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Full Length Research Article

Use of *Ricinus communis*, *Azadirachta indica*, *Phyllanthus emblica*, *Strychnos potatorum* and *Syzygium cumini* as Bio-adsorbent for Removal of Lead from Water

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Abstract

Potential of five different bio-adsorbent was conducted in order to verify the suitability for removing lead from water. To study the effect of bio-adsorbent dose, 5 doses of bio-adsorbent were considered ranging from 10 mg/L to 50 mg/L and 30 to 210 min. in a step of 10 mg/L and 30 min. contact time. Batch experiments were performed on lead residual concentrations limited to 2 ppm by using adsorption process *Ricinus communis* (Erand), *Azadirachta indica* (Neem), *Phyllanthus emblica* (Amla), *Strychnos potatorum* (Nirmali), and *Syzygium cumini* (Jamun). Regression analysis has been applied to study the performance of bio-adsorbents and its effect on residual concentrations, % removal of lead and pH values. The R^2 values for the developed correlation for residual concentrations are 94.26%, removal of lead 94.31%, and 98.69% for pH values. Contour plots are plotted to obtain better understanding of bio-adsorbents on residual concentrations, % removal of lead and pH values by varying quantity of dosages and contact timings.

***Key words*:** *Lead pollutant, Water pollution, Bio-adsorbent, Dosage, Contact time, Modeling*

Ecological imbalance because if exploitation of natural resources and industrialization has created many problems out of which water pollution is serious one. Heavy metals found in the water it is very dangerous to our environment [1]. Increased quantity of lead in wastewater has become a serious issue for environment. Lead is being toxic in nature and not useful to body [2]. Investigations are being carried out throughout the world to remove lead from water. As water containing lead is hazardous and causes various ailments to human body [3-4]. With the increase in industrialization, there has been an increase in the high usage of different metals, chemicals and materials, etc. for the production of various products which resulted in producing waste which is being released into nearby water resources. Also, lead is non-biodegradable that amplifies the problem of lead removal [5]. Heavy metals are waste product from industries and are also originated from various factors like geological weathering, processing of ores and metals, land fill waste, urban run-off, sewage effluent [6-7]. Intensive experiments are being carried out for identifying the various bio-adsorbents and its combination that are globally acceptable, economical and naturally available [8].

Now-a-day numerous researchers done work modern bio-adsorbents, but still study needs to performed for authenticating these bio-adsorbents for their long-term effects [9-10]. So, the present research work focuses on removal lead contaminant from water by using natural bio-adsorbents i.e., five different bio-adsorbents with dosage levels and different contact timings. The regression analyses were performed to analyze the effect of dosage and contact timings on residual concentrations, % removal of lead, and pH values [11-13]. In this investigation, five different bio-adsorbents are utilized by varying dosage level and contact timings for removing lead from contaminated water [14]. To study the effect of dosage, and contact timings on residual concentration, percentage removal of lead, and pH values. Regression analysis is carried out on with an accuracy of 98.69%.

MATERIALS AND METHODS

The experimental program has been carried out by using low-cost bio-adsorbent of *Ricinus communis*, *Azadirachta indica*, *Phyllanthus emblica*, *Strychnos potatorum*, and

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Syzygium cumini powder on water containing lead residual concentration limited to 2 ppm.

Preparation of bio-adsorbent for adsorption

The leaves and seeds of bio-sorbent were collected from plant, washed with distilled water to remove dust, adhering particles and further drying process was carried. Dried husk was grinded and powdered in electric grinder and then sieved. The sieved leaves were used for experimentation.

Measurement of pH value

The pH is value that expressed the intensity of acid ad alkaline condition of the solution. It was governed by H^+ and OH^- ion concentration present precisely. It is measured by pH meter using glass electrode, which generates the potential varying linearly with the pH of the solution which is measured. While performing experimentation the digital pH meter make by Decibel DB1011 was used and calibrated on two standard buffer solutions of pH 4 and pH 7. Rinsing of the pH meter with deionized distilled water was carried out and wipes it with tissue paper. The pH meter was dipped in to the sample solutions to take the readings until it reaches to stable value. Similar setup procedures were followed to take readings of other sample solutions.

Experimentation

While performing the experimentation, different parameters such as initial pH value, adsorbent dosage, initial concentration and the contact time were considered. The experimentation was performed on batch by taking each sample of 100 ml with limited residual concentrations of lead to 2 ppm and known dosage of bio-adsorbent and contact time to study the adsorptive removal of lead (Pb) from the water at a temperature of 35 °C with an uncertainty of ± 1 °C. The mixture was agitated in a temperature controlled shaker water bath at a constant speed and sample withdrawn after the completion of specific time considered for successful experimentation. The supernatant liquid was filtered using Whatman filter paper No. 42 and concentration of lead metal in solution was estimated using Atomic Absorption Spectroscopy (AAS). The effect of residual concentrations, % removal of lead, and pH values were studied on considered five bio-adsorbent. To optimize the performance of different bio-adsorbent the regression analysis was applied to estimate the residual concentrations, percent (%) removal of lead and pH values of sample solutions by considering dosage and contact time as a function. Technical specification of instruments with their uncertainties is shown in (Table 2).

Table 2 Technical specification instruments

Instruments	Model make	Range / least count	Percent uncertainty
Atomic Absorption Spectroscopy	Shimadzu	-	0.00
What-man filter paper	42 micron	1 micron (Accuracy>98%)	0.50
pH Meter (Digital type)	Decibel DB 1011	0-14	0.1
Mechanical Shaker	Limco	20-200 stroke/min.	1.00
Conical Flask (250 ml)	Borosil (Class-A)	50 ml	0.10
Beaker (100 ml)	Borosil (Class-A)	5.0 ml	0.10
Glass stirrer	Borosil (Class-A)	-	0.00
Micro pipettes	Borosil (Class-A)	0.2 ml	0.00
Digital weight Machine	Metis	0.01 g	0.10
Distilled water	Merck	-	0.00

Development of correlations

Development of correlations play an important role in prediction, with this approach an effort was made to understand the effect of different performance parameters such as residual concentrations, % removal of lead and pH values at various dosage levels of bio-adsorbent and contact timings. For modeling the principle of least square approximation of linear regression was applied by considering dependent and independent parameters from the experimental analysis. The different correlations were developed by using dosage and contact timings as a function [34].

$$Residual\ Concentrations_{(ppm)} = f(Dosage\ and\ Contact\ Time) \ldots\ldots (1)$$

$$Removal\ of\ Lead_{(\%)} = f(Dosage\ and\ Contact\ Time) \ldots\ldots (2)$$

$$pH\ Value_{(No.)} = f(Dosage\ and\ Contact\ Time) \ldots\ldots (3)$$

The correlations were developed by considering above principle equations. (Table 3) gives the information of linear correlations with their constants and the R^2 values.

Correlations from 4-8 predicts residual concentrations whereas correlations 9-13 and 14-18 predicts % removal of lead and pH values for different bio-adsorbents. For residual concentrations the highest accuracy of prediction was shown by *Azadirachta indica* bio-adsorbent whereas for % removal of lead and pH values predicted by *Azadirachta indica* and *Strychnos potatorum* bio-adsorbent.

Uncertainty analysis

The uncertainties present in the experimentations are calculated by using Kilns and McCLINTOCK method. The experimentation has been performed thrice to minimize the errors from the experimentation. The % uncertainties present in each parameters such as Filter paper, pH meter, Mechanical shaker, Glassware's are considered in calculations. The uncertainties present in each parameters are already mentioned in (Table 2).

$$\%\ Uncertainty = \sqrt{(Uncer.of\ filter\ paper)^2 + (Uncer.of\ pH\ meter)^2 + (Uncer.of\ Galsswares)^2}$$

[19]

= ± 1.14 %.

RESULTS AND DISCUSSION

Experimentation was performed to remove lead ions from water using low-cost bio-adsorbents and graphs are plotted for residual concentrations, % removal of lead and pH value against the Osage at specific intervals as shown in (Fig 2-4).

Table 3 Constants of linear correlations with their constants and R^2 values

Estimation of residual concentrations (ppm) for different bio-adsorbent	Constants	Dosage (mg/L)	Contact Time (min.)	R^2	Equation No.
Ricinus communis bio-adsorbent	0.3575	-0.002438	-0.000866	83.33	4
Azadirachta indica bio-adsorbent	1.4367	-0.011797	-0.001729	94.26	5
Phyllanthus emblica bio-adsorbent	2.0091	-0.005950	-0.001237	59.98	6
Strychnos potatorum bio-adsorbent	2.2889	-0.008600	-0.004062	74.39	7
Syzygium cumini bio-adsorbent	1.7969	-0.013880	-0.000839	72.51	8
Estimation of removal of lead (%) for different bio-adsorbent	Constants	Dosage (mg/L)	Contact Time (min.)	R^2	Equation No.
Ricinus communis bio-adsorbent	82.146	0.1214	0.04326	83.28	9
Azadirachta indica bio-adsorbent	28.160	0.5899	0.08648	94.31	10
Phyllanthus emblica bio-adsorbent	-0.450	0.2981	0.06190	59.97	11
Strychnos potatorum bio-adsorbent	-11.100	0.4680	0.14750	85.11	12
Syzygium cumini bio-adsorbent	10.130	0.6946	0.04210	72.50	13
Estimation of pH value (No.) for different bio-adsorbent	Constants	Dosage (mg/L)	Contact Time (min.)	R^2	Equation No.
Ricinus communis bio-adsorbent	0.7957	0.065290	0.004143	94.70	14
Azadirachta indica bio-adsorbent	2.1900	0.003043	0.001786	95.73	15
Phyllanthus emblica bio-adsorbent	0.9300	0.033290	0.006310	90.95	16
Strychnos potatorum bio-adsorbent	1.2300	0.033286	0.006190	98.69	17
Syzygium cumini bio-adsorbent	2.2270	0.046430	0.004452	86.52	18

(Fig 2) illustrates the residual concentrations versus dosage of bio-adsorbents. (Fig 2-A) illustrates the maximum and minimum residual concentration of lead for Erand bio-adsorbent 0.298 and 0.030 ppm with dosage of 50 and 10 mg/L at highest contact time 210 and 30 min. respectively. Similarly (Fig 2-B) 1.265-0.518, (Fig 2-C) 1.930-1.375, (Fig 2-D) 1.907-0.779, (Fig 2-E) 1.893-1.049 observed for *Azadirachta indica*, *Phyllanthus emblica*, *Strychnos potatorum*, and *Syzygium cumini* bio-adsorbents with dosage of 50 and 10 mg/L at highest contact time 210 and 30 min. respectively [15-19]. The highest accuracy of residual concentrations was seen in the *Ricinus communis* and least in *Phyllanthus emblica* bio-adsorbent. The residual concentrations were observed for different bio-adsorbent in chronological decreasing order as *Ricinus communis*, *Azadirachta indica*, *Strychnos potatorum*, *Syzygium cumini* and *Phyllanthus emblica*. The residual concentrations were observed decreased with increment of dosage of bio-adsorbent and contact timings [20-22].

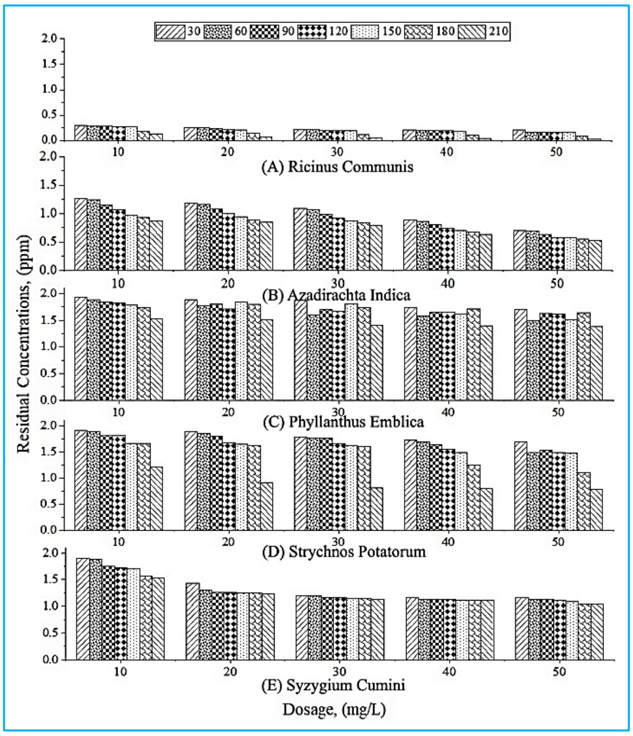

Fig 2 Residual concentrations versus dosage for different contact timings

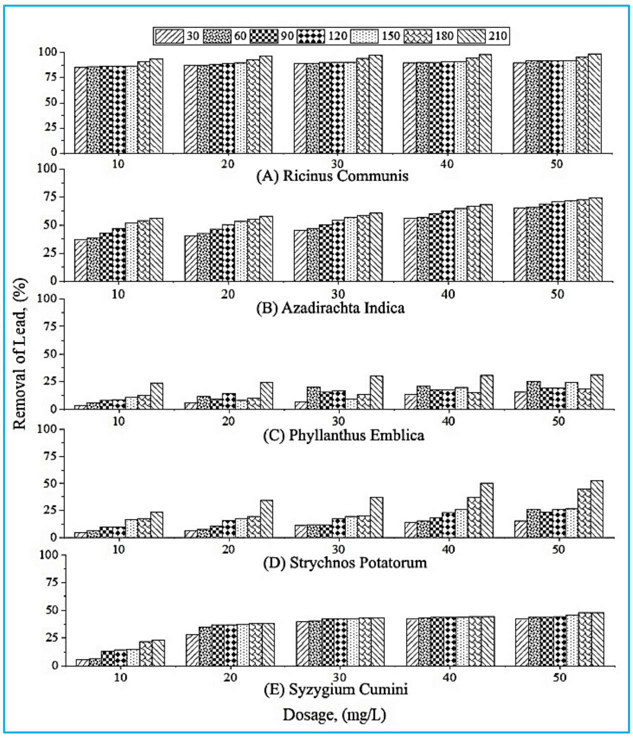

Fig 3 Percent (%) removal of lead versus dosage for different contact timings

(Fig 3) illustrates the % removal of lead versus dosage of bio-adsorbents. (Fig 3-A) illustrates the maximum and minimum removal of lead were observed for *Ricinus communis* bio-adsorbent 98.5 and 85.1% ppm with dosage of 50 and 10 mg/L at highest contact time 210 and 30 min. respectively. Similarly (Fig 3-B) 74.1-36.7%, (Fig 3-C) 31.3-3.5%, (Fig 3-D) 52.3-4.7, (Fig 3-E) 47.6-5.3% observed for *Azadirachta indica*, *Phyllanthus emblica*, *Strychnos potatorum*, *Syzygium cumini* bio-adsorbents with dosage of 50 and 10 mg/L at highest contact time 210 and 30 min. respectively. The highest accuracy of % removal of lead was seen in the Erand and least in *Phyllanthus emblica* bio-adsorbent [23-25]. The percent (%)

removal of lead was observed for different bio-adsorbent in chronological decreasing order as *Ricinus communis*, *Azadirachta indica*, *Strychnos potatorum*, *Syzygium cumini* and *Phyllanthus emblica*. The percent (%) removal of lead increases with the increment of dosage of bio-adsorbent and contact timings [26-27].

(Fig 4) illustrates the pH values versus dosage of bio-adsorbents. (Fig 4-A) illustrates the maximum and minimum pH values were observed for *Ricinus communis* bio-adsorbent 3.6 and 1.4 with dosage of 50 and 10 mg/L at highest contact time 210 and 30 min. respectively. Similarly, (Fig 4-B) 4.1-2.6, (Fig 4-C) 3.9-1.4, (Fig 4-D) 4.1-1.8, (Fig 4-E) 5.2-2.4 observed for *Azadirachta indica*, *Phyllanthus emblica*, *Strychnos potatorum*, *Syzygium cumini* bio-adsorbents with dosage of 50 and 10 mg/L at the contact time 210 and 30 min. respectively. The highest pH value was seen in the *Syzygium cumini* and least in *Ricinus communis*, *Phyllanthus emblica* bio-adsorbent [2]. The pH value was observed for different bio-adsorbent in chronological decreasing order as *Syzygium cumini*, *Azadirachta indica*, *Strychnos potatorum*, *Phyllanthus emblica* and *Ricinus communis*. The pH value increases with the increment of dosage of bio-adsorbent and contact timings [29].

(Fig 5) illustrate the contour plots for residual concentrations for different bio-adsorbents. The lower and higher residual concentration intensities was shown by clouds using red and blue colour. The dense red and blue cloud provides higher residual concentrations whereas residual concentration decreases as both the clouds come towards sparse. The least intensities was observed in *Ricinus communis* (A) whereas highest observed in *Strychnos potatorum* (D).

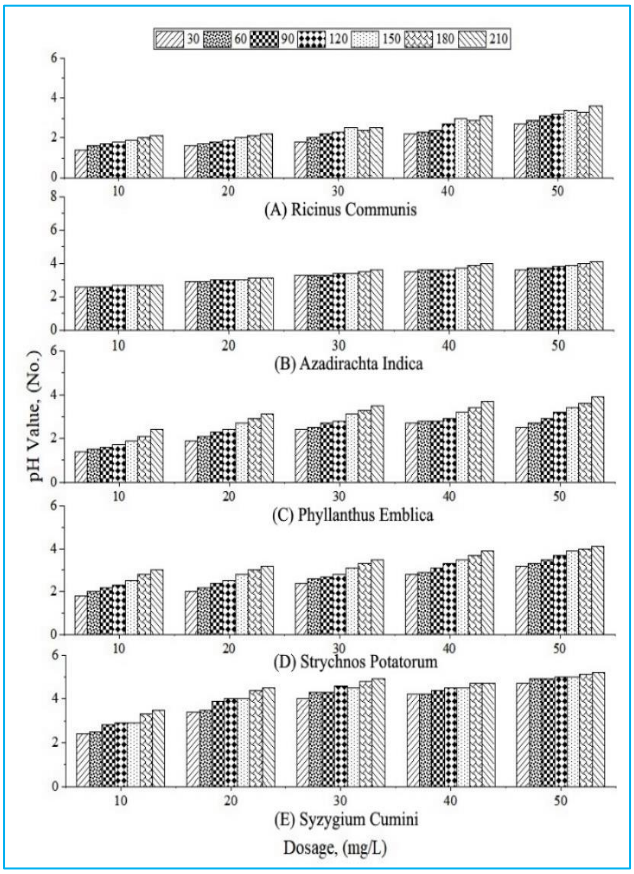

Fig 4 pH values versus dosage for different contact timings

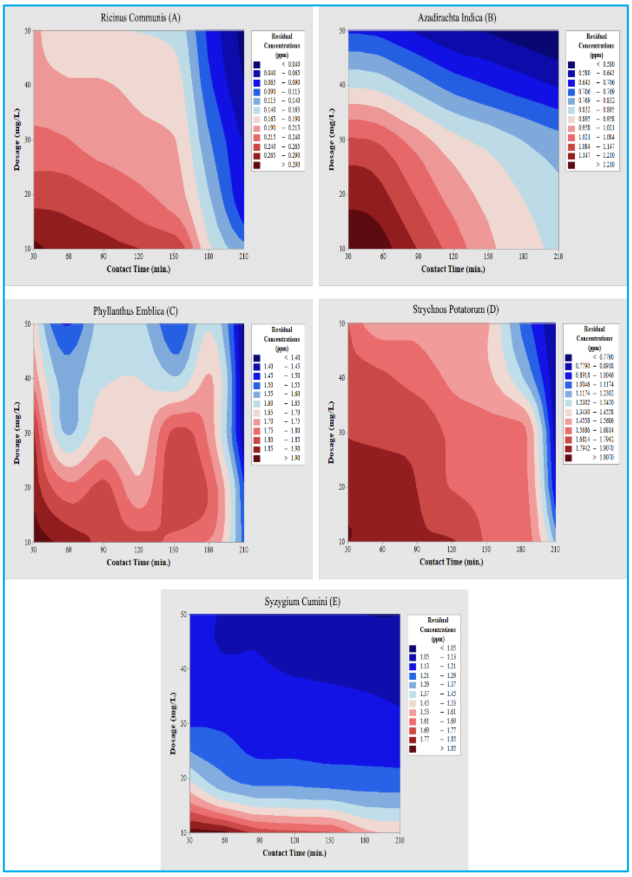

Fig 5 Contour plots for residual concentrations

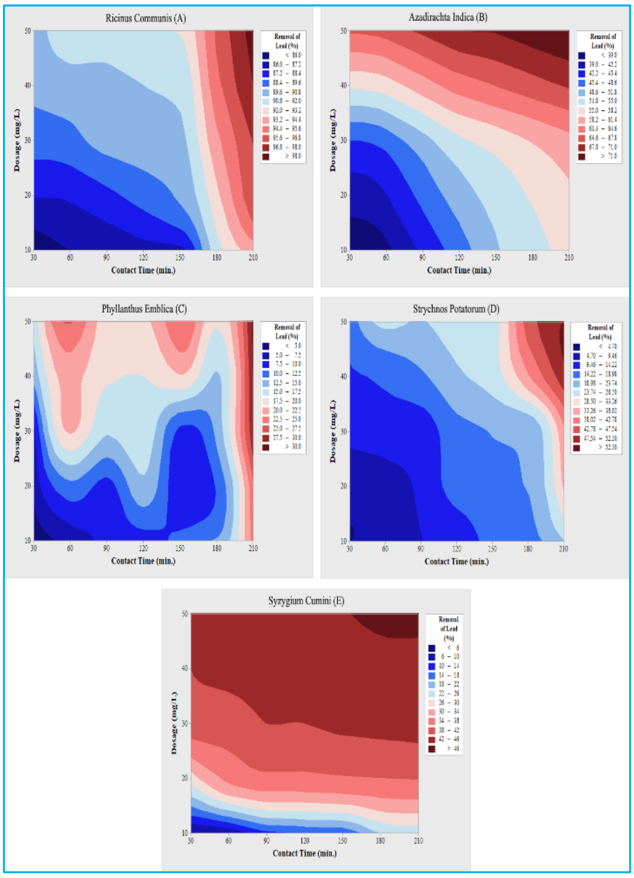

Fig 6 Contour plots for % removal of lead

(Fig 6) illustrate the contour plots for % removal of lead for different bio-adsorbents. Lead removal observed for all considered bio-adsorbents ranges from 4.70% to 98%. *Ricinus communis* (A) bio-adsorbent showed highest (> 98%) accuracy at 50 mg/l and 210 min. whereas *Phyllanthus emblica* (C) showed lowest (< 4.70%) at 10 mg/l and 30 min. in % removal of lead. % removal of lead increases with the increment of dosages of bio-adsorbents and contact timings. Highest %

removal of lead observed at 50 mg/l dosage and 210 min. contact timings in all considered bio-adsorbents [30-32].

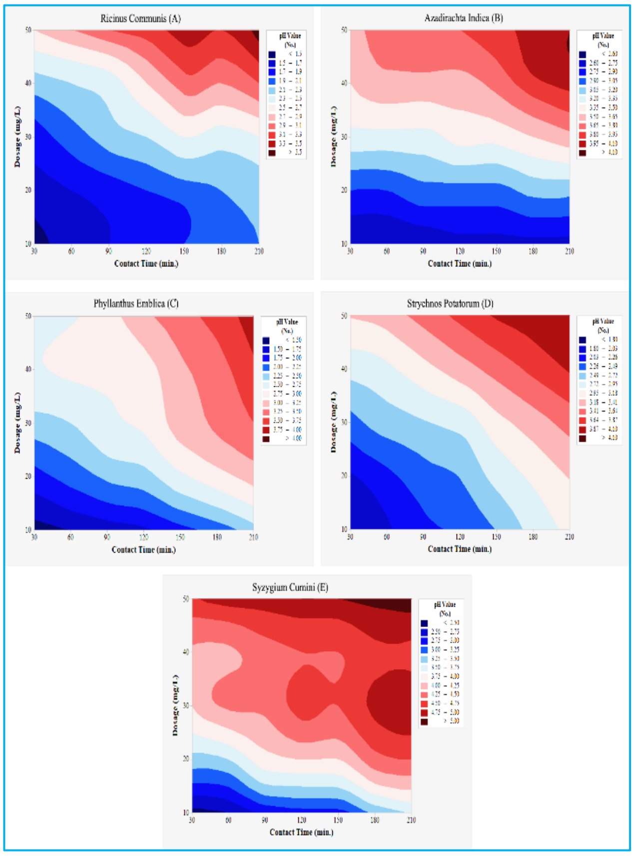

Fig 7 Contour plots for pH values

(Fig 7) illustrate the contour plots for pH values for different bio-adsorbents. Neutral pH value of water is around 7, but decreased and increased pH values from 7 shows acidic and alkaline nature. Acidic nature of pH values observed at lower dosages and contact time whereas the pH values improve with the increment of dosages of bio-absorbent and contact timings. The optimum pH values observed at 50 mg/l dosage and 210 min. contact timings in all considered bio-adsorbents [33].

CONCLUSION

Bio-adsorbent named as *Ricinus communis, Azadirachta indica*, *Phyllanthus emblica*, *Strychnos potatorum*, and *Syzygium cumini* has been successfully removed metallic pollutants such as lead. The experimentation was performed on limited 2 ppm residual concentration of lead in 100 ml sample concentrations and dosage of bio-adsorbent and contact time varies ranging from 10 to 50 mg/L and 30 to 210 min. in step of 10 mg/L and 30 min. The standard test procedures were adopted while performing the experimentation and the readings of residual concentrations, % removal of lead, and pH value of the solutions recorded time to time with variation of bio-adsorbent dosage from 10 to 50 mg/L. Regression analyses were performed to optimized the output parameters such as residual concentrations, % removal of lead, and pH value of the solutions by considering dosage of bio-adsorbent and contact time as a function. The following conclusions were drawn from the experimental analysis as well as regression analysis:
Decreased residual concentration is observed with an increment of dosage of bio-adsorbent and contact time. Similarly, % removal of lead and pH value increases with increment dosage of bio-adsorbent and contact time respectively. *Ricinus communis* bio-adsorbent showed better performance results in residual concentrations and % removal of lead whereas better pH values observed in *Syzygium cumini* bio-adsorbent. The regression analysis would be able to predict the residual concentrations by 94.26% with *Azadirachta Indica* whereas % removal of lead and pH value predicts 94.31% and 98.69% by *Azadirachta indica* and *Strychnos potatorum* bio-adsorbents. The contour plots are able to predict the residual concentrations, % removal of lead, pH value from dosage of bio-adsorbents and contact timings. The uncertainty ± 1.14% was present in the experimentation.

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