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Removal of Lead from Polluted Water Using *Ricinus communis* Powder as Bioadsorbent

R. Srinivasan*, ***P.A. Sadgir***
Department of Civil Engineering, Government College of Engineering, Aurangabad, Maharashtra, India

Abstract

This research paper presents the performance of Ricinus communis as a bio-adsorbent for the removal of lead from water. Among various pollutants, lead is the major pollutant in water. Conventionally, removal of lead is carried out with chemical treatments. In the present research work, aim is to remove lead by using naturally available ecofriendly, economical, nontoxic bio-adsorbent. After literature review, we have selected Ricinus communis for the removal of lead. Experiments were carried out with variation in contact time, variation in dosage and variation in concentration of bio-adsorbent. Research work was carried out by using atomic absorption spectroscopy (AAS-7000). For 2 ppm initial concentration of lead, optimum results were obtained with 210 min contact time; dose of 50 mg/l gives maximum removal efficiency of 98.51%. Similar results were obtained for 4, 6, 8 and 10 ppm initial concentration of lead with removal efficiency 81.78, 86.56, 86.45 and 93.10% for 210 min contact time.

Keywords: *Bio-adsorbent, Ricinus communis, dosage, contact time, atomic adsorption spectrophotometer*

****Author for Correspondence*** E-mail: srinivasan.rashmita@gmail.com

INTRODUCTION

Lead is a common environmental pollutant. Environmental contamination is caused due to industrial use of lead such as industries producing lead-acid batteries, lead wire or pipes and metal recycling foundries. Heavy metals are recognized as long-term hazardous contaminants because of their high toxicity, accumulation and retention in the human body. Lead ranks second in the list of prioritized hazardous materials issued by US Agency for Toxic Substances and Disease Registry. As per international lead association, it is reported that annual production of lead is estimated at approximately 5 million tonnes. *Ricinus communis* is the castor bean of castor-oil-plant, which is a species of perennial flowering plant in the spurge family. The *Ricinus communis* bean is indigenous to the southeastern Mediterranean Basin, Eastern Africa, and India, but is widespread throughout tropical regions. *Ricinus communis* seed is the also source of castor oil, which has a wide variety of uses.

As per food and agriculture organization of the United Nations, the top ten producer countries of *Ricinus communis* are given in Table 1.

Table 1: *Top Ten Producer Countries of Ricinus communis Seed.*

Country	Production (t)
India	1,744,000
China	60,000
Mozambique	60,000
Ethiopia	13,000
Thailand	12,000
Brazil	11,953
Paraguay	11,000
South Africa	6,200
Pakistan	6,000
Vietnam	6,000
World	**1,854,775**

LITERATURE REVIEW

Abbas *et al.* has presented a study on bio-absorption of lead, cadmium, copper and arsenic ions by using native algae [1]. The removal of Pb^{2+} using algae as absorption depends significantly on the pH of the solution and it is found to be around pH of 3–5. The optimum agitation speed to reach 90% removal efficiency was 300 osc/min for Pb^{+2}. The biosorption of Pb^{2+} onto algae followed the pseudo-second-order kinetic model.

Abbaszadeh *et al.* has presented a study on activated carbon produced from papaya peel as a locally available bio-derived adsorbent used for the removal of lead from metal-contaminated water [2]. They have concluded that best suitable pH is 5 and the pseudo-second-order model is well fitted to experimental results with an adsorbent dosage of 100 mg, Pb(II) ion concentration of 200 mg/l and a contact time of 2 h. Abdel-Halim *et al.* carried out a study on removal of lead from industrial waste water by using different types of natural materials [3]. They have concluded that the treated bone powder at 600ºC give highest adsorption of lead ions. Also, good adsorption capacity was obtained by active carbon and Nile rose plant powder but only 50% by using commercial carbon. The lead uptake was negligible with ceramics. Sdiri *et al.* studied natural clayey as adsorbent for removal of lead from aqueous solutions and concluded that high adsorptive capacities were obtained at pH-6 for 60 min and followed pseudo-second order kinetics [4]. Armando and Iraima carried out an experiment using adsorption isotherms and IR spectroscopy for the removal of lead [5]. Bhattacharjee *et al.* studied the adsorption of water soluble lead on poly-metallic sea nodule for decontamination of lead [6]. They have concluded that the use of Freundlich and Langmuir isotherm is best suitable at pH-6. It was possible to remove lead almost completely (>99.5%) from contaminated water bodies using appropriate dose of sea nodule. Biswajit and Sudip studied low cost natural biosorbents such as rice straw, rice bran, rice husk, coconut shell, neem leaves, and hyacinth roots are used for the removal of lead ions from aqueous solution and concluded that optimum pH is 5 [7]. The adsorption process follows the pseudo-second-order model for all the sorbents except rice and follow Freundlich sorption isotherm model. The maximum desorption efficiency was found for coconut shell, and it was comparable with other biosorbents. Natural sorbents can be used for effective removal Pb(II) ions from industrial wastewater containing Pb(II) ions. Chakravarty *et al.* studied the removal of lead ions from aqueous solution using the powder of heartwood as a biosorbent and concluded that optimum pH is 5 with a dosage of 20 mg/l having maximum removal efficiency of 97% within duration of 25 min [8] ions from aqueous solution using a biomass prepared from *Moringa oleifera* bark, an agricultural solid waste. They have concluded that optimum pH is 5 with duration of 30 min and adsorption process follows the pseudo-second-order model. Mishra and Patel [9] have carried out a study on low cost adsorbents for the removal of lead and zinc by using activated carbon, kaolin, bentonite, blast furnace slag and fly ash and they concluded that all the material have significant efficiency for lead removal [10]. Of the materials studied, bentonite and fly ash exhibited the highest adsorption capacities, the lowest residual concentration and thus the greatest removal capacities of lead and zinc. Basu *et al*. used lentil husk an agricultural waste as low cost adsorbent for removal of lead [11, 12]. Adsorption process was interpreted by Langmuir isotherm model and concluded that maximum removal efficiency is 67.42% with optimum pH of 5 at a temperature of 30ºC. Later on Basu *et al.* further extended their work by using cucumber peel as low cost adsorbent for removal of lead. They have concluded that optimum pH is 5 at a temperature of 30ºC for adsorption of Pb (II) by cucumber peel from actual industrial effluent. Verma and Suthar have studied the potential of duckweed for the removal of heavy metal (Lead and cadmium) from water under different pH value (5, 7, and 9) and different concentrations of metal [13]. The optimum removal efficiency of 98.1% is obtained at a pH of 7 with a dosage of 10 mg/l. They have concluded that the optimum range of pH is 5 for combined removal of (Pb and Cd).

Sai-Krishna *et al.* have carried out a review study on the removal of lead from drinking water, irrigation water using local material produced in agricultural or industrial operation as adsorbents [15]. The present investigation has been aimed to optimize the lead uptake from aqueous solution by using *Ricinus communis* and to know its effects on the lead percentage at different concentrations.

MATERIAL AND METHODS

Reagents

The working solution of concentrations (2–10 mg/l) of the heavy metals lead (Pb) was prepared by diluting the standard solutions (1000±0.01 mg/l) of the Pb solution in

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distilled water. The batch procedure was conducted at room temperature throughout all experimental stages).

Absorbent Preparation

The matured *Ricinus communis* were collected from the plant available in nearby area. The seeds were rinsed and then crushed with an analytical mill, sieved and stored in polypropylene bottles until use.

Batch Adsorption Experiments

Lead adsorption capacity of *Ricinus communis* from water was evaluated by batch system. All adsorption experiments were carried out in a batch system. Each flask was filled with 100 ml of solution and bioadsorbent was added as appropriate. The influence of several operational parameters on the bioadsorption characteristics of the metals such as contact time (30 to 210 min) at an interval of 30 min and initial metal concentration varied from 2 to 10 ppm. There was also variation in dosage from 10 to 50 mg/l and increased dosage at a rate of 10 mg/l. The residual concentration in the solutions was measured by using Atomic Absorption Spectrometer (AAS 7000) after separation of the bio adsorbent by filtration through Whatman Filter number 40.

Removal Efficiency of Lead Adsorption

The removal efficiency of the lead adsorption process was calculated using the equation given below:

$$\%\, removal = \frac{(C_o - C_e)}{C_o} x\ 100$$

Where, Co and Ce (mg/l) are liquid phase concentrations of lead initially and at equilibrium.

Optimum Lead Removed at Different Concentrations

Rao and Davim discussed about the optimum lead removed at different concentrations has been processed using optimization tool TOPSIS [14].

OBSERVATION AND DISCUSSION THROUGH GRAPHS

The observation on concentration of lead using bio-adsorbent is carried out from shown in Figures 1-10 for 2–10 ppm respectively.

- For 2 ppm, maximum removal of lead is obtained for a contact time of 180 min.
- The amount of dosage is directly proportional to the amount of lead concentration.

***Table 2:** Maximum Lead Removal Efficiency by Using Ricinus communis was Observed at a Dosage of 50 mg/l and Contact Time of 210 min (Final Residual Conc. of Lead) (ppm)).*

Sr. No.	Conc. of Lead (ppm)	Final Residual Conc. of Lead (ppm)	Maxi. Removal Efficiency (%)
1	2	0.0297	98.51
2	4	0.7288	81.78
3	6	0.8065	86.55
4	8	1.0842	86.44
5	10	0.6901	93.10

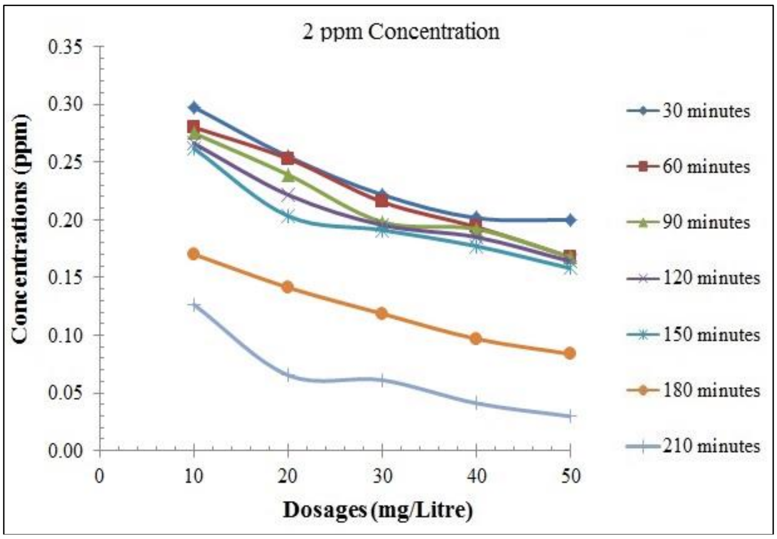

***Fig. 1:** Concentration of Lead for 2 ppm with Respect to Dosage.*

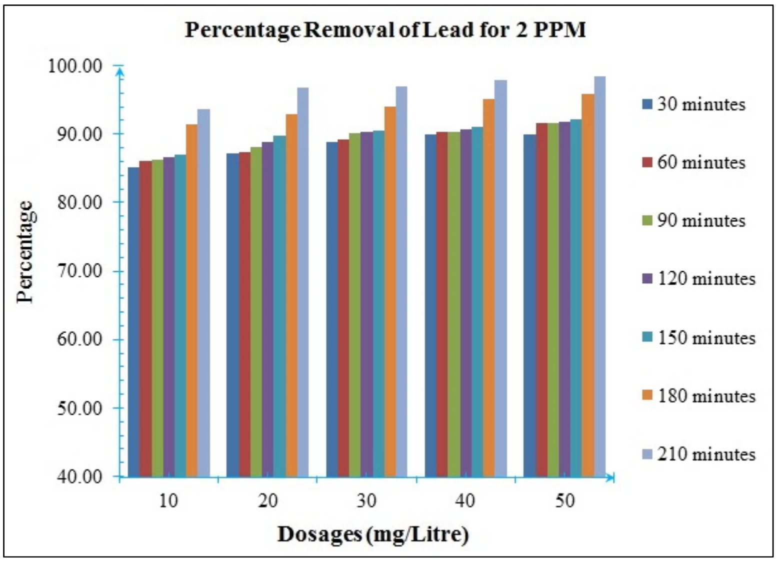

Fig. 2: *Percentage Removal of Lead for 2 ppm with Respect to Dosage.*

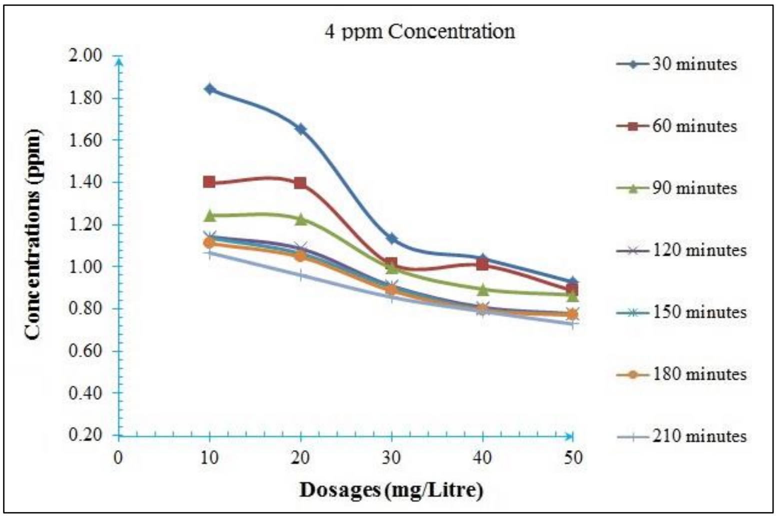

Fig. 3: *Concentration of Lead for 4 ppm with Respect to Dosage.*

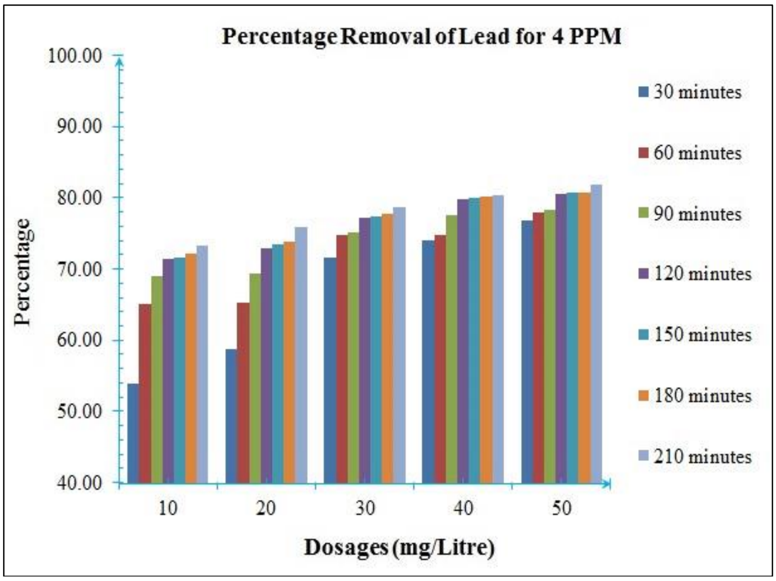

Fig. 4: *Percentage Removal of Lead for 4 ppm with Respect to Dosage.*

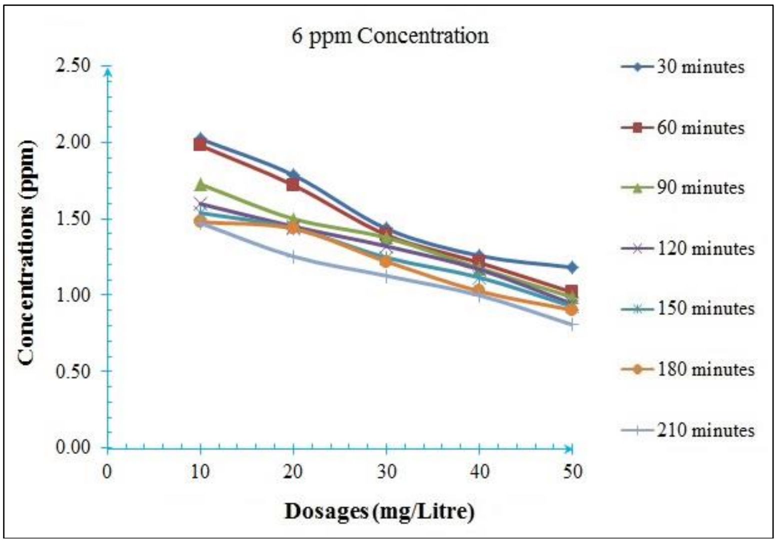

Fig. 5: *Concentration of Lead for 6 ppm with Respect to Dosage.*

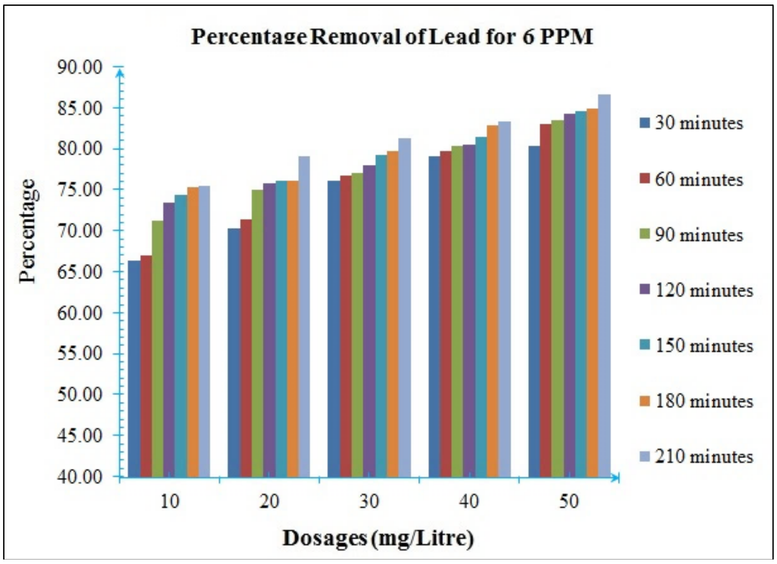

Fig. 6: *Percentage Removal of Lead for 6 ppm with Respect to Dosage.*

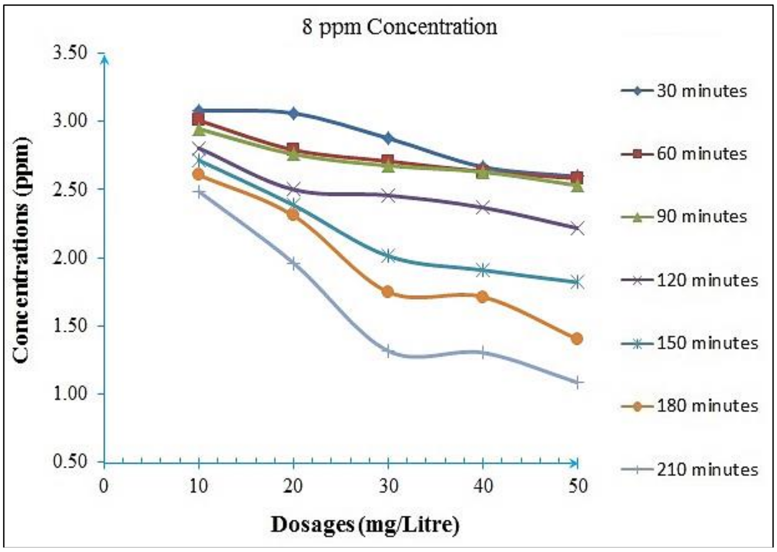

Fig. 7: *Concentration of Lead for 8 ppm with Respect to Dosage.*

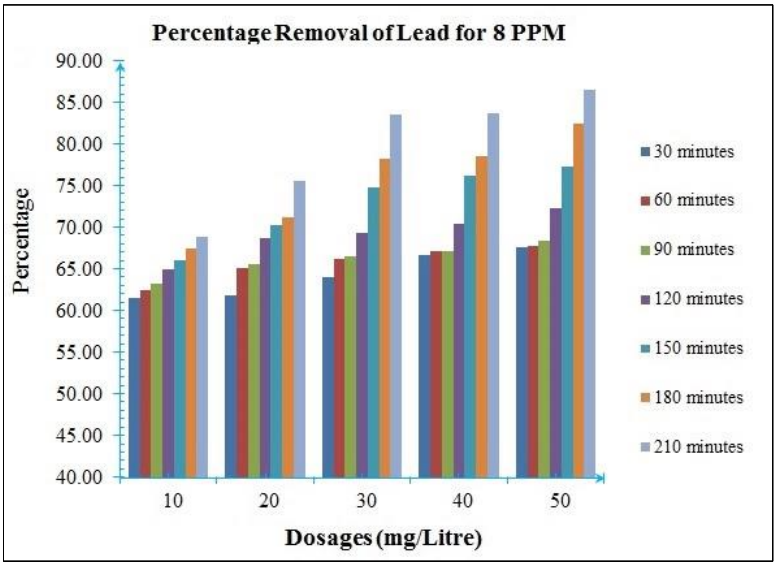

Fig. 8: *Percentage Removal of Lead for 8 ppm with Respect to Dosage.*

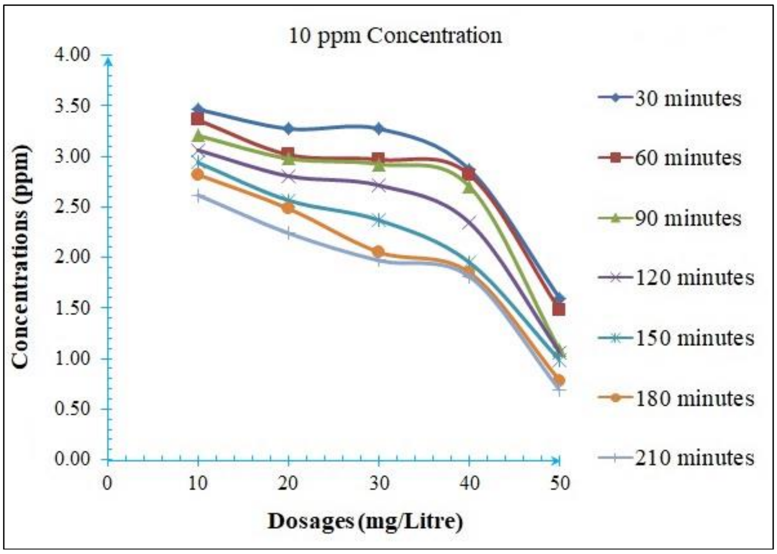

Fig. 9: *Concentration of Lead for 10 ppm with Respect to Dosage.*

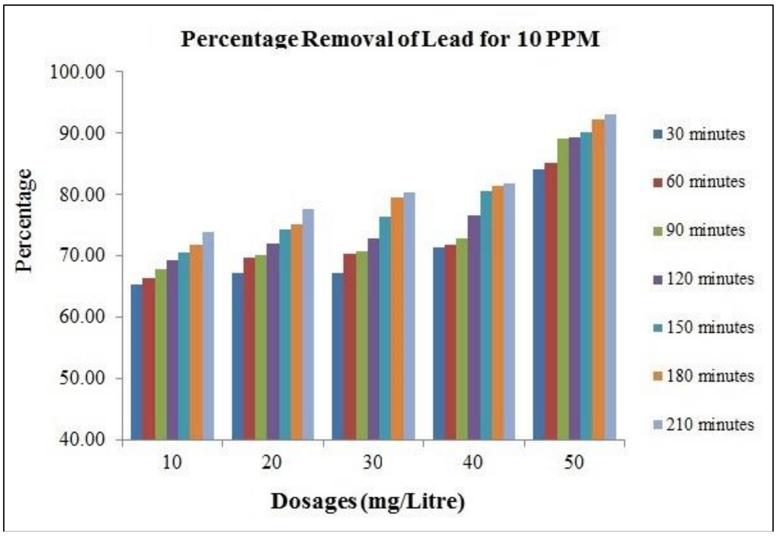

Fig. 10: *Percentage Removal of Lead for 10 ppm with Respect to Dosage.*

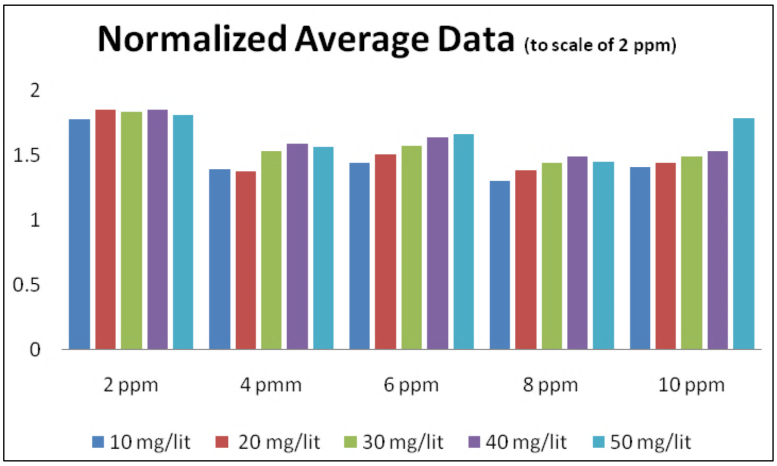

***Fig. 11:** Normalized Average Data to Scale of 2 ppm.*

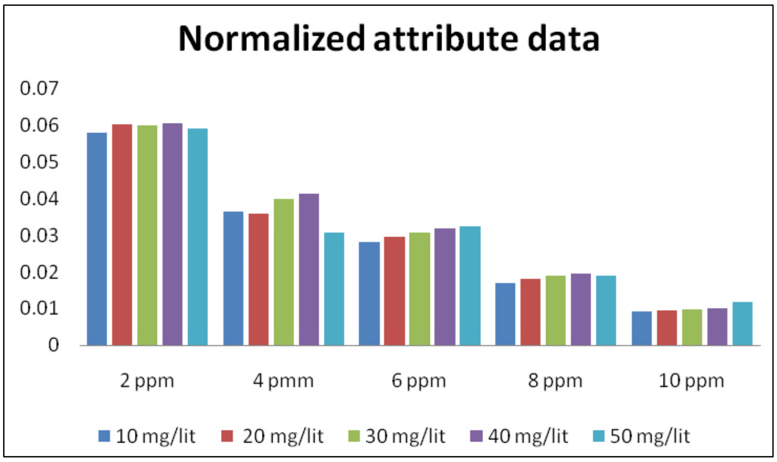

***Fig. 12:** Normalized Attribute Data.*

From the above figure, it is clear that value of concentration of bioabsorbent added to lead solution is different and there is need to bring on same scale for calculating the bioabsorbent required, so, data was normalized to one scale using simple correlated method. Normalized data is shown in Figure 11. The different values of concentration recorded have been used to form the matrix of 5×5 with concentration of *Ricinus communis* as limiting value. While deciding the attribute value for given 2, 4, 6, 8 and 10 ppm, the value were taken as 5, 4, 3, 2 ppm and respectively.

This value has been considered with taking in values of removing more lead with respect to less time of concentration required. Figure 12 shows the value of normalized attribute data in bar chart format. The matrix has been generated and solved to form normalized attribute table. The normalized attribute data will be used for calculating the V-Value and S-Value respectively. The results of V-Value and S-Value have been determined using TOPSIS and has been shown in Table 3. The V-Value is obtained by the multiplication of each element of the column of the matrix with its associated weight. V+ term indicates the best value of considered attribute among the values of attribute for different alternatives. V– term indicates the negative ideal value of considered attributes among the values of attribute for different alternatives.

***Table 3:** Result of V-Value and S-Value.*

	V-Value			S–Value	
	Term+	**Term-**		**Term +**	**Term -**
v 1	0.0604	0.0578	s 1	0.00635	0.00562
v 2	0.0414	0.0306	s 2	0.00653	0.00580
v 3	0.0325	0.0281	s 3	0.00675	0.00596
v 4	0.0193	0.0169	s 4	0.00689	0.00608
v 5	0.0116	0.0091	s 5	0.00638	0.00569

Table 4: *P-Value for Given Results.*

P-Value		
p 1	0.5303	A
p 2	0.5298	B
p 3	0.5310	C
p 4	0.5313	D
p 5	0.5288	E

Relative closeness of particular alternative to the ideal solution (P-Value) is shown in Table 3. The values of relative closeness of table shows that value of bioadsorbent for removal of lead with different concentration at different time period is D-C-A-B-E (A-2, B-4, C-6, D-8, E-10); and with efficiency of lead removal has been observed for concentration A-D-E-C-B (10 mg/l rated as 5, 20 mg/l rated as 4, 30 mg/l rated as 3, 40 mg/l rated as 2 and 50 mg/l rated as 1). Hence, 8 ppm concentration for lead removal using *Ricinus communis* as bioabsorbent is optimum result according to given method.

Relative closeness of particular alternative to the ideal solution (P-Value) is shown in Table 4. The values of relative closeness of table shows that value of bioadsorbent for removal of lead with different concentration at different time period as D-C-A-B-E. And with efficiency of lead removal has been observed for concentration A-D-E-C-B.

CONCLUSION

Based on the various observations of this investigation, it is concluded that:

- Lead is potentially removed by *Ricinus communis* and shows maximum 98.51% lead removal efficiency for 2 ppm lead concentration at a time period of 210 min.
- The lowest residual conc. of lead was 0.0297 ppm for 2 ppm at a time period of 210 min with adsorbent dosage of 50 mg/l.
- As per Topsis analysis method, optimum concentration is 8 ppm and corresponding dosage is 50 mg/l is obtained.
- For every concentration of lead, the amount of lead removal increases with respect to contact time period.

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