

# Extrapolation of data by mathematical calculation for removal of Fluoride, Arsenic, Lead by Non-conventional (NLP, PLP, ALP) absorbents

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Abstract - In the present study effect of PH solution has been studied for the removal of fluoride, lead and arsenic with the help of Neem Leaf Powder (NLP), Peepal Leaf Powder (PLP), Amla Leaf Powder (ALP, NLP, PLP, ALP leaves. The initial solution pH plays an important role in the adsorption of metal ions on various adsorbents. The Experimental results are summarized in the tables, it is having been observed that the % removal of lead and Arsenic is more dominant at pH – 6. adsorbed fluoride increased at lower pH in all cases that is at 2. The experimental values regarding removal of ions are extrapolated using MATLAB software to formulate corresponding quadratic equations. These equations can be used to interpolate the values of ions removal for pH values. The extrapolated values by MATLAB software helps, in theoretical calculations of the values without experiments, which in turn useful for the pilot project as well as to scale up the material at industrial level.

### I. INTRODUCTION

Asian countries use groundwater as a major source for drinking (Al-Hatim et al., 2015; Raj and Shaji, 2017). Asia's approximately population is 4.5 billion, and this is 60% of World's population (WPR, 2018). The supply of groundwater is getting decreased due to its misuse whereas the demand is getting increased in Asia because of increase in population (Gleeson et al., 2012; Gupta et al., 2013; Alhababy and Al-Rajab, 2015). Countries like India, Pakistan, China, Nepal and Bangladesh consume approximately 300km<sup>3</sup> of ground water in a year (Shah et al., 2003).

### Arsenic:

Arsenic is the predominately found as rare element in nature. Through many natural processes like biological activities, volcanic emissions and weathering reactions it is arranged in the environment (Kinniburg and Smedley 2001; Kapaj et al. 2006; Walter and Carter 1995). Use of arsenical products like pesticides and herbicides have decreased expressively in last decades, but for wood conservation its use is still same, but the influence of the arsenical compounds on the environment will remain for few years (Nadeem and Shafiq 2007; Faust et al. 1983). It is in group VA of periodic table and period 4 which arises in many minerals, mostly as As2O3. Ashes of coal also contain Arsenic. Most of the Arsenic compounds are strongly adorable to soil and because of this it cannot be transported to over long distance in groundwater and surface water. Arsenic is not good for skin, as it can damage the skin and have high chances of cancer.

### Lead:

Lead is one of the commonly available heavy elements in the environment (Greenwood and Earnshaw 1984). It is one of the furthermost toxic heavy metal, and food and water absorbs its inorganic form (Ferner 2001). Many diseases are caused by lead poisoning like teratogenic effect, dysfunctions in the kidneys, inhibition of the synthesis of hemoglobin, cardiovascular system, chronic damage to the central nervous system and peripheral nervous system, reproductive systems (Ogwuegbu and Muhanga 2005). And many more effects damage to the urinary tract which results in bloody urine. gastrointestinal tract, neurological disorder and permanent brain damage. Central nervous system, peripheral nervous system, gastrointestinal tract and organic forms also get affect from the inorganic form of lead. (McCluggage 1991; Ferner 2001; Institute of Environmental Conservation and Research INECAR 2000: Lenntech Water Treatment and Air Purification 2004). And the very importantly the brain of children also get affects by lead which results in low aptitude (Udedi 2003). Through calcium and zinc deficiencies its absorption is increased in the body. It is a member(metal) of IV group and VI period of the periodic table with atomic number 82, atomic mass 207.2, density 11.4gcm<sup>-3</sup>,



melting point 327.4°C, boiling point 1725°C. It occurs naturally in the environment and mostly found as mixed with some elements like oxygen, Sulphur, and it varies from 10 to 30 mg/kg in earth's crust. The ranking of lead in the industrial production of metals is fifth. In U.S. most of the Pb is used for the production of Pb storage batteries. Antimony, calcium, tin, strontium, silver, tellurium is some of the most common metal which are alloyed with Pb. Some general forms of Pb which are released into the soil, groundwater and surface water are Ionic lead, Pb (II), hydroxides and lead oxides and lead metal oxyanion complexes. Pb (II) and lead-hydroxy complexes are the most stable form of lead. The maximum reactive form of lead if Pb (II) which forms mononuclear and polynuclear oxides and hydroxides. Lead phosphate, lead carbonates and lead hydroxides are some of the major insoluble lead compounds. Due to microbial alkylation under anaerobic conditions tetramethyl lead can be formed. Pb (IV) compounds are mostly covalent but Pb (II) compounds are predominantly ionic (E.g.  $Pb2^{2+}$  and  $SO_4^{2-}$ ). Some compounds like PbO2 are strong oxidants of Pb (IV) compounds. It also forms some basic salts like Pb (OH)<sub>2</sub>·2PbCO<sub>3</sub>, which was once the most widely used white paint pigment and the source of considerable chronic lead poisoning.

Lead dioxide and lead sulphate are two of the most common of these two and they are also the participants in the reversible reaction which occurs during the charging and discharging of lead storage battery. Due to the extensive use and circulation of tetraethyllead as gasoline additive the toxicities and environmental effects of organo lead compounds are remarkable. The effects of the two routes of exposure inhalation and ingestion are the same. Lead gets collected in the body organs like brain and due to that it can lead to poisoning or death. Some organs which also get affected by the presence of lead are gastrointestinal tract, kidneys and central nervous system. Lower IQ, hyperactivity, shortened attention span and mental deterioration are some diminished development which are exposed due to lead to the children, specially the children under the age of six are at higher risk. Loss of memory decreased reaction time, insomnia, nausea, weakness of the joints, anorexia are some of the diseases which adults experience when exposed to lead. It also causes many serious injuries to the organs, like brain, red blood cells, kidneys and nervous system. When exposed to lead extensive range of biological effects can result depending upon the duration and level of exposure. The infants are more sensitive than adults get affected over a wide range of doses of various effects. No essential function is done by the lead in the human body, it can surely do harm after the acceptance of food, air, or water. Lead is a particularly dangerous chemical, as it can

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accumulate in individual organisms, but also in entire food chains.

Fluoride: The 13th most abundant element is fluorine, which contains 600-700 ppm of the crust by mass in the Earth's crust (Armienta and Segovia, 2008). Fluorinebearing minerals like cryolite, fluorapatite and hydroxyapatite which are found in sediments and local rocks are major source of fluorine in the water (Farooqi et al., 2007; Yadav et al., 2018a) and clay minerals (Katsanou et al., 2013). The obtained quantities of Fluorine in soil is 330 mg/kg (Dev and Giri, 2016), seawater 1.2-1.4 mg/L, groundwater 67 mg/L and surface water bodies < 0.1 mg/L (IPCS, 2002). The main reason for the existence of fluorine in the groundwater is due to weathering, subsequent percolating through soil and sediments and leaching processes. Temperature, pH, solubility of fluorine-bearing minerals and anion capacity of aquifer materials are some of the major factor that governs the release of Fluorine in the groundwater (Jha and Mishra, 2016). The installed tube wells at low depth results in enhancement of narrow groundwater by evaporation is related to the Fluorine infection of the groundwater (Patel et al., 2017). The major source of water supply in the Yuncheng Basin is groundwater since decades. In this region, endemic fluorosis was first confirmed in 1980s, and 22% of the villages in Linyi County had severe fluorosis due to the F- contamination in drinking water (Li et al., 2015). In controlling the fluorine in groundwater, the hydrological condition of groundwater is also an important factor. A recent report (Biglari et al., 2016) details numerous factors affecting the occurrence of F- in groundwater where groundwater is stored. The driving factors for fluorine enhancement in groundwater. In Qiji area (China) are fluorine-bearing mineral dissolution, cation exchange and alkaline conditions (Li et al., 2018). In mid-1960s in the Northern Thailand, studies by the United States Inter-Departmental Committee on Nutrition for National Defense (US IDCNND) were implemented on F--related fluorosis cases (Leatherwood et al., 1965). The idea that deep water is safer to drink than water found at more shallow levels is unsuccessful was determined through variable water depths resulted in unpredictable Fluorine concentrations (Chuah et al., 2016).

### **II. Materials and Methods**

### 1.1. PREPARATION OF LEAF POWDER (NLP,

### PLP AND ALP):

The preparation of the adsorbent, NLP, PLP and ALP included the various steps such as:



Firstly, Green neem leaves were collected from tree and were brought to the laboratory in plastic bags. The leaves were washed repeatedly with water to remove dust and then dry at room temperature in a shade. The dried leaves were ground and sieved to 50. The washed powder was dried for several hours at room temperature; then the powder was preserved in glass bottles for use as an adsorbent.

#### 1.2. PREPARATION OF IONS SOLUTION

In present study the removal of all selected ions by adsorption method was conducted in synthetic single ion solution. For this purpose, stock solution of desirable concentration for every ion was prepared. From this solution different standard solutions of 50 to 300 mg/L were prepared by dilution. 50 ml of each of these solutions was used in every experiment. All chemicals were used of A. R. Grade.

Effect of nature of adsorbent: The adsorption on all types of adsorbents was investigated. In each case a fixed amount (1.0 gm) was placed in a conical flask. An ion(s) solution was then added to each adsorbent followed by the pH adjustment by adding 0.01M NaOH of 0.1 m HCl. The flask was then capped and shaken for 1hr. at  $30^{\circ}C\pm 2^{\circ}C$ . This procedure was followed for all ions selected in the present investigation.

### 1.3. DETERMINATION METHODS OF IONS CONCENTRATION

Determination of Fluoride (F-) ion: JENWAY ion meter and a fluoride selective electrode (JENWAY ISE: 924305) equipped single junction calomel electrode was employed for the measurement of fluoride ion concentration.

#### **Determination of Lead (Pb<sup>2+</sup>) ion:**

Atomic absorption spectrophotometer AA-6300 SHIMADZU was used for determination of lead. Lead

Hollow Cathode Lamp at 283.3 nm and acetylene – air flame was used for this purpose.

## Determination of Arsenic (As<sup>3+/5+</sup>) ion:

The determination of arsenic in water samples was conducted by AAS with Flow Injection - Hydrides Generation (FI-HG) AAS system. AA-6300 SHIMADZU AAS, double beam atomic absorption spectrophotometer was also used for the determination of arsenic.

### Effect of pH on Lead removal

Effect of pH on Lead removal: . In the present study, for removal of lead, the initial solution pH was varied between 2.0 to 12.0. The results are summarized in table 1,2,3and figure1 at initial lead concentration: 0.1 mg/L, adsorbent dose: 1 gm/50mL, temperature:  $30^{\circ}\text{C} \pm 2^{\circ}\text{C}$ , contact time: 2hrs. and shaking time: 1hr. it is observed that the % removal of lead is more dominant at pH – 6. The highest adsorption capacity 84.0% in case of NLP, 72.2% in case of PLP **and 83.2%** in

case of ALP was obtained at pH = 6.0 then adsorption decreases with the increase of pH up to 10.0.



The adsorption of Pb2+ ion was found to be strongly dependent on the pH of solution fig.1 demonstrate that the optimum pH for the adsorption Pb2+ion was about 6 which were rather acidic.

At low pH there was excessive protonation of the active sites at NLP, PLP and ALP surface and this after refuses the formation of bonds between Pb2+ and active site, at moderate pH values 3-6 linked H+ is released from active sites and adsorbed amount of metal ions is generally found to increased. At higher pH (above-6) the precipitation is dominant or both ion exchange and aquous metal hydroxide formation may become significant mechanisms in the metal removal precess. The adsorption capacity of adsorbents at all used pH values were as follows: NLP > ALP > PLP.

Tabi No.	le 1		Lead on	to NLP				
	Amount of lead adsorbed at varying pH							
(Initial concentration: 0.1mg/L, Adsorbent dose: 1gm/50mL,								
	Te	inperature	Shaking time: 11	ntaet tille. 2 1r.)				
S. No.		pН	Equilibrium Concentration	Adsorbed amount (qe)	Removal (R)			
units	Sta	andards units	mg/L	mg/g	%			
1		2.0	0.05	0.04	48.2			
2		4.0	0.02	0.08	75.4			
3		6.0	0.01	0.09	84.0			
4		8.0	0.04	0.05	56.1			
5		10.0	0.05	0.04	47.5			



Table 2	No.		Lead onto PLP				
	I	Amount	of lead adsorbed at	varying pH			
(Init Ten	(Initial concentration: 0.1mg/L, Adsorbent dose: 1gm/50mL, Temperature: 30°C ± 2°C, Contact time: 2hr., Shaking time: 1hr.)						
S. No.	]	ρH	Equilibrium Concentration(Ce)	Adsorbed amount (q <sub>e</sub> )	Removal (R)		
units	Star u	ndards nits	mg/L	mg/g	%		
1		2.0	0.05	0.04	45.1		
2		4.0	0.03	0.06	68.4		
3		6.0	0.02	0.08	72.2		
4		8.0	0.03	0.07	64.3		
5		10.0	0.04	0.05	52.9		

Tab No.	le 3		Lead ont	to ALP				
	Amount of lead adsorbed at varying pH							
	(Initi	al conce	ntration: 0.1mg/L, 1gm/50mL,	, Adsorbent o	lose:			
Temp	eratu	re: 30°C	± 2°C, Contact tin 1hr.)	me: 2hr., Sha	king time:			
S. pH No.		рН	Equilibrium Concentration (C <sub>e</sub> )	Adsorbed amount (q <sub>e</sub> )	Removal (R)			
units	Sta	S ndards units	mg/L	mg/g	%			
1		2.0	0.05	0.04	46.1			
2		4.0	0.02	0.08	71.5			
3		6.0	0.01	0.09	83.2			
4		8.0	0.03	0.07	67.8			
5		10.0	0.07	0.03	38.1			

#### Mathematical equation:

Mathematical equation: The experimental values of NLP, PLP and ALP dosage on lead removal is extrapolated using MATLAB software to formulate corresponding quadratic equations relating to

- • Amount of pH (x) and Equilibrium Concentration (y)
- $\bullet$  Amount of pH (x) and Adsorbed amount (y)
- Amount of pH (x) and Removal (y)

These equations can be used to interpolate the values of lead removal for any amount of adsorbent.

The results are summarized in table 4,5,6.

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Table No. 4		Lead onto NLP					
	Amount of lead adsorbed at varying pH						
(Initial concentration: $0.1$ mg/L, Adsorbent dose: 1gm/50mL, Temperature: $30^{\circ}C \pm 2^{\circ}C$ , Contact time: 2hr., Shaking time: 1hr.)							
S. No.	pН	Equilibrium Concentration (Ce)	Adsorbed amount (qe)	Removal (R)			
Mathematical expressions	x	y=- 0.0002x <sup>4</sup> +0.0046x <sup>3</sup> - 0.0317x <sup>2</sup> +0.0717x- 0.0000000000002	Y==0.0003x <sup>4</sup> - 0.0056x <sup>3</sup> +0.0377x <sup>2</sup> - 0.08x+0.09	Y==0.1919x <sup>4</sup> - 4.2115x <sup>3</sup> +29.02x <sup>2</sup> - 65.629x+94			
1	3	0.0378	0.0624	60.1264			
2	4	0.016	0.12	84.855			
3	6	0.0462	0.1768	72.7844			
4	8	0.1188	0.3096	42.8314			

Table No. 5		Lead onto PLP				
		Amount of lead adsorl	oed at varying pH			
(Initial concentration: $0.1$ mg/L, Adsorbent dose: 1gm/50mL, Temperature: $30^{\circ}C \pm 2^{\circ}C$ , Contact time: 2hr., Shaking time: 1hr.)						
S. No.	р Н	Equilibrium Concentration(Ce)	Adsorbed amount (qc)	Removal (R)		
Mathematica l expression	x	$Y=-0.00008x^4 +0.0018x^3 - 0.0122x^2+0.0229x+0.0 4$	Y==0.0001x <sup>4</sup> - 0.0032x <sup>3</sup> +0.0257x <sup>2</sup> -0.0696x+0.1	Y==0.1667x <sup>3</sup> - 4.4482x <sup>2</sup> +33.687x -5.82		
1	3	0.04102	0.0442	59.7081		
2	5	0.0245	0.057	72.2475		
3	7	0.02782	0.0146	69.2053		
4 9 0.04522		-0.1214	58.5831			
5	10	0.04	0.05	52.9		

Table No. 6 Lead onto ALP						
Amount of lead adsorbed at varying pH						
(Initial concentration: 0.1mg/L, Adsorbent dose: 1gm/50mL,						
Temperature: $30^{\circ}C \pm 2^{\circ}C$ , Contact time: 2hr., Shaking time: 1hr.)						
S. No.	pН	Equilibrium Concentration (Ce)	Adsorbed amount (qe)	Removal (R)		
Mathematical Expressions	x	Y=0.003x <sup>2</sup> - 0.0339x+0.106	Y=- 0.0034x <sup>2</sup> +0.0392x- 0.024	y=- 2.4518x <sup>2</sup> +28.436x- 1.4		
1	3	0.0313	0.063	61.8418		
2	5	0.0115	0.087	79.485		
3	7	0.0157	0.0838	77.5138		
4	9	0.0439	0.0534	55.9282		

# Effect of pH on fluoride removal

**2.Effect of pH on fluoride removal:** the removal of an ion by adsorption is highly dependent of pH of solution which affects the surface change of adsorbent and the degree of ionization by speciation of adsorbate. The effect of pH studied at  $30^{\circ}C \pm 2^{\circ}C$ , initial fluoride concentration: 5mg/L, adsorbent dose: 1gm/50mL, contact time: 2hrs. and shaking time: 1hr. with varying pH.





The results are summarized in table 7,8,9 and figure 2 with increase pH of the solution from 2.0 to 12.0 the extent of removal decreases 81.49 to 32.35 in case of NLP, 79.42 to 34.30 in case of PLP, 83.36 to 31.28 in case of **ALP. The figure shows that the adsorbed fluoride increased at lower pH in all cases. This behaviour is due to excess of OH- ions compete effectively with fluoride ions, at higher pH resulting the decrease in the amount of fluoride removed. The surface of the adsorbent gets positively charged fluoride ions through electrostatic force of attraction at lower pH. The adsorption capacity of adsorbents at all used pH values were as follows: ALP > NLP > PLP.** 

Adsorption of F- - The solution pH shows significant effects on the removal of adsorbates from water because the variation on solution pH significantly alters the surface charge of adsorbents, as well as solution phase chemistry of the adsorbate.

Fluoride can be adsorbed on the surface of adsorbents by the following reactions:

HF			$\mathrm{H^{+}} + \mathrm{F^{-}}$	
$\equiv POH$	$[ + H^+$	←→	POH <sub>2</sub> <sup>+</sup>	
$\equiv POH$	[ + OH-		► $PO^- + H_2O^-$	C C
$\equiv POH$	$I_2^+ + F^-$	$\leftrightarrow$	$PF + H_2O$	
$\equiv POH$	[ + F-	$ \rightarrow $	$\bullet$ PF + OH	-
Where	POH P	OH2 + an	d PO-are the	e n

where POH, POH2+ and PO-are the neutral, protonated and deprotonated sites on NLP, PLP and ALP and PF is the active site fluoride complex.

At lower pH, the surface of the NLP, PLP and ALP adsorbents is predominantly positive since more protonation takes place with the adsorbent sites through equation 2 and the fluoride species exist predominantly as HF (pKa = 3.2), which is weakly ionized, thus the removal of fluoride is less. With increase in solution pH the dissociation of the HF increases and the positive charge density NLP, PLP and ALP adsorbents also gradually decreases. However, up to pH 7 it remains predominantly positively charged with some neutral sites, which results maximum removal of fluoride at pH 7.

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However, above pH 7 the increase in solution pH converts the surface of the NLP, PLP and ALP adsorbents as predominantly negatively charged through equation 3, where fluoride also predominantly exists as negatively charged fluoride ion. Thus, the repulsive forces between the peepal leaf powder adsorbent and the fluoride reduces chemisorption of fluoride at pH greater than 7 as a result the % removal of fluoride decreases.

Table No. 7		Fluoride onto NLP					
	Amount of fluoride adsorbed at varying pH						
7	(Initial concentration: 5mg/L, Adsorbent dose: 1gm/50mL, Temperature: $30^{\circ}C \pm 2^{\circ}C$ , Contact time: 2hr., Shaking time: 1hr.)						
S. No.	рН	Equilibrium Concentration (Ce)	Adsorbed amount (qe)	Removal (R)			
units	Standards units	mg/L	mg/g	%			
1	2.0	0.92	4.08	81.49			
2	4.0	1.58	3.42	68.51			
3	6.0	2.19	2.81	56.25			
4	8.0	2.57	2.43	48.60			
5	10.0	3.39	1.61	32.35			
Table No.	8	Fluoride onto PLP					

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	Amount of fluoride adsorbed at varying pH (Initial concentration: 5mg/L, Adsorbent dose: 1gm/50mL, Temperature: 30°C ± 2°C, Contact time: 2hr., Shaking time: 1hr.)						
S. No.	рН	Equilibrium Concentration (Ce)	Adsorbed amount (q <sub>e</sub> )	Removal (R)			
units	S Standards units	mg/L	mg/g	%			
1	2.0	1.02	3.98	79.42			
2	4.0	1.78	3.22	64.51			
3	6.0	2.13	2.87	57.24			
4	8.0	2.81	2.19	43.62			

5 10		0.0	3.29	1.71	34.30	
Tab	le No. 9		Fluor	ide onto ALP		
		Amount of	fluoride adsorbed	l at varying pH		
(Initial concentration: 5mg/L, Adsorbent dose: 1gm/50mL, Temperature: $30^{\circ}C \pm 2^{\circ}C$ , Contact time: 2hr., Shaking time: 1hr.)						
S. No.	S. No. pH		Equilibrium ncentration (C <sub>e</sub> )	Adsorbed amount (q <sub>e</sub> )	Removal (R)	
units	Standards	units	mg/L	mg/g	%	
1	2.0		0.83	4.17	83.36	
2	4.0		1.78	3.22	64.52	
3	6.0		2.09	2.91	58.26	
4	8.0		2.61	2.39	47.63	
5	10.0		3.43	1.57	31.28	

#### Mathematical equation

Mathematical equation: The experimental values of NLP, PLP and ALP dosage on fluoride removal is



extrapolated using MATLAB software to formulate corresponding quadratic equations relating to

- $\bullet$  Amount of pH (x) and Equilibrium Concentration (y)
- $\bullet$  Amount of pH (x) and Adsorbed amount (y)
- Amount of pH (x) and Removal (y)

These equations can be used to interpolate the values of Fluoride removal for any amount of adsorbent.

The results are summarized in table 10,11,12

Table No. 10		Fluoride onto NLP					
Amount of fluoride adsorbed at varying pH							
(Initial concentration: 5mg/L, Adsorbent dose: 1gm/50mL,							
Temperature: $30^{\circ}C \pm 2^{\circ}C$ , Contact time: 2hr., Shaking time: 1hr.)							
	рН	Equilibrium	Adsorbed amount	Removal			
S. No.		Concentration	(qe)	( <b>R</b> )			
		(Ce)					
Mathematical expression	x	y=0.0051x <sup>3</sup> - 0.0903x <sup>2</sup> +0.759x- 0.29	Y=- 0.0051 <sup>3</sup> +0.0903x <sup>2</sup> - 0.759x+5.25	y=- 0.0971x <sup>3</sup> +1.713x <sup>2</sup> - 14.661x+104.98			
1	3	1.312	3.648	73.7923			
2	5	1.885	3.075	62.3625			
3	7	2.3476	2.6124	52.9847			
4	9	2.9446	2.0154	40.9981			

Table No. 11		Fluoride onto PLP					
Amount of fluoride adsorbed at varying pH							
(1	(Initial concentration: 5mg/L, Adsorbent dose: 1gm/50mL,						
Tem	perati	are: $30^{\circ}C \pm 2^{\circ}C$ , Conta	ct time: 2hr., Shaking	time: 1hr.)			
		Equilibrium	Adsorbed amount	Removal			
S. No.	рН	Concentration (Ce)	(qe)	( <b>R</b> )			
Mathematical expression	x	y=- 0.0033x <sup>4</sup> +0.0816x <sup>3</sup> - 0.6993x <sup>2</sup> +2.6888x- 2.16	y=0.0033x <sup>4</sup> - 0.0816x <sup>3</sup> +0.6993x <sup>2</sup> - 2.6887x+7.16	y=- 0.2915x <sup>3</sup> +4.4525x <sup>2</sup> - 26.009x+115.96			
1	3	1.5486	3.4517	70.135			
2	5	1.939	3.0615	60.79			
3	7	2.4614	2.5393	52.085			
4	9	3.231	1.7699	30.028			

Table No. 12	2	Fluoride onto ALP						
Amount of fluoride adsorbed at varying pH								
(In	(Initial concentration: 5mg/L, Adsorbent dose: 1gm/50mL,							
Tempe	Temperature: $30^{\circ}C \pm 2^{\circ}C$ , Contact time: 2hr., Shaking time: 1hr.)							
		Equilibrium	Adsorbed amount (q <sub>e</sub> )	Removal				
S. No.	pН	Concentration (Ce)		( <b>R</b> )				
Mathematical Expression	x	y=0.0177x <sup>3</sup> - 0.2925x <sup>2</sup> +1.7342x- 1.61	y=- 0.0177x <sup>3</sup> +0.2925x <sup>2</sup> - 1.7342x+6.61	y=- 0.3531x <sup>3</sup> +5.81x <sup>2</sup> - 34.392x+131.73				
1	3	1.438	3.562	71.3103				
2	5	1.961	3.039	60.8825				
3	7	2.268	2.732	54.5627				
4	9	3.2086	1.7914	35.4021				

#### Effect of pH on Arsenic removal

Effect of pH on Arsenic removal: The solution pH is an important factor for all water treatment process because it affects among others, the speciation of the metals in water [140]. Thus effect of pH on arsenic removal from aqueous solutions was determined over the pH range 2.0 to 10.0 at initial arsenic concentration: 0.1mg/L, adsorbent dose: 1 gm/50 mL, temperature:  $30^{\circ}\text{C} \pm 2^{\circ}\text{C}$ , contact time: 2hrs. and shaking time: 1hr. The results are summarized in table 13,14,15and figure 3 removal of arsenic in figure indicated that at pH- 6.0 the removal efficiency was 80.74% in case of NLP, 79.82% in case of PLP and 88.16% in case of ALP. A steep decrease was observed after pH- 6.0, when pH was higher than 6.0, the arsenic removal decreased with increase in pH. Increase in pH decreased arsenic adsorption due to chelation with the release of H+ ions. It was found to be relatively better removed at the same pH consistent. The adsorption capacity for ALP was higher than that of NLP and PLP other adsorbents at all used pH values. So the increasing order of pH values as follows:

ALP > NLP > PLP.



Table N	No. 13		Arsenio	e onto NLP			
	Amount of arsenic adsorbed at varying pH						
(Initial concentration: 0.1mg/L, Adsorbent dose: 1gm/50mL, Temperature: $30^{\circ}C \pm 2^{\circ}C$ , Contact time: 2hr., Shaking time: 1hr.)							
S. No.	1	bH       Equilibrium Concentration(C <sub>e</sub> )       Adsorbed amount (q <sub>e</sub> )       Removal (R)					
units	Standa	rds units	mg/L	mg/g	%		
1		2.0	0.02	0.08	74.34		
2		4.0	0.02	0.08	79.40		
3		6.0	0.01	0.09	80.74		
4		8.0	0.05	0.47	46.15		
5	1	0.0	0.07	0.30	39.85		



Table N	e No. 14 Arsenic onto PLP							
	Amount of arsenic adsorbed at varying pH							
	(Initial concentration: 0.1mg/L, Adsorbent dose: 1gm/50mL, Temperature: $30^{\circ}C \pm 2^{\circ}C$ . Contact time: 2hr., Shaking time: 1hr.)							
S. No.	No. pH Equilibrium Adsorbed amount (qe) Removal (R)							
units	Stan	dards units	mg/L	mg/g	%			
1		2.0	0.02	0.08	71.32			
2		4.0	0.02	0.08	78.42			
3		6.0	0.02	0.08	79.82			
4		8.0	0.05	0.04	44.16			
5		10.0	0.07	0.03	38.59			

Table N	No. 15		Arsenic onto ALP					
	Amount of arsenic adsorbed at varying pH							
	(Initial concentration: 0.1mg/L, Adsorbent dose: 1gm/50mL,							
	Tem	perature: 30°	$C \pm 2^{\circ}C$ , Contact time:	2hr., Shaking time:	1hr.)			
S. No.		pH Equilibrium Adsorbed Removal						
		Concentration(Ce) amount (qe)						
units	Standards units		mg/L	mg/g	%			
1		2.0	0.02	0.08	76.24			
2		4.0	0.02	0.08	79.93			
3		6.0	0.01	0.09	88.16			
4		8.0	0.05	0.04	45.37			
5		10.0	0.07	0.03	39.49			

**Mathematical Formulation**: The experimental values of NLP, PLP and ALP dosage on Arsenic removal is extrapolated using MATLAB software to formulate corresponding quadratic equations relating to

- • Amount of pH (x) and Equilibrium Concentration (y)
- Amount of pH (x) and Adsorbed amount (y)
- Amount of pH (x) and Removal (y)

These equations can be used to interpolate the values of Arsenic removal for any amount of adsorbent.

The results are summarized in table 16,17,18

Table No. 16	5	Arsenic onto NLP					
Amount of arsenic adsorbed at varying pH							
(Initial concentration: 0.1mg/L, Adsorbent dose: 1gm/50mL,							
Temp	Temperature: $30^{\circ}C \pm 2^{\circ}C$ , Contact time: 2hr., Shaking time: 1hr.)						
S. No.	рН	Equilibrium Concentration(Ce) Adsorbed amount (qe) Removal (R)					
Mathematical Expression	x	y=0.0013x <sup>3</sup> - 0.0163x <sup>2</sup> +0.0625x- 0.05	y=0.0075x <sup>3</sup> - 0.0887x <sup>2</sup> +0.3225x- 0.27	y=- 0.671x <sup>3</sup> +7.5875x <sup>2</sup> - 24.206x+97.77			
1	3	0.0259	0.1017	75.3225			
2	5	0.0175	0.0625	82.5525			
3	7	0.0347	0.2137	69.9625			
4	9	0.1399	0.9153	5.3445			

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Table No. 17	'	Arsenic onto PLP				
Amount of arsenic adsorbed at varying pH						
(Ini	(Initial concentration: 0.1mg/L, Adsorbent dose: 1gm/50mL,					
Temp	eratur	e: $30^{\circ}C \pm 2^{\circ}C$ , Contac	t time: 2hr., Shaking	g time: 1hr.)		
	pН	Equilibrium	4.111			
S. No.		Concentration(Ce)	amount (qe)	Removal (R)		
Mathematical expressions	x	y=0.0006x <sup>3</sup> - 0.0075x <sup>2</sup> +0.0275x- 0.01	y=- 0.0008x <sup>3</sup> +0.01x <sup>2</sup> - 0.0367x+0.12	y=- 0.6533x <sup>3</sup> +7.1275x <sup>2</sup> - 20.922x+89.88		
1	3	0.0212	0.0783	73.6224		
2	5	0.015	0.0865	81.795		
3	7	0.0208	0.0787	68.5916		
4	9	0.0674	0.0165	2.6538		

Table No. 18	Arsenic onto ALP						
Amount of arsenic adsorbed at varying pH							
(In	(Initial concentration: 0.1mg/L, Adsorbent dose: 1gm/50mL,						
Temj	peratu	re: $30^{\circ}C \pm 2^{\circ}C$ , Conta	et time: 2hr., Shaking	time: 1hr.)			
S. No.	рН	Equilibrium Concentration(Ce) Adsorbed amount (qe) Removal (R)					
Mathematical expressions	x	y=0.0013x <sup>3</sup> - 0.0163x <sup>2</sup> +0.0625x- 0.05	y=- 0.0015x <sup>3</sup> +0.0187x <sup>2</sup> - 0.0717x+0.16	y=- 1.1575x <sup>3</sup> +14.457x <sup>2</sup> - 52.49x+132.65			
1	3	0.0259	0.0727	74.0405			
2	5	0.0175	0.0815	86.9375			
3	7	0.0347	0.0599	76.5905			
4	9	0.1399	-0.0641	-12.561			

#### **Conclusion and Recommendation**

Lead, fluoride and Arsenic have their toxic effect on human as well as environment, so it is utmost important to remove it from the water. NLP, PLP, ALP leaves after experiments showed greater adsorption area and strong affinity toward the ions at different pH. The experimental values of fluoride, arsenic and lead dosage on NLP, PLP and ALP removal is extrapolated using MATLAB software to formulate corresponding quadratic equations. These equations can be used to interpolate the values of ions removal for any amount of pH. The extrapolated values by MATLAB software helps, in theoretically calculating the values without experiments, which in turn useful for the pilot project as well as to scale up the material at industrial level.

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