certain amount of sodium arsenite salt ($Na_2HAsO_3{\cdot}5H_2O$) in double distilled water. The solutions for the experiments, each with distinct conditions, were prepared by diluting the stock solution accordingly. As outlined in the experimental design, the synthetic wastewater solution underwent vortexing and stirring for varying durations. The PJB-As(III) solution underwent centrifugation at 6000 Revolutions per minute (rpm) for 10 minutes (min) utilizing the Z205-A centrifuge model-USA (United States of America) to effectively separate any solid particles. The indirect assessment of As(III) ion adsorption involved measuring the concentration of the remaining metalloid in the supernatant using a flame-type atomic absorption spectrometer. The kinetics associated with the biosorption of As(III) by PJB were examined in batch systems at ambient temperature. The kinetics of As(III) biosorption by PJB was investigated in batch systems at ambient temperature. The removal of As(III) per gram of PJB and its uptake efficiency were determined using Eqs 1-3 (Samimi and Safari, 2022).

$$\text{Arsenic uptake efficiency: } \frac{(C_0 - C_e)\times 100}{C_0}\% \quad (1)$$

$$q_e = \frac{\mathrm{V}.(C_0 - C_e)}{M} \quad (2)$$

$$q_t = \frac{V}{M}(C_0 - C_t) \quad (3)$$

Where, q_e and q_t represent the PJB biosorption capacity measured in milligrams per gram (mg/g) at equilibrium and at time t (min). C_0 and C_e denote the initial and final concentrations of As(III) (mg/g). M indicates the dosage of PJB (g), while V refers to the volume of the As(III) solution (L).

Table 1: The experimental factors and the range of levels

Independent variables		Levels and ranges		
Operational parameters	Symbol	-1	0	+1
PJB-to-arsenic ratio	PA	2:1	5:1	8:1
pH of synthetic wastewater	pH	1.5	4.5	7.5
Contact time (min)	t	10	50	90

Table 2: The responses associated with three independent variables based on DOE

Run. no.	Operational variables			Response
	Y_{PA}	Y_{pH}	Y_t	As. R%
1	0	-1	1	18.14
2	-1	0	1	34.28
3	1	0	-1	39.55
4	0	0	0	34.89
5	0	-1	-1	13.36
6	1	0	1	69.20
7	0	0	0	37.82
8	0	1	1	80.23
9	1	-1	0	18.21
10	-1	0	-1	29.12
11	0	1	-1	61.82
12	-1	1	0	56.09
13	-1	-1	0	9.55
14	1	1	0	78.62
15	0	0	0	36.40

Design of experiments (DOE) and removal optimization

The Box Behnken design (BBD) was utilized in the study's design (using Minitab-18 software) to comprehensively assess the impact of independent variables and their interactions on the As(III) uptake from synthetic wastewater. The evaluation of optimal conditions for independent variables to maximize As(III) removal efficiency was conducted using response surface methodology (RSM) based on BBD (Aghajani *et al*., 2024; Kamaraj *et al*., 2024). The operating parameters listed in Table 1 were studied at three different levels, resulting in 15 runs that incorporated three center points. The independent variables examined included the ratio of PJB to arsenic (PA), the potential of hydrogen (pH) level of a synthetic wastewater solution containing arsenic ions, and the duration of contact time (t).

The results of DOE concerning the operating variables are presented in Table 2. A statistical analysis of the mathematical model was conducted, which included an analysis of variance (ANOVA) at a significance level of 5 percents (%) (Moghadam and Samimi, 2022; Ebrahimzadeh *et al*., 2024).

The full quadratic model illustrating the relationship between the amount of As(III) removal percentage (*As.R%*) and the response variables is represented by Eq. 4 (Samimi and Mansouri, 2024).

$$As.R\% = a_0 + \sum_{i=1}^{3} a_i Y_i + \sum_{i=1}^{3} a_{ii} Y_i^2 + \sum_{i=1}^{2} \sum_{j=i+1}^{3} a_{ij} Y_{ij} \qquad (4)$$

Where, Y_i and Y_{ij} are the encoded independent variable; a_0, a_i, α_{ii} and a_{ij} denote intercept, linear, second order and interaction terms, and *As.R%* is the response variable. As outlined in prior studies, the F-value calculated for evaluating the statistical significance of the models was determined accordingly (Samimi and Moghadam, 2024b).

RESULTS AND DISCUSSION

Model fitting and statistical analysis by BBD

The relationship between experimental conditions and arsenic uptake response was characterized by quadratic polynomial equations, which were derived from the statistical modeling of the experimental data (Samimi and Shahriari Moghadam, 2018). According to the statistical analysis based on BBD, the ultimate predicted model equation, in terms of coded factors, is represented in Eq. 5.

$$\begin{aligned} As.R\ \% = {} & 36.37 + 9.57\ Y_{PA} + 27.19\ Y_{pH} + 7.25\ Y_t \\ & + 1.95\ Y_{PA}^2 + 2.30\ Y_{pH}^2 + 4.72\ Y_t^2 + 3.47\ Y_{PA}.Y_{pH} \\ & + 6.12\ Y_{PA}.Y_t + 3.41\ Y_{pH}.Y_t \end{aligned} \qquad (5)$$

The arsenic removal efficiency obtained from 15 experimental runs, varied between 9.55% and 80.23% as indicated in Table 2.

The ANOVA results for As(III) biosorption were analyzed to assess the validity and adequacy of the BBD model, and to determine the significance of the main parameters (Table 3). An elevated F-value, together with p-values under 0.05, demonstrates a more substantial significance for the factors being analyzed (Samimi *et al*., 2023b). Based on the results

shown in Table 3 the BBD model used in the study was significant with an F-value of 86.08 and a p-value less than 0.0001. All the coded terms of linear (Y_{PA}, Y_{pH}, and Y_t), one of the 2-way interaction term ($Y_{PA}.Y_t$), and one of the square term (Y_t^2) were significant, meaning their changes effectively describe As(III) adsorption onto PJB. The items with p-values greater than 0.05, (Y_{PA}^2,Y_{pH}^2, $Y_{PA}.Y_{pH}$, $Y_{pH}.Y_t$) were found to be non-significant. The removal of As(III) from synthetic wastewater, as well as the predicted values obtained from the full quadratic model, is depicted in Fig. 1, which is presented as a normal probability plot. The selected regression model has a coefficient of determination (R^2) value of 0.9936, which means that the independent studied variables explain 99.36% of the variation in arsenic uptake by PJB. A regression model exhibiting an R^2 value greater than 0.9 demonstrates a robust correlation. The predicted

Table 3: The ANOVA results of the reduced quadratic model for As(III) biosorption

Source	Degrees of freedom (DF)	Sum of squares (SS)	Mean squares (MS)	F-Value	P-Value	Significant (✓) Not significant (×)
Regression	9	7414.51	823.83	86.08	< 0.001	✓
Linear	3	7066.08	2355.36	246.09	< 0.001	✓
Y_{PA}	1	732.30	732.30	76.51	< 0.001	✓
Y_{pH}	1	5913.28	5913.28	617.83	< 0.001	✓
Y_t	1	420.50	420.50	43.93	0.001	✓
Square	3	103.96	34.65	3.62	0.100	×
Y_{PA}^2	1	14.02	14.02	1.47	0.280	×
Y_{pH}^2	1	19.51	19.51	2.04	0.213	×
Y_t^2	1	82.22	82.22	8.59	0.033	✓
2-Way Interaction	3	244.48	81.49	8.51	0.021	✓
$Y_{PA}.Y_{pH}$	1	48.09	48.09	5.02	0.075	×
$Y_{PA}.Y_t$	1	149.94	149.94	15.67	0.011	✓
$Y_{pH}.Y_t$	1	46.44	46.44	4.85	0.079	×
Residual error	5	47.86	9.57			-
Lack-of-Fit	3	43.56	14.52	6.76	0.132	×
Pure Error	2	4.29	2.15	-	-	-
Total	14	7462.37	-	-	-	-

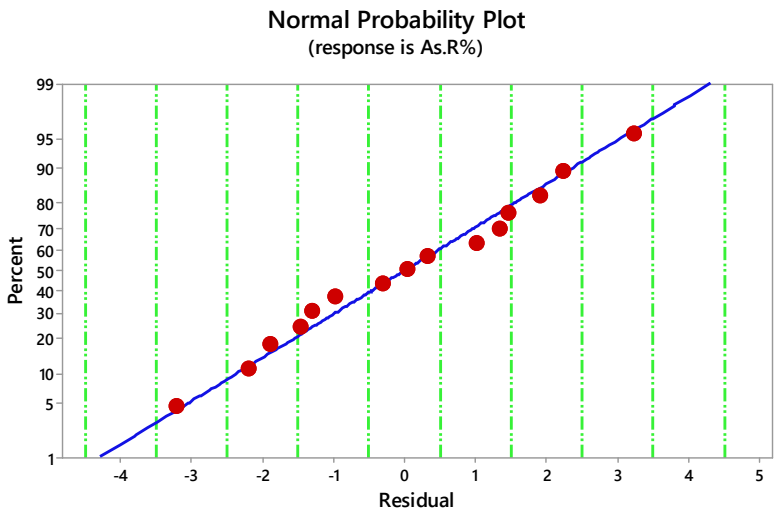
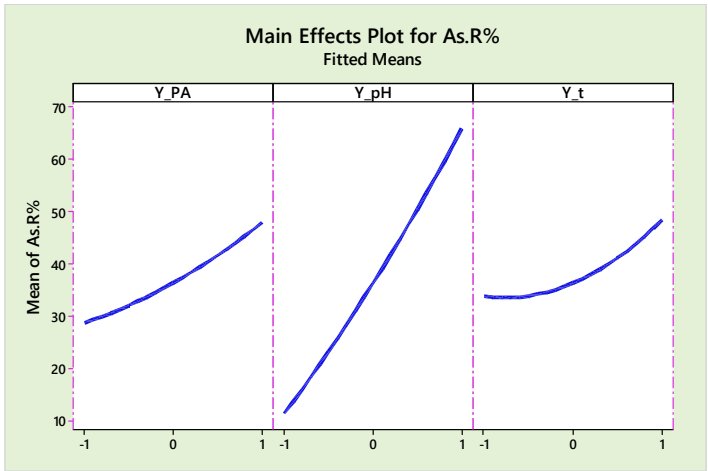


Fig. 1: Normplot of standardized residuals for As(III) removal

(a)



(b)

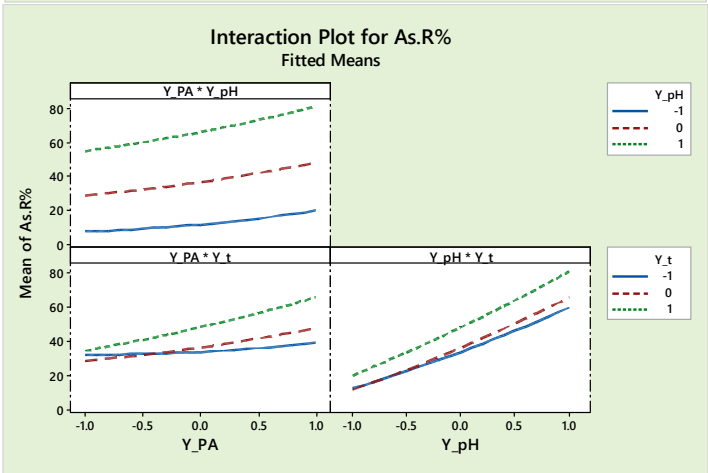


Fig. 2: The mean effects diagram (a) and 2-way interaction plot (b) of studied factors affected on As(III) uptake

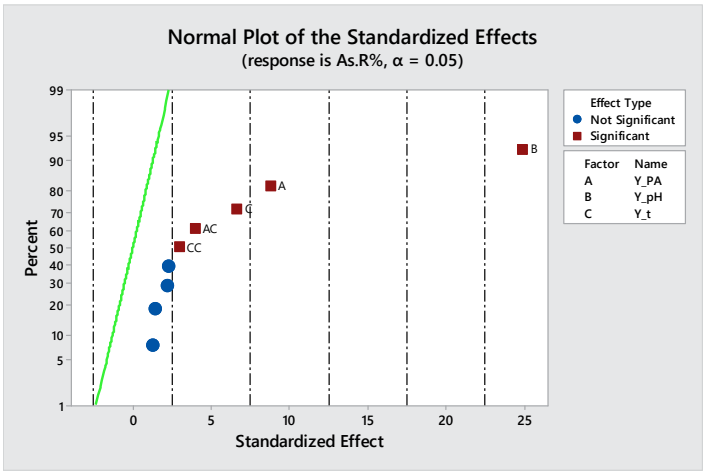


Fig. 3: Normplot of the standardized effects for As(III) uptake by PJB

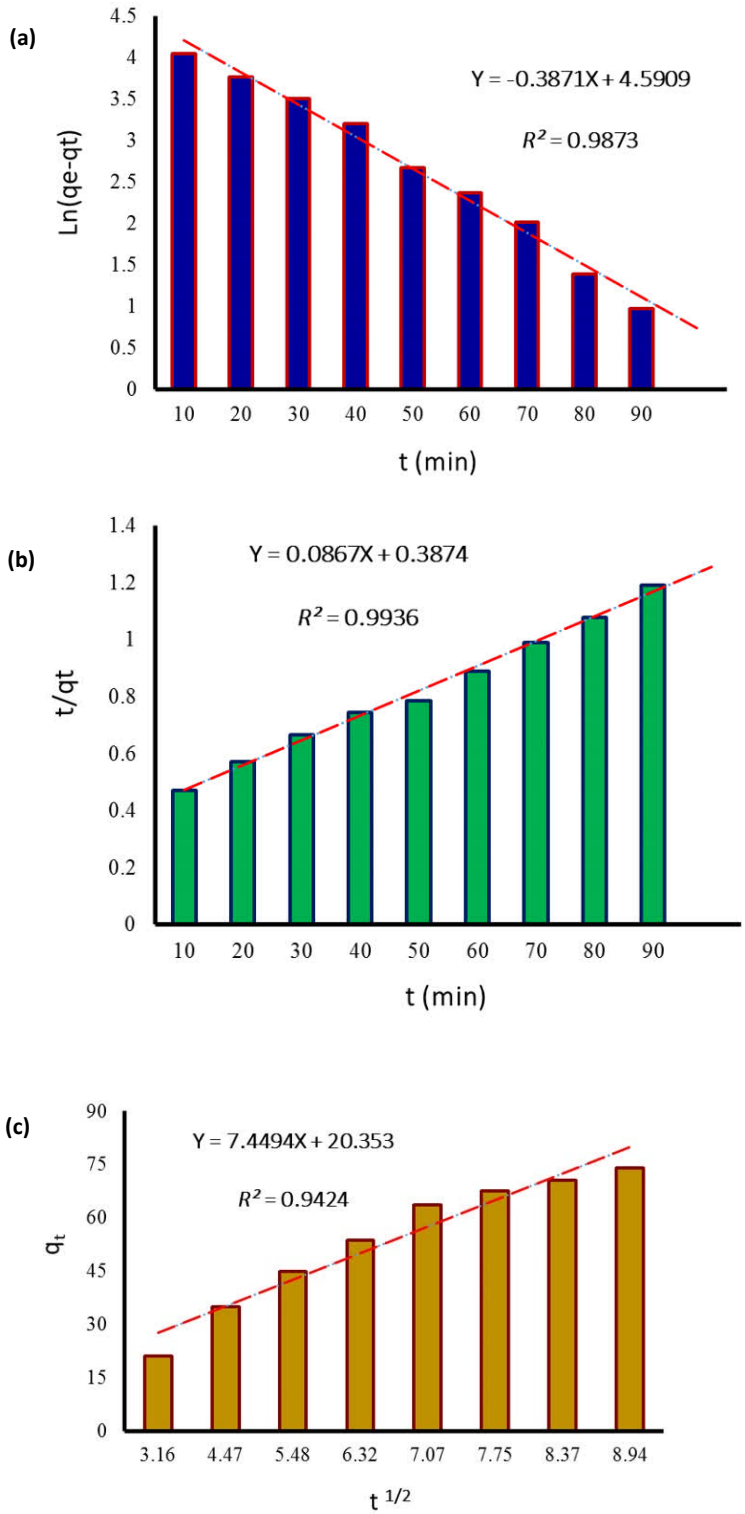


Fig. 4: Kinetics curves of a) P-F-O, b) P-S-O, and c) I-D-M related to the As(III) biosorption by PJB

Table 4. The constant parameters associated with P-F-O, P-S-O, and I-D-M.

Models	P-F-O			P-S-O			I-D-M		
	q_e	k_1	R^2	q_e	k_2	R^2	k_p	C	R^2
	98.58	0.0387	0.987	114.94	1.95×10^{-4}	0.994	9.39	-6.667	0.986

coefficient (R^2_{pred}) value of 0.9053 was in reasonable agreement with the adjusted coefficient (R^2_{adj}) of 0.9820. The analysis showed a positive agreement between the experimental values and the predicted values that corresponded to them.

The main effects and interactions of the variables affecting As(III) removal values, as determined by the BBD model, are depicted in the graphical representation illustrated in Fig. 2. As(III) uptake was evidently enhanced at higher levels of all factors, with a more significant increasing trend noted in the Y_pH factor in relation to the removal percentage. This trend was also corroborated by the interaction effects of the variables.

The standardized effects linked to the removal of As(III) are depicted in Fig. 3. The coded factors B, A, C, AC, and CC (Y_{pH} , Y_{PA} , Y_t , $Y_{PA}.Y_t$, and Y_t^2), respectively are positioned further from the hypothetical italic line, thereby underscoring the significance of these factors. The analysis results validate the data acquired through the regression equation. The results presented in Table 3 of the BBD indicate that the p-value for the *lack-of-fit* term was not significant (0.132), affirming the model's validity. According to the optimization result for As(III) removal by PJB, maximum metalloid uptake was 92.6%, achieved at maximum operational factor levels (PA = 8:1, pH of synthetic wastewater = 7.5, and contact time = 90 min). The validation results determined that PJB efficiency in As(III) removal from the synthetic solution was 91.11%. The narrow gap between the predicted values generated by the model and the actual measurements reinforces the model's credibility and high level of accuracy.

Kinetics of As(III) biosorption

The study of kinetics in adsorption processes plays a key role in evaluating the performance of adsorbents and in understanding the mechanisms that govern these interactions (Qiu *et al*., 2009; Samimi and Moeini, 2020). Adsorption is widely used for environmental remediation, including the removal of dyes, heavy metals, and other hazardous substances from aqueous solutions (Dubey and Rao, 2012; Lou, 2017; Safari *et al*., 2019; Samimi and Shahriari-Moghadam, 2023). Comprehending adsorption kinetics is fundamental for determining the suitability of adsorbents in the treatment of wastewater and air, highlighting its importance as a key area of study in environmental remediation (Kajjumba *et al*., 2018). The evaluation of the sorption rate of As(III) by PJB over time was conducted primarily through the application of adsorption kinetics, employing both the pseudo-first-order (P-F-O) and pseudo-second-order (P-S-O) kinetic models, along with the intraparticle diffusion mechanism (I-D-M). The linear representations of these models are delineated in Eqs. 6, 7, and 8. (Azimi *et al*., 2019; Samimi and Amiri, 2024).

$$\ln\left(q_e - q_t\right) = \ln q_e - k_1 t \tag{6}$$

$$\frac{t}{q_t} = \frac{1}{k_2 q_e^2} + \frac{t}{q_e} \tag{7}$$

$$q_t = k_p t^{\frac{1}{2}} + C \tag{8}$$

Where,

Parameter of k_2 (g/(mg.min)): adsorption rate constants for P-S-O

Parameter of k_1 (1/min): adsorption rate constants for P-F-O

Parameter of k_p (mg/(g.min$^{1/2}$): I-D-M constant

The kinetics study was performed with all runs maintained at a pH level of 7.5. Figs. 4a-c illustrate the kinetics graphs for P-F-O, P-S-O, and I-D-M in relation to the biosorption of As(III).

P-F-O kinetics having a higher R^2 than P-S-O kinetics does not necessarily indicate the true adsorption mechanism (Vareda, 2023). According to the summary in Table 4, the P-S-O kinetics demonstrate a superior R2 value of 0.994 when compared to P-F-O's 0.987 and I-D-M's 0.986. This finding implies that the chemical interaction between the functional groups of PJB and As(III) is the key rate-limiting step in the adsorption process of the metalloid (Samimi and Shahriari-Moghadam, 2021).

CONCLUSION

Industrial wastewater containing heavy metals and metalloids presents serious environmental and health risks, attributed to their toxic properties, durability in the environment, and potential for bioaccumulation in biological systems. These contaminants can negatively impact plant growth, crop yields, and food safety when absorbed by farmlands. Arsenic is classified as a metalloid and can be found in both inorganic and organic forms, with the inorganic variants typically exhibiting higher toxicity. Arsenic contamination in wastewater is a significant environmental concern, particularly in effluents from metallurgical and chemical industries. It is imperative to treat wastewater with arsenic, as it poses a substantial threat to human health, the integrity of ecosystems, and agricultural productivity. Arsenic contamination affects millions of people worldwide, causing various health issues including skin cancers and internal carcinomas. While conventional methods like reverse osmosis and ion exchange are effective in treatment, they come with high costs and result in the production of sludge. The use of biomass-derived adsorbents is increasingly seen as a viable, environmentally sustainable, and cost-efficient method for addressing water pollution. In the current research, biomass obtained from the fruit of *Prosopis juliflora* was assessed for its ability to adsorb As(III) from synthetic wastewater. The findings indicated that all chosen experimental parameters, including the PJB-to-As(III) ratio, the pH of the synthetic wastewater, and the residence time, had a significant impact on the uptake of As(III) by PJB. This study aimed to examine the parameters and perform numerical optimization of the quadratic model to establish the ideal conditions for maximizing As(III) biosorption by PJB. The results of the statistical analysis indicated that the BBD model is highly accurate in predicting the optimal conditions for the adsorption of As(III) by PJB. Results from the optimization study on the elimination of As(III) from synthetic solutions via PJB demonstrate that the maximum uptake of the metalloid reached 92.6%, which was observed at the highest levels of the selected operational parameters. The sorption of As(III) adhered to a P-S-O model (R^2= 0.994), indicating that the primary factor limiting the uptake of the analyte was the chemical interaction between the functional groups present in PJB and the metalloid ions. The biomass obtained from the non-edible parts of Prosopis juliflora showed significant effectiveness in removing As(III) removal from aquatic ecosystems.

AUTHOR CONTRIBUTIONS

The corresponding author, M. Samimi, managed the project, supervised various stages of the study, wrote the original draft, and carried out the analysis and validation experiments. J. Nouri reviewed and edited the manuscript.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

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ABBREVIATIONS

%	Percent
°C	Degree Celsius
µm	Micrometre
ANOVA	Analysis of variance
BBD	*Box-Behnken* Design
C_0	Initial arsenic concentrations
As(III)	Arsenite
As(V)	Arsenate
$Na_2HAsO_3 \cdot 5H_2O$	Sodium arsenite salt
C_e	Final As(III) concentrations
As.R	As(III) removal
C_t	As(III) concentrations at time t
DOE	Design of experiments
Eq.	Equation
Fig.	Figure
g	Gram
I-D-M	Intraparticle diffusion mechanism
L	Liter
mg	Milligram
mg/g	Milligram per gram
mg/L	Milligram per liter
mL	Milliliter
min	Minute
No.	Number
PA	PJB-to-arsenic ratio
P-F-O	pseudo-first-order
PJB	*Prosopis juliflora* fruit biomass
pH	Potential of hydrogen
P-S-O	pseudo-second-order
q_e	Biosorption capacity (at equilibrium)
q_t	Biosorption capacity (at time t)
R^2	Coefficient of determination
R^2_{adj}	Adjusted R^2
R^2_{pred}	Predicted R^2
rpm	Revolutions per minute
RSM	Response surface methodology
V	Volume
Y_{PA}	PJB-to-arsenic ratio - Coded factor
Y_{pH}	pH value - Coded factor
Y_t	Contact time - Coded factor
a_0	Offset term
a_i	Linear term
a_{ii}	Quadratic term
a_{ij}	Interaction term

REFERENCES

Abdallat, R.; Bdour, A.; Abu Haifa, A.; Al Rawash, F.; Almakhadmah, L.; Hazaimeh, S., (2024). Development of a sustainable, green, and solar-powered filtration system for E. coli removal and greywater treatment. Global J. Environ. Sci. Manage., 10(2): 435-450 (**16 pages**).

Abubakar, A.; Yusuf, H.; Syukri, M.; Nasution, R.; Yusuf, M.; Idroes, R., (2023). Heavy metals contamination in geothermal medicinal plant. Global J. Environ. Sci. Manage., 9(4): 995-1004 (**10 pages**).

Aghajani, M.J.; Ghani, M.; Raoof, J.B., (2024). Synthesis of MOF-5 modified Bi2WO6 polyoxometalate accommodated on the pores of hollow fiber for HF-SPME of acetamiprid, abamectin and diazinon and their determination by high performance liquid chromatography-ultraviolet. Chem. Methodol., 8(4): 279-292 (**14 pages**).

Al-Azzawi, M.A.; Saleh, W.R., (2023). Fabrication of Environmental Monitoring Amperometric Biosensor Based on Alkaloids Compound Derived from Catharanthus Roseus Extract Nanoparticles for Detection of Cadmium Pollution of Water. Chem. Methodol., 7(5): 358-371 (**14 pages**).

Asadullah, M.; Ain, Q.u.; Ahmad, F., (2022). Investigation of a Low Cost, Stable and Efficient Adsorbent for the Fast Uptake of Cd (II) from Aqueous Media. Adv. J. Chem. A., 5(4): 345-356 (**12 pages**).

Azimi, N.; Azimi, P.; Samimi, M.; Mansouri Jalilian, T., (2019). Ultrasonic-assisted adsorption of Ni (II) ions from aqueous solution onto Fe_3O_4 nanoparticles. Adv. Nanochem., 1(2): 66-72 (**7 pages**).

Bakar, B. A.; Idawanni, I.; Azis, A.; Kurniawati, S.; Giamerti, Y.; Yardha, Y.; Purba, R.; Abdullah, S.; Jonharnas, J.; Mustikawati, D.R., (2024). Bibliometric analysis of biochar application for environmental management in agricultural sector. Global J. Environ. Sci. Manage., 10(SI): 237-250 (**14 pages**).

Balasubramanian, N.; Madhavan, K., (2001). Arsenic removal from industrial effluent through electrocoagulation. Chem. Eng. Technol., 24(5): 519-521 (**3 pages**).

Cheraghipoor, M., Zakeri, M.; Moghadam, H.; Samimi, M., (2024). A Feasibility Study for the Preparation of Green Copper-Colored Mica Pearlescent Pigments. Adv. J. Chem. A, 7(3): 338-346 (**9 pages**).

Douglas, I., (2018). The challenge of urban poverty for the use of green infrastructure on floodplains and wetlands to reduce flood impacts in intertropical Africa. Landsc. Urban Plan., 180: 262-272 (**11 pages**).

Dubey, S.S.; Rao, B.S., (2012). Kinetic models in adsorption-a review. Asian J. Res. Chem., 5(1): 8-13 (**6 pages**).

Ebrahimzadeh, P.; Maleki, B.; Ghani, M.; Peiman, S., (2024). High-performance Fe3O4@ SiO2@ Mel@ DABCO catalyst for synthesis of chromene derivatives and solid phase microextraction of fipronil and prometryn in food samples followed by HPLC-UV determination. Chem. Methodol., 8(11): 833-855 (**23 pages**).

Ehzari, H.; Safari, M.; Samimi, M.; Shamsipur, M.; Gholivand, M.B, (2022). A highly sensitive electrochemical biosensor for chlorpyrifos pesticide detection using the adsorbent nanomatrix contain the human serum albumin and the Pd: CdTe quantum dots. Microchem. J., 179: 107424 (**10 pages**).

Elhadeuf, K.; Bougdah, N.; Balaska, F.; Chikhi M., (2023). Experimental Study and Modeling by the Complete Factorial Plan of the Elimination of Textile Dye by Electrocoagulation Using Aluminum from Recycled Cans. Chem. Methodol., 7(3): 183-199 (**17 pages**).

Erdag, E.; Kucuk, M.; Aksoy, U.; Abacioglu, N.; Ozer Sehirli, A., (2023). Docking Study of Ligands Targeting NLRP3 Inflammatory Pathway for Endodontic Diseases. Chem. Methodol., 7(3): 200-210 (**11 pages**).

Eshetu, A.A.; Asegie, A.M.; Addisalem, S.T.; Hailu, F.; Tamerat, T., (2024). Beyond eradication: Unveiling local voices and proactive management strategies for Prosopis juliflora in eastern Ethiopia's arid landscape. Scientific African, 26: e02462 (**15 pages**).

Fatima, N.; Waheed, H.; Raza, A.; Mukhtar, A.; Ahmad, F., (2024). A Critical Review on Membrane Technology and Its Application in CO2 Capturing. Chem. Methodol., 8(9): 662-698 (**38 pages**).

Gebrehiwot, K.; Steger, C. (2024). A Systematic Review of Prosopis juliflora (Sw.) DC. Research in Ethiopia Reveals Gaps and Opportunities for Advancing Management Solutions. Environ. Sustain. Indic., 100506 (**12 pages**).

Goudarziafshar, H.; Zafari, M.; Moosavi-Zare, A.A.R., (2024). Catalytic application of porous carbon/Fe_3O_4 nanocomposite on the synthesis of pyranopyrazole derivatives. Chem. Methodol, 8(11): 820-832 (**13 pages**).

Handayani, T.; Djarot, I.N.; Widyastuti, N.; Arianti, F.D.; Pertiwi, M.D.; Rifai, A.; .; Sitomurni, A.I.; Nur M.M.A.; Parminto, A. K.; Nurmala Dewi, R.; Nuha, N.; Hariyanti, J.; Pinardi, D.; Suryana, Y.; Aziz, A.; Rochmadi, T.; Syamsudin, E.; Lomak P.A.; Hadi, A.; Yuniastuti, E.; Putri, N.A., (2024). Biogas quality and nutrient remediation in palm oil mill effluent through chlorella vulgaris cultivation using a photobioreactor. Global J. Environ. Sci. Manage., 10(4): 1519-1542 (**24 pages**).

Hawrami, K.A.; Baset, A.K., (2024). Trace element concentrations, spatial distribution patterns, and risk potential in soils from urban and peri urban agriculture. Global J. Environ. Sci. Manage., 10(4): 2045-2066 (**22 pages**).

Hammond, C.M.; Root, R.A.; Maier, R.M.; Chorover, J., (2018). Mechanisms of arsenic sequestration by Prosopis juliflora during the phytostabilization of metalliferous mine tailings. Environ. Sci. Technol, 52(3): 1156-1164 (**9 pages**).

Kajjumba, G.W.; Emik, S.; Öngen, A.; Özcan, H.K.; Aydın, S., (2018). Modelling of adsorption kinetic processes—errors, theory and application. Advanced sorption process applications, 1-19 **(19 pages).**

Kamaraj, M.; Kamali, P.; Kaviya, R.; Abishek, K.; Navinkumar, B.; Nithya, T.G.; Aravind, J., (2024). Human hair biochar to remove malachite green dye and bisphenol-A contamination. Global J. Environ. Sci. Manage., 10(3): 1005-1016 (**12 pages**).

Qiu, H.; Lv, L.; Pan, B.C.; Zhang, Q.J.; Zhang, W.M.; Zhang, Q.X., (2009). Critical review in adsorption kinetic models. J. Zhejiang Univ. Sci., 10(5): 716-724 (**9 pages**).

Lou, S., (2017). Applied adsorption kinetics model for removal of hazards from aqueous solution: more informational parameters for industrial design. Journal of Environmental Science and Public Health, 1(4): 228-239 (**12 pages**).

Luo, T.; Cui, J.; Hu, S.; Huang, Y.; Jing, C., (2010). Arsenic removal and recovery from copper smelting wastewater using TiO2. Environ. Sci. Technol., 44(23): 9094-9098 (**5 pages**).

Mehari, Z.H., (2015). The invasion of Prosopis juliflora and Afar pastoral livelihoods in the Middle Awash area of Ethiopia. Ecological Processes, 4: 1-9 (**9 pages**).

Moghadam, H.; Samimi, M., (2022). Effect of condenser geometrical feature on evacuated tube collector basin solar still performance: Productivity optimization using a Box-Behnken design model. Desalination. 542: 116092 (**8 pages**).

Mohadesi, M.; Gouran, A.; Darabi, F.; Samimi, M., (2024a). Sunflower seed pulp ash as an efficient and eco-friendly adsorbent for Congo red uptake: characteristics, kinetics, and optimization. Water Pract. Technol., 19(1): 228-240 (**12 pages**).

Mohadesi, M.; Samimi, M.; Chahardoli, F.; Kasaie, M.R.; Gouran, A., (2024b). Simultaneous removal of Pb (II) and Cr (VI) from a steel company wastewater using various green adsorbents: Material characterization and numerical optimization. Water Pract. Technol., 19(11): 4473-4485 (**13 pages**).

Nicomel, N.R.; Leus, K.; Folens, K.; Van Der Voort, P.; Du Laing, G., (2016). Technologies for arsenic removal from water: current status and future perspectives. Int. J. Environ. Res. Public Health, 13(1): 62 (**24 pages**).

Oliver Paul Nayagam, J.; Prasanna, K., (2023). Response surface methodology and adaptive neuro-fuzzy inference system for adsorption of reactive orange 16 by hydrochar. Global J. Environ. Sci. Manage, 9(3): 373-388 (**16 pages**).

Osipova, E.S.; Gladkov, E.A., (2024). Heracleum Sosnowskyi Manden. as a Source of Valuable Chemicals (Elimination with Utility). Chem. Methodol., 8(12): 944-956 (**13 pages**).

Phewnil, O.; Pattamapitoon, T.; Semwimol, N.; Wararam, W.; Duangmal, K.; Intaraksa, A.; Chunkao, K.; Maskulrath, P; Hanthayung, S.; Wichittrakarn, P., (2024). Effects of landslide hazards on quality of stream water and sediments. Global J. Environ. Sci. Manage., 10(3): 1099-1116 (**18 pages**).

Rembold, F.; Leonardi, U.; Ng, W.T.; Gadain, H.; Meroni, M.; Atzberger, C., (2015). Mapping areas invaded by Prosopis juliflora in Somaliland on Landsat 8 imagery. In Remote Sensing for Agriculture, Ecosystems, and Hydrology XVII, SPIE. 9637: 295-306 (**12 pages**).

Sabilillah, A.M.; Palupi, F.R.; Adji, B.K.; Nugroho, A.P., (2023). Health risk assessment and microplastic pollution in streams through accumulation and interaction of heavy metals. Global J. Environ. Sci. Manage., 9(4): 719-740 (**22 pages**).

Safari, M.; Moghadam, M.S.; Samimi, M.; Azizi, Z., (2019). Study of the Optimal Conditions for Zn+2 Removal Using the Biomass of Isolated Bacteria from Ravang Mine. Iran. J. Soil Water Res., 50(1): 149-160 (**12 pages**).

Samimi, M., (2024). Efficient biosorption of cadmium by *Eucalyptus globulus* fruit biomass using process parameters optimization. Global J. Environ. Sci. Manage., 10(1): 27-38 (**12 pages**).

Samimi, M.; Amiri, K., (2024). Zinc alginate beads as an effective biosorbent for the removal of Eosin-B from aquatic solutions: Equilibrium, kinetics, and thermodynamic behaviors. Chem. Methodol., 8(5): 351-363 (**13 pages**).

Samimi, M.; Moeini, S., (2020). Optimization of the Ba+ 2 uptake in the formation process of hydrogels using central composite design: Kinetics and thermodynamic studies of malachite green removal by Ba-alginate particles. J. Part. Sci. Technol., 6(2): 95-102 (**8 pages**).

Samimi, M.; Validov, S., (2018). Characteristics of pDNA-loaded chitosan/alginate-dextran sulfate nanoparticles with high transfection efficiency. Rom. Biotech. Lett. 23(5): 13996-14006 (**11 pages**).

Samimi, M.; Moghadam, H., (2024a). Modified evacuated tube collector basin solar still for optimal desalination of reverse

osmosis concentrate. Energy. 289: 129983 (**8 pages**).
Samimi, M.; Moghadam, H., (2024b). Investigation of structural parameters for inclined weir-type solar stills, Renew. Sustainable Energy Rev., 190: 113969 (**10 pages**).
Samimi, M.; Mansouri, E., (2024). Efficiency evaluation of Falcaria vulgaris biomass in Co(II) uptake from aquatic environments: characteristics, kinetics and optimization of operational variables. Int. J. Phytoremed., 26(4): 493-503 (**11 pages**).
Samimi, M.; Nouri, J., (2023). Optimized Zinc Uptake from the Aquatic Environment Using Biomass Derived from Lantana Camara L. Stem, Pollution, 9(4): 1925-1934 (**10 pages**).
Samimi, M.; Safari, M., (2022). TMU-24 (Zn-based MOF) as an advance and recyclable adsorbent for the efficient removal of eosin B: Characterization, equilibrium, and thermodynamic studies. Environ. Prog. Sustain. Energy, 41(5): e13859 (**9 pages**).
Samimi, M.; Shahriari Moghadam, M., (2018). Optimal conditions for the biological removal of ammonia from wastewater of a petrochemical plant using the response surface methodology. Global J. Environ. Sci. Manage., 4(3): 315-324 (**10 pages**).
Samimi, M.; Shahriari Moghadam, M., (2020). Phenol biodegradation by bacterial strain O-CH1 isolated from seashore. Global J. Environ. Sci. Manage., 6(1): 109-118 (**10 pages**).
Samimi, M.; Shahriari-Moghadam, M., (2021). Isolation and identification of *Delftia lacustris* Strain-*MS3* as a novel and efficient adsorbent for lead biosorption: Kinetics and thermodynamic studies, optimization of operating variables. Biochem. Eng. J., 173: 108091 (**9 pages**).
Samimi, M.; Shahriari-Moghadam, M., (2023). The *Lantana camara* L. stem biomass as an inexpensive and efficient biosorbent for the adsorptive removal of malachite green from aquatic environments: kinetics, equilibrium and thermodynamic studies. Int. J. Phytoremed., 25(10): 1328-1336 (**9 pages**).
Samimi, M.; Shahriari-Moghadam, M., (2024). Bioaccumulation efficiency comparison of heavy metals in Verbascum speciosum, Acantholimon hohenackeri, Acanthophyllum microcephalum, and Euphorbia macroclada, grown around lead and zinc mines. Iranian Journal of Research in Environmental Health, 9(4): 349-360 (**12 pages**).
Samimi, M.; Shahriari Moghadam, M., (2025). Efficient biodegradation of crude oil by novel *Pseudomonas aeruginosa* strain isolated from petrochemical wastewater: identification and optimization. Pet. Sci. Technol., 43: 1-18 (**18 pages**).
Samimi, M.; Zakeri, M.; Alobaid, F.; Aghel, B., (2023a). A Brief Review of Recent Results in Arsenic Adsorption Process from Aquatic Environments by Metal-Organic Frameworks: Classification Based on Kinetics, Isotherms and Thermodynamics Behaviors. Nanomater., 13(1): 60 (**12 pages**).
Samimi, M.; Mohammadzadeh, E.; Mohammadzadeh, A., (2023b). Rate enhancement of plant growth using Ormus solution: optimization of operating factors by response surface methodology. Int. J. Phytoremed., 25(12): 1636-1642 (**7 pages**).
Sulistyowati, L.; Yolanda, Y.; Andareswari, N., (2023). Harbor water pollution by heavy metal concentrations in sediments. Global J. Environ. Sci. Manage., 9(4): 885-898 (**14 pages**).
Vahabisani, A.; An, C., (2021). Use of biomass-derived adsorbents for the removal of petroleum pollutants from water: a mini-review. Environ. Syst. Res., 10(1): 25 (**10 pages**).
Vareda, J.P., (2023). On validity, physical meaning, mechanism insights and regression of adsorption kinetic models. J. Mol. Liq., 376: 121416 (**14 pages**).
Yadav, N.; Rana, A.C., (2020). Pharmacological and pharmacognostical aspect of Prosopis juliflora: A review. World journal of advanced research and reviews, 8(1): 036-052 (**17 pages**).
Younas, M.; Bacha, A.U.R.; Khan, K.; Nabi, I.; Ullah, Z.; Humayun, M.; Hou, J., (2024). Application of manganese oxide-based materials for arsenic removal: A review. Sci. Total Environ., 170269.
Zodi, S.; Potier, O.; Michon, C.; Poirot, H.; Valentin, G.; Leclerc, J.P.; Lapicque, F., (2011). Removal of arsenic and COD from industrial wastewaters by electrocoagulation. J. Electrochem. Sci. Eng., 1(1): 55-65 (**11 pages**).

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