Studies on Adsorption Characteristics of Lithomargic clay (Shedi soil) Blended with Bentonite as a Landfill Liner

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Abstract - The liner is the most important element of a waste disposal landfill. It protects the environment from harm. It acts as barrier to prevent or minimize the migration of pollutants into the environment from the landfill. Liners are commonly composed of compacted natural inorganic clays or clayey soils. Clayey soils are used for constructing landfill liners because they have low hydraulic conductivity and can attenuate inorganic contaminants. Commercially available fine grained clayey soil such as bentonite is commonly used for liners materials. The present study is carried out to evaluate the capability of lithomargic clay (shedi soil) blended with 5% and 7.5% bentonite clay liner to attenuate contaminant of sodium and chloride.The blended soils were tested for adsorption of sodium and chloride by batch adsorption test.
KEYWORDS: Lithomargic clay, Bentonite clay, Landfill, Adsorption

I.INTRODUCTION

Solid wastes are those organic and inorganic waste materials produced by various activities of the society, which have lost their value to the first user. Improper disposal of solid wastes pollutes all the vital components of the living environment (i.e., air, land and water) at local and global levels [1]. The problem is more acute in developing nations than in developed nations, as their economic growth as well as urbanization is more rapid. There has been a significant increase in MSW (municipal solid waste) generation in India in the last few decades. This is largely because of rapid population growth and economic development in the country. Due to rapid growth of urban population, as well as constraint in resources, the management of solid waste poses a difficult and complex problem for the society and its improper management gravely affects the public health and degrades environment. Solid waste can be defined as any solid or semi-solid substance or object resulting from human or animal activities, discarded as useless or unwanted. It is an extremely mixed mass of wastes, which may originate from household, commercial, industrial or agricultural activities. Solid waste is a broad term, which encompasses all kinds of waste such as Municipal Solid Waste (MSW), Industrial Waste (IW), Hazardous Waste (HW), Bio-Medical Waste (BMW) and Electronic waste (E-waste) depending on their source & composition. It consists of organic and inorganic constituents which may or may not be biodegradable. On one hand, the recyclable components of solid waste could be useful as secondary resource for production processes. . On the other hand, some of its toxic and harmful constituents may pose a danger if not handled properly. Source reduction, recycling and composting, waste-to-energy conversion facilities, and land filling are the most basic approaches to waste management.

Even after recycle and reuse, sufficiently large quantity of waste remains, which is disposed in low-lying areas without undertaking any precautions [2]. This practise has led to major environmental issue, as the rainwater percolating down from the waste carries pollutants with it and joins water bodies. The contamination of water bodies decreases their dissolved oxygen level and makes the environment unsuitable for the survival of aquatic animals. Water bodies near waste dump sites are also found to be contaminated with micro-organisms which have considerable public health implications. It has been estimated that unlined sanitary landfills in a fairly wet climate will produce leachate containing hazardous chemicals such as lead at concentrations above the drinking water standards for several thousand years. It is not surprising that the landfills constructed by the Romans about 2000 years ago are still producing leachate [3].

Hence there is an urgent need of a scientific method for disposal of waste i.e. by placing the wastes in a landfill. Engineered landfills contain the waste in such a manner that human health and the environment will not be affected [4]. Landfills usually have liner systems and other safeguards to prevent the pollution of groundwater [5] and [6].

II.STUDY AREA

The present study was carried out in Mangalore region (Latitude 13° 03ᴵN, Longitude 74° 47ᴵE), i. e. southwest coast of India which receives rainfall of nearly 3500 mm/year during the monsoon (June to September). Lateritic soil and lithomargic clay (shedi soil) clay are the two types of soils commonly found in the study region. lithomargic clay is a silty soil with approximately 60% of fines proportion. It exhibits variegated colours, cream, red, purple and yellow being most common. For the experimental investigation, naturally occurring lithomargic clay has been procured from the Haleangadi, approximately 6 kilometres away from National Institute of Technology Karnataka (NITK), Surathkal.

Bentonite clay has been procured from Bangalore. It is highly colloidal and plastic clays composed mainly of montmorillonite mineral and are formed by the alteration of volcanic ash. Its main characteristics are large cation-exchnage capacity, large specific surface area, high swelling potential and low hydraulic conductivity to water.

III.LITERATURE REVIEW

Kim (2002) conducted the laboratory batch test to determine the mechanism by which thiolane and sulfolane adsorb on soil materials. It was found that thiolane is more strongly adsorbed onto clay materials than sulfolane as Kd showed 9.1 ± 0.41 L/kg and 1.14 ±0.16 L/kg, respectively. He studied the interactions between solute and clay by considering the activity rather than the concentration of the competing molecules. He also studied the variation of pH on the degree of adsorption capacity of clay on solutes.

Taha et al., (2003) studied the adsorption of phenol in granite residual soil and kaolinite and concluded that the residual soil possesses a greater adsorption capacity compared with kaolinite. A linear relationship was obtained for results involving only low concentrations. The highly non-linear relationships, which cover the whole set of data, was transformed linearly using the Linearized Freundlich and Langmuir isotherms.

Kim et al., (2003) has investigated the effect of the soil solids concentration in batch tests on the measured values of the partition coefficient (kd) of organic pollutants in landfill liner material. The observed partition coefficients decreased logarithmically as the soil solids concentrations increased, but stabilized when the soil solids concentration exceeded a certain value. It was concluded that below 50g/l soil solids concentration, the partition coefficients measured using batch tests were significantly greater than using column tests.

Hai-jun et al., (2009) studied the effect of soil-solids concentration and temperature in batch tests on the adsorption of Cr(VI) onto landfill liner materials, and concluded that the values of isotherm parameters measured using batch tests under low soil-solids concentrations will not properly simulate the field situation, and retardation factors of clay landfill liners systems will be overestimated.

IV.EXPERIMENTAL ADSORPTION STUDY

Adsorption plays a major role in assessing the migrational characteristics of the solute in the soil liner system. Higher the adsorption, lower will be the migration and pollution due to contamination. Hence adsorption tests were conducted using sodium and chloride. Lithomargic clay, bentonite clay, lithomargic clay blended with 5% and 7.5% bentonite clay were used to study the attenuation characteristic of the soil to be proposed as a liner material.

The study was carried by preparing various standards of different concentration of sodium from 30 mg/L to 1500 mg/L, Chloride ranging from 46 mg/L to 2299.9 mg/L.The ratio of volume of contaminant to the mass of solid for sorption study is maintained as a constant throughout. Isotherms (the amount of adsorbate on the adsorbent as a function of its concentration at constant temperature) are plotted for all the cases with the soil surface. The isotherms plotted were used to find partition coefficient and other important parameters to establish relationship between contaminant concentration and sorption. For every isotherm two sets of variations are plotted, with one for lower concentration ranging from 30 mg/L to 80 mg/L and the other for combined test results ranging from 30 mg/L to 1500 mg/L for sodium and chloride solution.

The test is carried out by first measuring the concentration of standard solution (C_i) and later measuring the concentration of the contaminant (C) in the solution at equilibrium with the soil after contact period of 15 days.

From the initial and final concentration of contaminant, the mass of contaminant sorbed on soil is calculated.

Sorption "S" is mathematically expressed as

$$S=\frac{(C_i-C)\times V_f}{M_s}$$

Where,

S – Mass of contaminant sorbed per unit dry mass of soil (mg/kg)
C_i – Initial concentration of contaminant in solution (mg/L)
C – Concentration of contaminant in solution at equilibrium (mg/L)
M_s– Weight of soil (g)
V_f– volume of solute (ml)

V.RESULTS AND DISCUSSIONS

A.ADSORPTION OF SODIUM ON SOIL

Sodium is a chemical element with symbol Na (from Latin: natrium) and atomic number 11.Sodium is the sixth most abundant element in the Earth's crust. Many salts of sodium are highly water-soluble, and their sodium has been leached by the action of water so that chloride and sodium are the most common dissolved elements by weight in the Earth's bodies of oceanic water. The dietary reference intake (DRI) for sodium is 2.3 grams per day, but on average people 3.4 grams per day, the maximum amount that promotes hypertension; this in turn causes 7.6 million premature deaths worldwide. It becomes mandatory to check the addition of sodium to groundwater through landfills as sodium rich soil is unsuitable for irrigation purpose. The results obtained from the test are listed in Table.1

Table.1 Adsorption test results for sodium as contaminant

Sodium concentration		Lithomargic clay		Bentonite clay		Lithomargic clay + 5% Bentonite clay		Lithomargic clay + 7.5% Bentonite clay	
Initial conc, C_i (mg/L)	Initial pH	Final conc, C (mg/L)	Final pH	Final conc, C (mg/L)	Final pH	Final conc, C (mg/L)	Final pH	Final conc, C (mg/L)	Final pH
30	7.14	27.0	6.39	175	8.59	65.8	6.21	85.7	6.25
40	7.08	35.5	6.13	178	8.56	80.3	6.50	92.0	6.92
50	7.04	44.0	5.62	184	8.54	92.1	6.27	100.0	6.28
60	6.98	52.0	5.73	189	8.59	105.0	6.25	106.0	7.04
80	7.00	69.0	5.77	198	8.61	130.0	5.85	119.7	6.43
100	6.92	86.0	5.57	210	8.58	154.6	6.31	123.7	6.95
200	6.87	175.0	5.38	275	8.63	211.5	6.09	209.5	6.53
300	6.90	265.0	5.33	351	8.58	290.0	5.66	295.0	6.58
400	7.06	355.0	5.32	436	8.59	380.0	5.75	390.0	6.34
600	7.10	540.0	4.97	610	8.56	563.0	5.36	575.0	6.28
800	6.85	720.0	4.89	796	8.52	750.0	5.37	760.0	6.20
1000	6.92	900.0	4.96	986	8.45	936.0	5.36	940.0	6.37
1200	7.00	1080.0	4.80	1174	8.43	1120.0	5.45	1126.0	6.40
1400	6.73	1260.0	5.84	1368	8.38	1300.0	5.51	1308.0	6.36
1500	6.68	1350.0	4.82	1460	8.30	1390.0	5.18	1400.0	6.04

Table1 shows the initial pH values of the sodium solutions and final equilibrium pH of the solutions interaction with Lithomargic clay, bentonite and blended soils. It shows the changes in the final equilibrium pH of sodium interaction with bentonite clay are slightly higher than the initial pH, but final pH of lithomargic clay and blended soil are slightly lower than the initial pH.

Linear adsorption isotherm for sodium

The adsorption test were carried out on test soils to evaluate the sodium attenuation capacity. The results obtained from the tests are listed in Table.2

Table.2 Linear adsorption isotherm test results for sodium

Shedi soil		Bentonite clay		Lithomargic clay + 5% Bentonite clay		Lithomargic clay + 7.5% Bentonite	
Final conc, C (mg/L)	Sorption, S (mg/kg)	Final conc, C (mg/L)	Sorption, S (mg/kg)	Final conc, C (mg/L)	Sorption, S (mg/kg)	Final conc, C (mg/L)	Sorption, S (mg/kg)
27.0	15.0	175	-5800	65.8	-179.0	85.7	-278.5
35.5	22.5	178	-5520	80.3	-201.5	92.0	-260.0
44.0	30.0	184	-5350	92.1	-210.5	100.0	-250.0
52.0	40.0	189	-5168	105.0	-225.0	106.0	-230.0
69.0	55.0	198	-4700	130.0	-250.0	119.7	-198.5
86.0	70.0	210	-4400	154.6	-273.0	123.7	-118.5
175.0	125.0	275	-3000	211.5	-57.5	209.5	-47.5
265.0	175.0	351	-2040	290.0	50.0	295.0	25.0
355.0	225.0	436	-1420	380.0	100.0	390.0	50.0
540.0	300.0	610	-400	563.0	185.0	575.0	125.0
720.0	400.0	796	160	750.0	250.0	760.0	200.0
900.0	500.0	986	560	936.0	320.0	940.0	300.0
1080.0	600.0	1174	1040	1120.0	400.0	1126.0	370.0
1260.0	700.0	1368	1280	1300.0	500.0	1308.0	460.0
1350.0	750.0	1460	1600	1390.0	550.0	1400.0	500.0

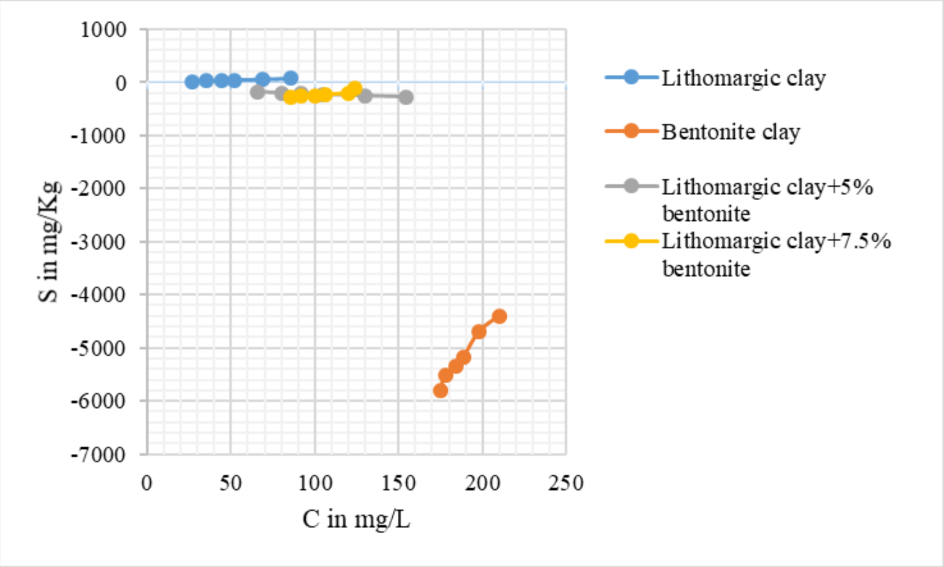

Fig.1Linear adsorption isotherm test results for low concentration of sodium (0-86mg/L)

Table.2 Coefficient of distribution (k_d) values of test soils for low concentration of sodium

Parameter	Coefficient of distribution k_d (L/kg)			
Soil	Lithomargic clay	Bentonite clay	Lithomargic clay +5% bentonite	Lithomargic clay + 7.5% bentonite
Low concentration	0.944	5.65	1.03	2.317

Fig.1 shows low concentration of sodium on adsorption test, results plotted for linear isotherm and distribution coefficient values (k_d) for bentonite clay, lithomargic clay and blended soils are approximated by a linear isotherm shown in Table.2**.** It is observed that Coefficient of distribution for bentonite clay and blended soil are more than one, it indicate that desorption of bentonite and blended soil with sodium. The value of k_d for lithomargic clay is 0.944, it represent that favourable sorption of sodium on lithomargic clay.

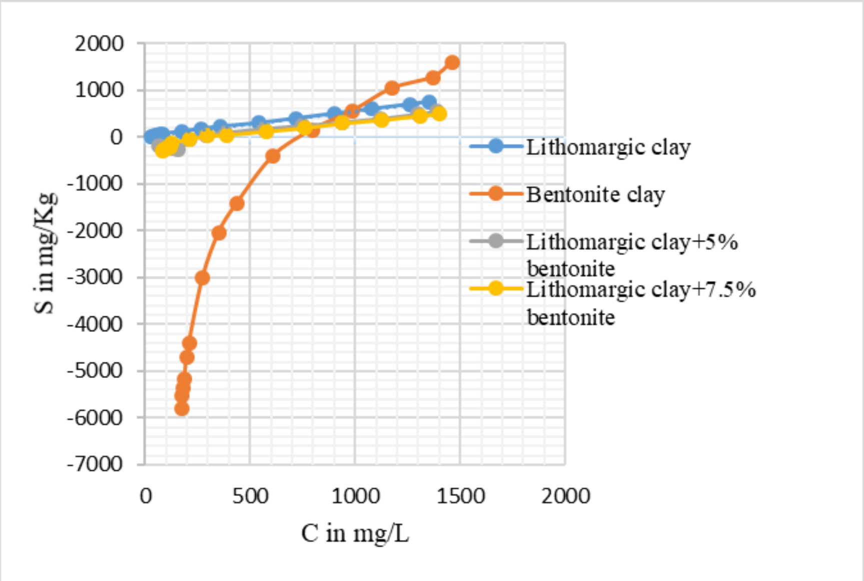

Fig.2 Linear adsorption isotherm for combined test results of sodium

Table.3 Coefficient of distribution (k_d) values of test soils for sodium

Parameter	k_d (L/kg)			
Soil	Lithomargic clay	Bentonite clay	Lithomargic clay +5% bentonite	Lithomargic clay + 7.5% bentonite
Combined test results	0.54	0.69	0.59	0.55

The linear isotherms for combined test results are plotted in Fig.2. As observed from Fig. 2, the test results still follow a linear relationship for the tested soils. As such there is significant deviation of the test data when compared and analysed with linear relationship of low concentration results plotted in Fig.1. As observed from Fig.2 bentonite clay and its blended soil are in desorption at low concentration and sorption characteristics at higher concentration. The reason for this behaviour is due to there is a possibility of movement of sodium contaminant from an area of greater concentration of soil towards an area of lower concentration of solution till equilibrium concentration is reached (i.e molecular diffusion). The corresponding values of distribution coefficient (k_d) of lithomargic clay and blended soils are shown in Table.3. Thus from Fig.2 it is observed that the sorption and desorption characteristics of bentonite clay, lithomargic clay and its blended soil are different.

Linearized Freundlich adsorption isotherm for sodium

The logarithmic values of sorption (S) and concentration (C) are calculated and listed in Table 4.

Table.4 Linearized Freundlich adsorption isotherm test results for sodium.

Lithomargic clay		Bentonite clay		Lithomargic clay + 5% Bentonite		Lithomargic clay + 7.5% Bentonite	
Log C	Log S	Log C	Log S	Log C	Log S	Log C	Log S
1.43	1.18	2.24	-	1.82	-	1.93	-
1.55	1.35	2.25	-	1.90	-	1.96	-
1.64	1.48	2.26	-	1.96	-	2.00	-
1.72	1.60	2.28	-	2.02	-	2.03	-
1.84	1.74	2.30	-	2.11	-	2.08	-
1.93	1.85	2.32	-	2.19	-	2.09	-
2.24	2.10	2.44	-	2.33	-	2.32	-
2.42	2.24	2.55	-	2.46	1.70	2.47	1.40
2.55	2.35	2.64	-	2.58	2.00	2.59	1.70
2.73	2.48	2.79	-	2.75	2.27	2.76	2.10
2.86	2.60	2.90	2.20	2.88	2.40	2.88	2.30
2.95	2.70	2.99	2.75	2.97	2.51	2.97	2.48
3.03	2.78	3.07	3.02	3.05	2.60	3.05	2.57
3.10	2.85	3.14	3.11	3.11	2.70	3.12	2.66
3.13	2.88	3.16	3.20	3.14	2.74	3.15	2.70

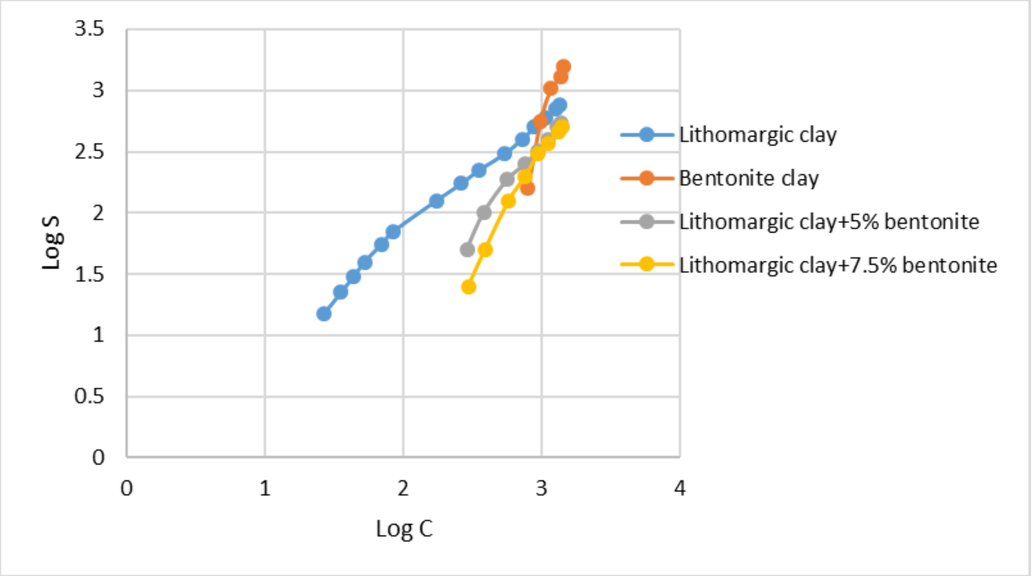

Fig.3 Linearized Freundlich adsorption isotherm for combined test results of sodium

Table.5 Freundlich's constants (K and N) for sodium

Soil	Lithomargic clay		Bentonite clay		Lithomargic clay +5% Bentonite		Lithomargic clay +7.5% Bentonite	
Parameter	K (mg/Kg)	N (Kg/L)	K (mg/Kg)	N (Kg/L)	K (mg/Kg)	N (Kg/L)	K (mg/Kg)	N (Kg/L)
Combined test results	0.892	0.94	$1.42*10^{-6}$	2.48	$1.05*10^{-5}$	2.51	$7.45*10^{-6}$	2.53

The adsorption combined test results for Freundlich isotherm have been plotted in a linearized form and from the straight lines the parameters K and N have been found out. It is observed that the sorption characteristics of bentonite clay, lithomargic clay and blended soil are different. The parameters K and N indicate that favourable sorption of sodium with lithomargic clay, bentonite clay and its blended soils at higher concentration (Taha et al.2003).

Langmuir adsorption isotherm for sodium

Table.6 Langmuir adsorption isotherm test results for sodium

Lithomargic clay		Bentonite clay		Lithomargic clay + 5% Bentonite		Lithomargic clay + 7.5% Bentonite	
C (mg/L)	C/S (kg/L)	C (mg/L)	C/S (kg/L)	C (mg/L)	C/S (kg/L)	C (mg/L)	C/S (kg/L)
27	1.80	175	-0.03	65.8	-0.37	85.7	-0.31
35.5	1.58	178	-0.03	80.3	-0.4	92.0	-0.35
44	1.47	184	-0.03	92.1	-0.44	100.0	-0.40
52	1.30	189	-0.04	105.0	-0.47	106.0	-0.46
69	1.25	198	-0.04	130.0	-0.52	119.7	-0.60
86	1.23	210	-0.05	154.6	-0.57	123.7	-1.04
175	1.40	275	-0.09	211.5	-3.68	209.5	-4.41
265	1.51	351	-0.17	290.0	5.80	295.0	11.80
355	1.58	436	-0.31	380.0	3.80	390.0	7.80
540	1.80	610	-1.53	563.0	3.04	575.0	4.60
720	1.80	796	4.98	750.0	3.00	760.0	3.80
900	1.80	986	1.76	936.0	2.93	940.0	3.13
1080	1.80	1174	1.13	1120.0	2.80	1126.0	3.04
1260	1.80	1368	1.07	1300.0	2.60	1308.0	2.84
1350	1.80	1460	0.91	1390.0	2.53	1400.0	2.80

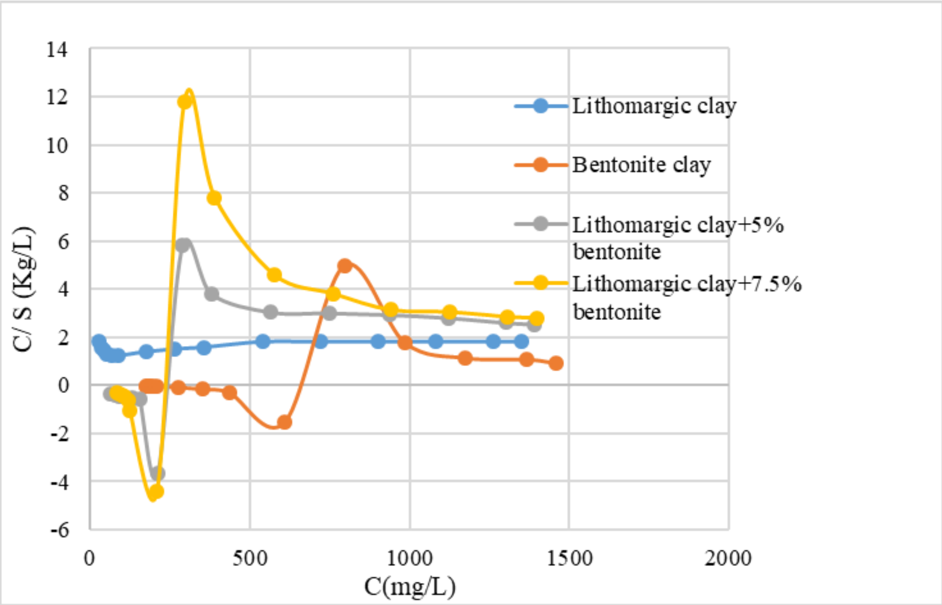

Fig.4 Langmuir adsorption isotherm of combined test results for sodium

Table.7 Langmuir constants (α and β) of combined test results for sodium

Soil	Lithomargic clay		Bentonite clay		Lithomargic clay +5% Bentonite		Lithomargic clay +7.5% Bentonite	
Parameter	α (L/mg)	β (mg/Kg)	α (L/mg)	β (mg/Kg)	α (L/mg)	β (mg/Kg)	α (L/mg)	β (mg/Kg)
Combined test results	0.0002	3333.33	-0.0046	88.5	-0.06	370.37	0.0032	384.6

The linearized Langmuir plotted for combined test results are shown in Fig.4. It was observed that the adsorption test data plotted on linearized Langmuir isotherm had a very low value of α. This indicates that the values predicted significantly underestimates when compared to other two types of isotherms. The corresponding values of α and β for each type of soil are given in Table.7.As observed from Fig.4 it is evident that the lithomargic clay adsorbs 3333.33mg of sodium per kg of soil; bentonite clay adsorbs 88.5 mg of sodium per kg of soil, lithomargic clay blended with 5% and 7.5% of bentonite clay sorbs 370.37 mg and 385 mg of sodium per kg of soil respectively.

B.ADSORPTION OF CHLORIDE ON SOIL

The human body needs chloride for metabolism (the process of turning food into energy). The amount of chloride in the blood is carefully controlled by the kidneys. Healthy individuals can tolerate the intake of large quantities of chloride provided that there is a concomitant intake of fresh water. Chloride increases the electrical conductivity of water and thus increases its corrosions. In metal pipes, chloride reacts with metal ions to form soluble salts, thus increasing levels of metals in drinking-water. Though chloride is found to have no direct health implications, it becomes necessary to study the inclusion of chloride to groundwater because of its effect on pipes and machinery of the treatment plant.

Linear adsorption isotherm for chloride

The adsorption test was carried out on soils to evaluate the chloride attenuation capacity of the soils. The results obtained from the test are listed in Table 8.

Table.8 Linear adsorption isotherm test results for chloride

Initial Conc of Cl (mg/L)	Lithomargic clay		Bentonite clay		Lithomargic clay + 5% Bentonite		Lithomargic clay + 7.5% Bentonite	
	Final conc, C (mg/L)	Sorption , S (mg/kg)	Final conc, C (mg/L)	Sorption, S (mg/kg)	Final conc, C (mg/L)	Sorption , S (mg/kg)	Final conc, C (mg/L)	Sorption, S (mg/kg)
46.0	45.0	5.0	220.0	-6959.8	142.5	-482.5	180.0	-668.7
61.0	57.5	17.5	237.5	-7059.8	157.5	-482.5	190.0	-641.6
76.0	70.0	30.0	255.0	-7159.8	170.0	-470.0	202.5	-627.0
92.0	82.5	47.5	275.0	-7319.8	180.0	-440.0	215.0	-612.5
122.5	110.0	62.5	310.0	-7499.8	210.0	-437.5	242.5	-595.8
152.5	137.5	75.0	335.0	-7299.8	240.0	-437.5	272.5	-591.6
310.0	287.5	112.5	490.0	-7199.8	387.5	-387.5	425.0	-583.2
465.0	437.5	137.5	625.0	-6399.8	537.5	-362.5	575.0	-562.3
620.0	587.5	162.5	775.0	-6199.8	675.0	-275.0	725.0	-541.4
930.0	887.5	212.5	1100.0	-6799.8	987.5	-287.5	1025.0	-499.7
1250.0	1187.5	312.5	1400.0	-5999.8	1300.0	-250.0	1325.0	-457.9
1550.0	1475.0	375.0	1700.0	-5999.8	1600.0	-250.0	1625.0	-416.1
1850.0	1762.5	437.5	1999.9	-5999.8	1900.0	-250.0	1925.0	-374.3
2149.9	2049.9	500.0	2299.9	-5999.8	2199.9	-250.0	2224.9	-332.5
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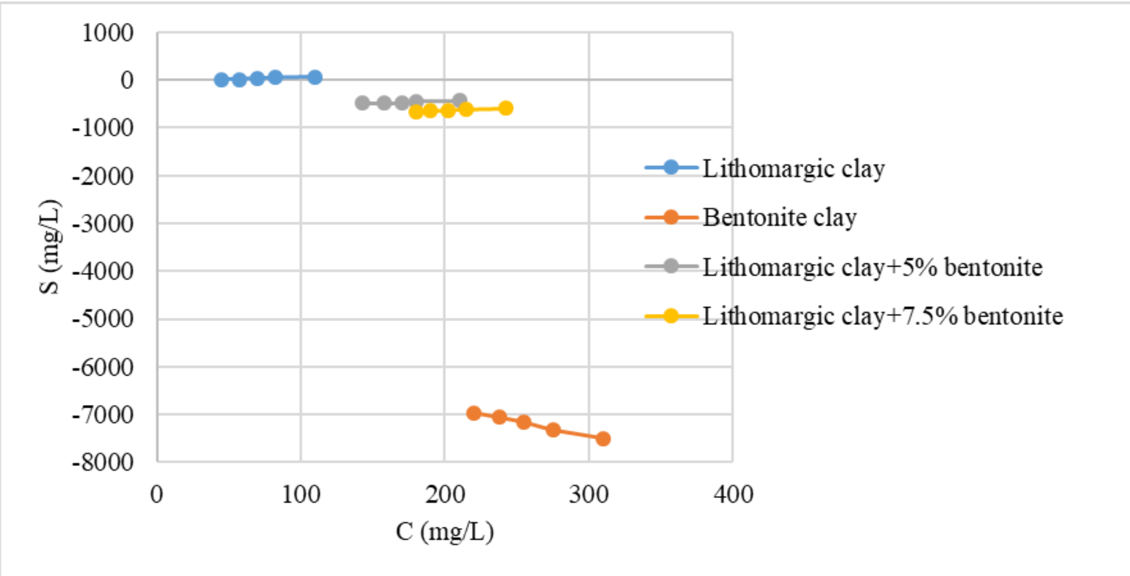

Fig.5 Linear adsorption isotherm test results for low concentration of chloride (0-122.5mg/L)

Table.9 Coefficient of distribution (k_d) values of test soils for low concentration of chloride

Parameter	k_d (L/kg)			
Soil	Lithomargic clay	Bentonite clay	Lithomargic clay +5% Bentonite	Lithomargic clay + 7.5% Bentonite
Low concentration	0.61	-0.77	0.78	1.1

From the results plotted in Fig.5 it is observed that the interaction of chloride is more on lithomargic clay (k_d=0.61, R^2=0.972). The corresponding value of k_d for bentonite clay is -0.77.The negative sign indicate that desorption of chloride with bentonite clay. The reason for this behaviour due to presence of montomorillonite as a predominant mineral in bentonite clay and there is a possibility of large quantity of negatively charged chloride molecule on its surface, hence movement of chloride molecule from an area of greater concentration of soil towards an area of lower concentration of solution till equilibrium condition is reached due to molecular diffusion. It indicates that there is desorption of chloride with bentonite clay, but it observed from Fig.5 desorption decreases with increase of concentration of solution. When lithomargic clay is blended with 5% and 7.5% bentonite the linear desorption isotherm for low concentration as shown in Fig. 5.

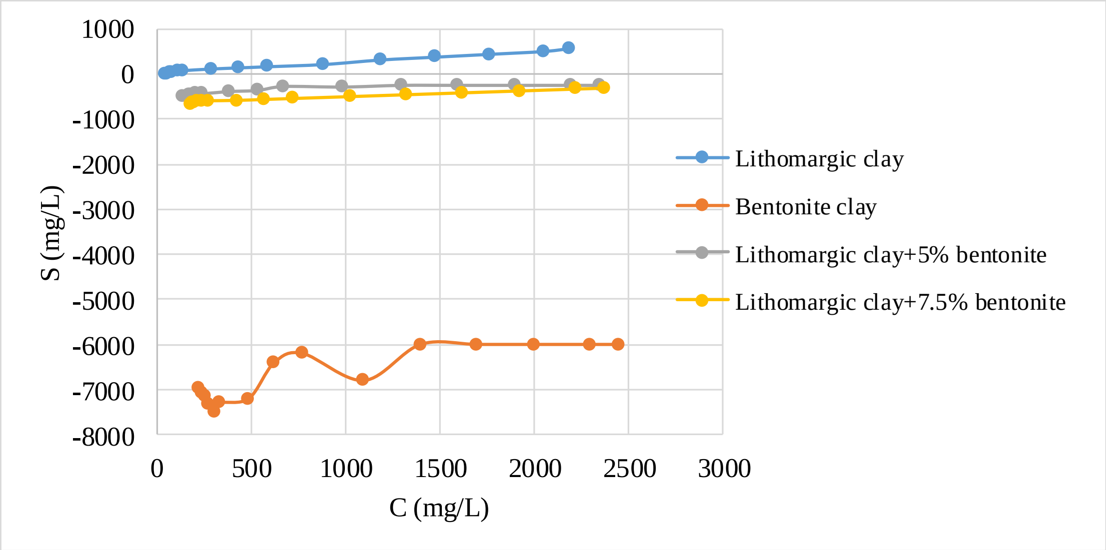

Fig.6 Linear adsorption isotherm for combined test results of chloride.

Table.10 Coefficient of distribution (k_d) values of test soils for chloride

Parameter	k_d (L/kg)			
Soil	Lithomargic clay	Bentonite clay	Lithomargic clay +5% Bentonite	Lithomargic clay + 7.5% Bentonite
Combined test results	0.24	0.08	0.11	0.145

The linear adsorption isotherm, for combined tests soil results are plotted in Fig.6. As observed from Fig.6, the test results still there is linear relationship. As such there is no significant deviation of the test data when compared and analysed with linear relationship of low concentration results plotted in Fig.5. From Fig.6 it is observed that the interaction of chloride is more on lithomargic clay with k_d = 0.24 (R^2=0.993). The corresponding values of distribution coefficient (k_d) of bentonite clay and blended soil are shown in Table.10. Thus from Fig.6 it is observed that the sorption characteristic of lithomargic clay and desorption characteristics of bentonite clay and its blended soils.

Linearized Freundlich adsorption isotherm for chloride

Table.11Linearized Freundlich adsorption isotherm test results for chloride as contaminant.

Lithomargic clay		Bentonite clay		Lithomargic clay + 5% Bentonite		Lithomargic clay + 7.5% Bentonite	
Log C	Log S	Log C	Log S	Log C	Log S	Log C	Log S
1.65	0.70	2.34	-	2.15	-	2.26	-
1.76	1.24	2.38	-	2.20	-	2.28	-
1.85	1.48	2.41	-	2.23	-	2.31	-
1.92	1.68	2.44	-	2.26	-	2.33	-
2.04	1.8	2.49	-	2.32	-	2.38	-
2.14	1.88	2.53	-	2.38	-	2.44	-
2.46	2.05	2.69	-	2.59	-	2.63	-
2.64	2.14	2.80	-	2.73	-	2.76	-
2.77	2.21	2.89	-	2.83	-	2.86	-
2.95	2.33	3.04	-	2.99	-	3.01	-
3.07	2.49	3.15	-	3.11	-	3.12	-
3.17	2.57	3.23	-	3.20	-	3.21	-
3.25	2.64	3.30	-	3.28	-	3.28	-
3.31	2.70	3.36	-	3.34	-	3.35	-
3.34	2.75	3.39	-	3.37	-	3.38	-

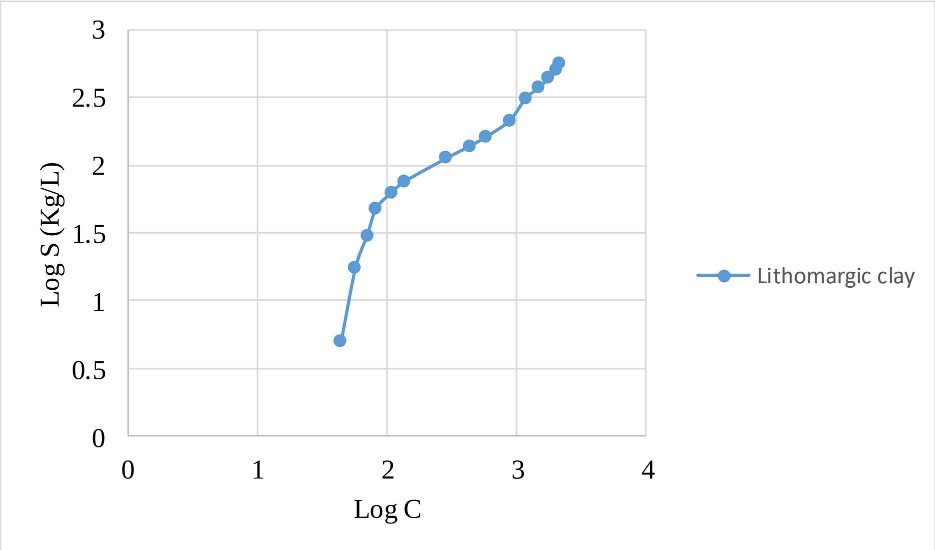

Fig.7 Freundlich adsorption isotherm for chloride

Table.12 Freundlich's constants (K and N) for chloride

Soil	Lithomargic clay		Bentonite clay		Lithomargic clay +5% Bentonite		Lithomargic clay +7.5% Bentonite	
Parameter	K (mg/Kg)	N (Kg/L)	K (mg/Kg)	N (Kg/L)	K (mg/Kg)	N (Kg/L)	K (mg/Kg)	N (Kg/L)
Combined test results	0.91	0.515	-	-	-	-	-	-

From the Fig.7 the adsorption test results for Freundlich adsorption isotherm have been plotted in a linearized form. From the straight lines the values of K and N have been found out. For lithomargic clay the parameters K and N are 0.91mg/kg and 0.515Kg/L respectively. Similarly Results for bentonite clay and its blended soils are not displayed on the graph as the regression value was become zero (i.e. parameters K and N are found to zero).

Langmuir adsorption isotherm for chloride

Table.13 Langmuir adsorption isotherm test results for chloride

Lithomargic clay		Bentonite clay		Lithomargic clay + 5% Bentonite		Lithomargic clay + 7.5% Bentonite	
C (mg/L)	C/S (kg/L)	C (mg/L)	C/S (kg/L)	C (mg/L)	C/S (kg/L)	C (mg/L)	C/S (kg/L)
45.00	9.00	219.99	-0.03	142.50	-0.30	179.99	-0.27
57.50	3.29	237.49	-0.03	157.50	-0.33	189.99	-0.30
70.00	2.33	254.99	-0.04	170.00	-0.36	202.49	-0.32
82.50	1.74	274.99	-0.04	179.99	-0.41	214.99	-0.35
110.00	1.76	309.99	-0.04	209.99	-0.48	242.49	-0.41
137.50	1.83	334.99	-0.05	239.99	-0.55	272.49	-0.46
287.49	2.56	489.99	-0.07	387.49	-1.00	424.99	-0.73
437.49	3.18	624.98	-0.10	537.48	-1.48	574.98	-1.02
587.48	3.62	774.98	-0.13	674.98	-2.45	724.98	-1.34
887.48	4.18	1099.97	-0.16	987.47	-3.43	1024.97	-2.05
1187.47	3.80	1399.96	-0.23	1299.96	-5.20	1324.96	-2.89
1474.96	3.93	1699.95	-0.28	1599.96	-6.40	1624.95	-3.91
1762.45	4.03	1999.94	-0.33	1899.95	-7.60	1924.95	-5.14
2049.94	4.10	2299.94	-0.38	2199.94	-8.80	2224.94	-6.69
2187.44	3.89	2449.93	-0.41	2349.93	-9.40	2374.93	-7.62

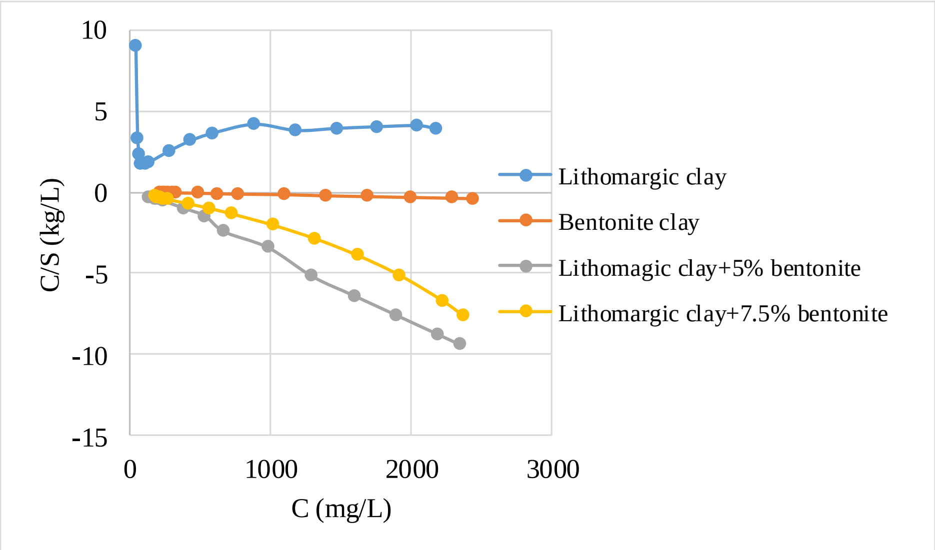

Fig.8 Langmuir adsorption isotherm test results for combined concentration of chloride

Table.14 Langmuir constants (α and β) of test soils for chloride

Soil	Lithomargic clay		Bentonite clay		Lithomargic clay +5% Bentonite		Lithomargic clay +7.5% Bentonite	
Parameter	α (L/mg)	β (mg/Kg)	α (L/mg)	β (mg/Kg)	α (L/mg)	β (mg/Kg)	α (L/mg)	β (mg/Kg)
Combined test results	0.0001	2500	-0.017	-714.3	-0.0095	-238.1	-0.0057	-322.6

The linearized Langmuir isotherm plots for combined test results are shown in Fig.8. It was observed that the adsorption test data plotted on linearized Langmuir isotherm had a very low value of α. From the Fig.8 it is evident that the lithomargic clay adsorbs 2500mg of chloride per kg of soil, but bentonite clay desorbs -714.3 mg of chloride per kg of soil, lithomargic clay blended with 5% and 7.5% of bentonite clay desorbs -238.1 mg and -322.6 mg of chloride per kg of soil respectively. The negative sign indicating that desorption of chloride with bentonite clay and its blended soil.

IV.CONCLUSIONS

Based on the results presented in this paper, the following conclusions are drawn.

- Coefficient of distribution (kd) values obtained from linear adsorption isotherms, Freundlich's constants (K & N) and Langmuir adsorption isotherms for sodium indicates that the blended soil shows the favourable sorption at higher concentration, but desorption at lower concentration.
- Langmuir adsorption isotherms for sodium indicates that lithomargic clay adsorbs 3333.33mg of sodium per kg of soil, bentonite clay adsorbs 88.5 mg of sodium per kg of soil, lithomargic clay blended with 5% and 7.5% of bentonite clay sorbs 370.37 mg and 385 mg of sodium per kg of soil respectively.
- Coefficient of distribution (kd) values obtained from linear adsorption isotherms, Freundlich's constants (K & N) and Langmuir adsorption isotherms for chloride indicates that lithomargic clay show favourable sorption, but bentonite clay and blended soil shows the desorption.
- Langmuir adsorption isotherms for chloride indicates that lithomargic clay adsorbs 2500mg of chloride per kg of soil, but bentonite clay desorbs -714.3 mg of chloride per kg of soil, lithomargic clay blended with 5% and 7.5% of bentonite clay desorbs -238.1 mg and -322.6 mg of chloride per kg of soil respectively. The negative sign indicating that desorption of chloride with bentonite clay and its blended soil.

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