Deportation of Heavy Metals from Waste Water Utilizing Soil Aquifer Treatment (SAT) With Adsorbent

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Abstract

The creating characteristic treatment framework is SAT (Soil Aquifer Treatment), which is the most capable advancement relies upon the physical and broad biogeochemical forms in the soil and artesian basin for water quality change. In mix with other treatment innovations SAT can deliver profluent of attractive quality for roundabout consumable utilize. In the present examination, the heavy metals attributes like the quantitative, appropriation and speciation in different profundities of soils of a two year worked lab scale was analyzed. Here, the clayey sand (SC), inorganic silt with sand (MI-SAND), and silty sand (SM) are the three soils tests utilized for experimentation. To redesign the deportation effectiveness of SAT for ejection of heavy metals, for example, Hexavalent Chromium, Nickel, Zinc and Copper alongside the Eucalyptus Leaves, Saw Dust, and Citrus Limetta are used as the Adsorbent. The exploratory information were broke down by the Langmuir demonstrate and the Freundlich model of adsorption. As indicated by the adsorption harmony comes about, the heavy metals were successively expelled and isolated from the reproduced wastewater. This technique grasps that the SAT system with adsorbent is more viable in treating destructive wastewater.

Keywords: Adsorbent, noxious wastewater, eucalyptus leaves, sawdust, citrus limetta Isotherm, SAT.

1. Introduction

One of the world's most rich assets is water; around 2.5% of the world's water is new. For human utilize more than 66% of this sum is inaccessible, since it exists in icy masses, snow, ice and permafrost [1]. Along these lines the major worldwide ecological and human wellbeing concern is the tainting of the constrained new water assets and more nations end up industrialized [2]. The ask for water kept extending in household, mechanical and horticultural part which moreover diminishes the available water resources, as a result of quick improvement in populace and urbanization [3]. Likewise, in future the volume of waste water created by these zones is depended upon to increase which applies weight on the present wastewater offices. The availability of hypothesis, support and operational costs enables these countries to adjust the trial of developing their present offices in the created nations [4]. After fractional treatment the waste water is either discharged for getting water bodies will bring up in creating nations or on account of budgetary assets nonattendance and skill in specialized to treat the waste water to the levels of optional or tertiary emanating to make the waste water offices [5]. In making countries this proposes the reuse of water not just engaging however absolutely unavoidable to increment in negative prosperity impacts and debasement of getting water bodies. The weight on new water resources are gainfully decreases, freshwater pretreatment to the fundamental profluent level can be joined with trademark and in every way that really matters stable improvement i.e., SAT (Soil Aquifer Treatment) [6]. At that point, one of the challenges looked by the human culture over the globe is water shortage where the supply of crisp water is obliged [7]. The defilement of surface water and ground water, water assets uneven scattering, and consistent dry seasons which are the factors prompts by overall atmosphere example and it doesn't have truly influenced water deficiency [8, 9]. Prior to the complete of 2013, 800 million people on the world didn't approach the water supply improvement and the upgraded sanitation is drawn nearer by 2.5 billion people as demonstrated by WHO and UNICEF. The aggregate populace is envisioned to increase in consistently 2014 of 7.2 to 9.3 billion out of 2050 and correspondingly the urban populace is addition from 3.4 billion to 6.4 billion. This brisk advancement in rates of populace and urbanization will apply more worry in open water assets due to increase in water enthusiasm for age of sustenance [10].

A sincere strategy for "Counterfeit" water accumulating with fitting workplaces is required to alter these issues [11]. Among the advances soil aquifer treatment can constantly and dependably make treated wastewater of satisfactory quality [12]. In the waste water treatment innovation SAT can be seen to be a negligible exertion sensible tertiary, from the auxiliary treated wastewater for consumable and non-consumable uses it can create fantastic gushing [13, 14]. Because of lacking treatment in immense creating nations, in light of poor wastewater quality the utilization of PE (Primary Effluent) in SAT framework in these countries can augment these current water assets to mind the creating water request and water availability upgrade for different uses [15]. The infiltrated wastewater mixed with the ground water and the direct improvement through the aquifer constructs the contact time with the material of aquifer provoking further water cleaning [16, 17]. The SAT framework execution is site specific and is controlled by wastewater quality, hydrogeology and the sewage application term on the attack bowls [18, 19]. Besides, the SAT framework with adsorbents may treat the wastewater containing the heavy metals [20]. Here, the treatability SAT angles are considered using differing adsorbents and soil. Rest of the paper arranged by the going with: the proposed work explain the proof is by and large depicted all through the segment 3; the prescribed system approach extraordinary outcomes impacts and also the related talks are given in area 4; and moreover segment 5 finales the paper; in segment 2 the momentum look into work is inspected. The escalated elucidation of proposed technique is cleared up.

2. A Brief Review of Recent Research Works

In the writing different research works have just existed, which relies upon the depiction of wastewaters, treatment decisions available and their propriety and examinations are finished in this field. Here, a bit of the works is assessed.

D Yadav and S Srivastava [21] have presented an experiment for considering adsorption and de-adsorption of Mn^{+7} ion by carbon nanotubes, by using $KMnO_4$ as source of Mn^{+7} ions. The concentration of Mn^{+7} ions was calculated by UV-Visible spectrophotometer. The carbon nanoparticles have demonstrated a promising efficiency as an adsorbent, attributable to their large surface area and affinity for heavy metal ions. Here, the CNT adsorbent Mn^{+7} ions effectively and brought down its concentration to as low as 3ppm, from an initial prepared level of 150ppm. Further, the CNT surface retained the adsorbed Mn^{+7} ions even when it was agitated in fresh sample of distilled water, showing that CNT doesn't have de-adsorbed tendency under normal conditions. Li Fang *et al.* [22] exhibited a novel strategy and applied for the treatment of simulated wastewater containing multiple heavy metals. A sorbent of ZnS nanocrystals (NCs) were synthesized and showed the performance of cadmium, lead, zinc and copper removal. In their work the removal efficiency of heavy metals are obtained as 99.9%, 99.8%, 90.8%, and 66.3%, respectively.

M. Adeli *et al.* [23] suggested a sodium dodecyl sulphate-coated Fe_3O_4 nanoparticle (SDS- Fe_3O_4 NPs) for removal of Cu (II), Ni (II) and Zn (II) ions from wastewater samples. The effect of pH solution, SDS, Fe_3O_4 NPs and salt addition on removal efficiency of the metal ions were investigated and optimized. On the removal efficiency of the metal ions the salt addition has a negative effect, thus extraction follows the ion exchange mechanism. Adsorption equilibrium of the metal ions reveals that data were fitted well to the Langmuir isotherm. The desorption experiments by elution of the adsorbent show that the SDS- NPs with methanol could be reconditioned without significant loss of its initial properties even after three adsorption-desorption cycles. A new high efficient super paramagnetic nanosorbent, EDTA functionalized Fe_3O_4 nanoparticles was synthesized by E Ghasemi [24] and it was used for the adsorption and removal of heavy metals from the samples in environment. The synthesized magnetic nanoparticles properties were characterized by scanning electron microcopy (SEM), FT-IR (Fourier transform infrared spectroscopy) and X-ray powder diffraction (XRD). After the adsorption process, by applying as external magnetic field, the separation of Fe_3O_4@EDTA nanoparticles from the aqueous solution was simply achieved.

P Bartczak *et al.* [25] introduced the physicochemical and a morphological property with chitin/lignin utilized as an effective adsorbent of environmentally toxic metals from model system. Particularly significant was its use in the real industrial waste neutralization. On the functional adsorbent the ions are adsorbed for example; Ni^{2+}, Cu^{2+}, Zn^{2+} , and Pb^{2+} ,confirming the high sorption capacity of the newly obtained product, primarily from the biopolymers component due to the presence of numerous active functional groups on its surface. However, the highest affinity for the surface of the sorbent was found in the case of lead ions, was explained in the atomic structure.

3. Materials and Methods

3.1. Description of SAT

Soil Aquifer Treatment (SAT) is a land based MAR (Managed Aquifer Recharge) innovation, which is progressively embraced as a helpful auxiliary intends to dependably improve the water assets and diminish aimless release of treated wastewater to water bodies. SAT is a geo-cleaning framework, before it blends with the local groundwater the aquifer is energized with mostly treated wastewater through unsaturated soil strata. Figure 1 demonstrates the SAT framework schematic cross section.

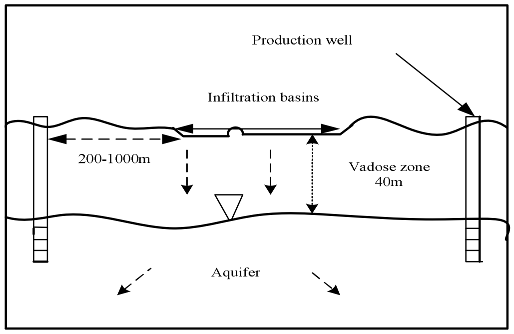

Figure 1. Schematic cross section of the SAT system

The SAT framework execution is assessed in treating wastewaters with and without adsorbents, in which the segment contemplates are completed. In the trial thinks about, four PVC pipes of 6 inches distance across and length of 1.5 meters were made and work for a time of more than 2 years used as segments [26]. With a peristaltic pump, the influents were connected to the SAT inquire about office scale; by then finished the soil surface consistently passed on using a mini-sprinkler. In the downstream mode the segments were worked and hence thought to be predominantly unsaturated. By the overhead tank the wastewater to be attempted was reinforced into these segments. Altering the spill out of overhead tank to the point, which the enduring ponding profundities were, kept up, finished the SOIL mass. However to deal with ponding profundity the over stream pipe was in like manner fitted to the section. The base of every section was stopped with 60 µm work inside keeping in mind the end goal to keep the dirt escape. The test reenactment of SAT for the deportation of heavy metals in wastewater is shown in fig.2.

Figure 2. Soil aquifer treatment (SAT) system experimental setup

3.2. Sampling area and soil selection

On the Deccan level, the Bangalore city is situated in the southern piece of Karnataka state and furthermore which is the capital city of Karnataka state. The dirt's were inspected in southern Karnataka, situated at 12.9716°N scope and 77.5946°E longitude or more the ocean level normal height of 900 meters (3,000ft). The city is having 8.42 million populace and the populaces of 8.52 million are metropolitan. In experimentation the soil tests were gathered from three better places of Bangalore and are classified into SC (clayey sand) from CV Raman Nagar, inorganic silt with sand (MI-SAND) is gathered from Uttarahalli, and silty sand(SM) from Nelmangala. The photographic perspective of soil tests are appeared in figure 3.

Figure 3: photographic view of soil samples

3.3. Samples Preparation and Analysis

In addition, the chose soil tests were investigated for different parameters. The parameter investigated incorporates level of sand, silt, gravel and clay from the sieve analysis, liquid limit, plasticity index, plastic limit separately. Subsequently in the segment the soil tests gathered in the field are filled and afterward the dry thickness of soil filled in the segments is kept up same as that of soil in the field. Under this condition in any case soil weight that can be filled in the segment was assessed by increasing volume of the segment and dry thickness of the soil field. The heaviness of the soil is computed by the substance in field water, which brought about measure of water to be included. The figured water sum was added to decide the soil weight and get ready soil glue. In segment the soil glue arranged was filled in four layers. While compact the space possessed by the soil will be one fourth of the volume of the soil. However conjunction with soil the adsorbents were put in the section and assessment was done by barring the profundity of the adsorbent filled in the segment. Beneath table demonstrates the geo-specialized properties of soils.

Table 1. Geo-Technical Properties of Soils Used For Experimentation

SI. No	Parameters	Values*		
		SC	MI with sand	SM-MH
1	Field density– Inplace density (gm/cc) Inplace dry density (gm/cc)	1.80 1.62	1.66 1.50	1.76 1.50
2	Field Moisture content (%)	11.33	10.65	17.26
3	Specific gravity (G)	2.60	2.59	2.65
4	Differential free swell (%)	15.4	12.1	17.6
5	Liquid limit (%)	37.5	36.4	53.9
6	Plastic limit (%)	21.7	NP	29.7
7	Plasticity index (%)	15.8	NP	24.2
8	Permeability (cm/sec)	12.3×10^{-5}	9.4×10^{-4}	11.9×10^{-5}
9	Direct shear test : - C (Kg/cm^2) Φ (Degree)	0.10 23.0	0.28 18.0	0.16 22.0
10	Compaction test (Light):- γ_{dmax} (gm/cc) O.M.C (%)	1.78 12.96	1.63 11.56	1.72 12.24

11	Sieve analysis :- % of Gravel % of Sand % of Silt & Clayey	 5.10 53.7 41.2	 5.50 40.9 53.6	 14.5 35.8 49.7
12	Hydrometer analysis: - % of Clayey % of Silt	 22.0 19.2	 1.4 52.2	 19.7 30.0

3.4. Simulated wastewater preparation

Mechanical wastewater containing heavy metals are gathered from various units and used as influent of the SAT framework. The overwhelming metals, for example, nickel, cadmium, zinc, copper, hexavalent chromium are created from the uses of electroplating and metal surface treatment process. The figure 4 (an) and (b) demonstrates the photographic perspective of wastewater nourishing game plan and emanating accumulation framework.

(a) (b)

Figure 4. Photographic view of wastewater (a) feeding arrangement and (b) effluent collection system

3.4.1. Heavy metals in industrial waste: By and large, the metal whose thickness surpasses 5g per cubic centimeter is considered as heavy metals. For different parameters the poisonous wastewaters gathered from the sources are dissected and are showed up in table 2.

Table 2. Characteristics of Wastewater Used For Experimentation

SI. No	Parameters	Contents in wastewaters stated*			
		Cr^{+6}	Nickel	Zinc	Copper
1	pH	7.32	6.5	6.32	7.2
2	Total solids, Mg/L	400	323	210	230
3	T.D.S, Mg/L	285	247	195	210
4	COD, Mg/L	160	240	150	180
5	Chlorides (as Cl), Mg/L	150	92	110	150
6	TKN, Mg/L	105	130	135	160
7	Phosphate(as P), Mg/L	6	6	6	6
8	Potassium,Mg/L	4	4	4	4
9	Hexavalent Chromium , Mg/L	4	ND	ND	ND
10	Zinc, Mg/L	ND	ND	7	ND
11	Nickel,Mg/L	ND	5	ND	ND
12	Copper, Mg/L	ND	ND	ND	5

*** Average values of two samples ND- Not Detected**

3.5. Conventional process for removal

The chemical precipitation, flotation, adsorption, ion exchange, and electrochemical deposition are traditional procedures for expelling heavy metals from wastewater. Adsorption is most generally used for heavy metal expulsion from inorganic emanating. In this experimentation three adsorbents; eucalyptus leaves, saw dust and citrus limetta are utilized which are the generally accessible materials from the surroundings of Bangalore.

3.5.1. Adsorption on Eucalyptus Leaves (Nilgiri leaves): The new leaves of eucalyptus were gathered and washed three times in refined water and afterward permitted to dry in the sun for 2 days as showed up in figure 5 (a). The leaves were grounded and sieved through 1mm. IS-work. The eucalyptus leaves were dealt with according to the system [27]. Around half of the zinc ions are expelled from the aggregate centralization of zinc by utilizing this experimentation.

Figure 5(a). photographic view of died eucalyptus leaves

3.5.2. Adsorption on Citrus Limetta (Mosambi peel): The system given by [28] is utilized to treat the Mosambi peel (citrus limetta). The organic product external peels is considered as waste item by the natural product juice offering shops were gathered, dried, slashed, cleaned and absorbed refined water for 24 hours. The drenched peels were dried in sun and after that controlled. In the experimentation the chose molecule measure is 0.6 mm which can be appeared in figure 5 (b).

Figure 5(b). Photographic view of cleaned citrus limetta

3.5.3. Adsorption on Saw Dust: A practical, open and viable sorbent is sawdust was dealt with according to the strategy given by [29]. It was sieved through IS mesh No. 50-60 and with refined water washed a few times. At that point it was treated with 0.1 M watery arrangement of disodium hydrogen phosphate for 24 hrs. Further, it was separated and washed a few times till no phosphate was discharged in washing. Once more, they were dried at in a broiler and utilized for experimentation. Figure 5 (c) demonstrates the sawdust. Table 3 illustrates the properties of physical and chemical with adsorbents that utilized in experimentation.

Figure 5(c). Photographic view of saw dust

Table 3. Physical-Chemical Properties of Adsorbents Used For Experimentation

Sl. No.	Parameter	Values*		
		Saw dust	Eucalyptus leaves	Mosambi peel(Citrus Limetta)
1	P^H	7.3	6.71	5.28
2	EC, (µs/sec)	0.102	0.34	0.23
3	T.D.S, Mg/L	0.123	0.087	0.092
4	Hexavalent Chromium (Cr^{+6}), Mg/L	0.0083	0.013	0.0079
5	Zinc, Mg/L	0.1973	0.004	0.0025
6	Nickel, Mg/L	AB	0.0029	0.003
7	Copper, Mg/L	AB	0.03	0.042

***AB**-Absent

3.6. Adsorption Equilibrium

In the purpose of optimizing the condition of an adsorption framework for metal ion take-up, the correlation establishment for equilibrium curves is critical. Under a given set of condition the maximum capacity of the adsorbent can be anticipated while the adsorption capacity is dependent only on the equilibrium curve established between the site adsorbed and concentrations of metal solution. In the investigation, the isotherm models for heavy metal adsorption are Langmuir model and the Freundlich model.

3.6.1. Langmuir isotherm Model: The model computes the amount of adsorbed molecules onto a solid surface and is frequently utilized to depict the solute adsorption. In this way, the equilibrium distributions of metal ions between the solid and liquid phases are represented by Langmuir isotherm [30]. This adsorption is legitimate just for monolayer adsorption onto a surface containing a limited number of identical sites. The model accepts on the surface the adsorption energies are uniform and no transmigration of adsorbate in the surface plane. The theoretical equation for equilibrium is expressed as:

$$q_e = \frac{K_L C_e}{1 + a_L C_e} \tag{1}$$

Where, q_e represents solid phase adsorbate equilibrium concentration (mmol/g), C_e represents aqueous phase adsorbate equilibrium concentration (mmol/L), K_L (L/g) and a_L (L/mmol) are the Langmuir isotherm constants. The monolayer capacity can be calculated from $q_{\max} = K_L / a_L$.

The linear form of the Langmuir model is described in equation (2).

$$\frac{C_e}{q_e} = \frac{1}{a_L q_{\max}} + \frac{1}{q_{\max}} C_e \quad (2)$$

Where $q_{\max}$: maximum adsorption capacity (mg/g)

The Langmuir parameters $q_{\max}$ and a_L values are calculated from the slope and intercept of the linear plot q_e versus C_e.

3.6.2. The Freundlich isotherm Model: The empirical equation is a freundlich equation proposed by Freundlich [31]. It is used to symbolize the organic components in solution and also assume the adsorption sites are not identical. It is commonly applied in heterogeneous surfaces and multilayer adsorption on the adsorbate. The equation is empirical and affirmed as:

$$q_e = K_F C_e^{\frac{1}{n}} \quad (3)$$

The linearized form of above equation is,

$$\log q_e = \log K_F + (1/n) \log C_e \quad (4)$$

Where, C_e is the equilibrium concentration in mg/l,

q_e is the amount of adsorbate adsorbed per unit weight of adsorbent in mg/g,

K_F Is a parameter related to the temperature,

1/n is a measure of intensity of adsorption.

Generally, it is stated that values of n in the range of 2 to 10 represent good adsorption, 1-2 will be moderately difficult and n<1 shows poor adsorption characteristics, therefore this model is only valid in a narrow range of concentrations.

4. Results and Discussion

This segment displays, the operation of adsorption isotherm and SAT system on the wastewater at three distinct soils of MI-sand (inorganic silt with sand), clayey sand (SC), silty sand (SM) moreover with three various adsorbents of eucalyptus leaves, sawdust and citrus limetta and consequences of analysis are conveyed under varied conditions and discussions are carted away.

4.1. Modeling of Adsorption Isotherm

The isotherm analysis in equilibrium data for heavy metals adsorption can be mathematically expressed as far as adsorption isotherm models. The adsorption equilibrium is depicted by utilizing the Langmuir and the Freundlich demonstrate. The main goal is to assess the most appropriate correlations for equilibrium curves and afterward optimize the design of a sorption system. The experiments were performed and the experimental data were attained by charting the measure of heavy metals adsorbed by sawdust, eucalyptus leaves and citrus limetta at equilibrium (q_e) versus the equilibrium concentration of heavy metals (C_e).

4.1.1. Performance of Freundlich Adsorption Isotherm: The impact of beginning metal concentration on copper, zinc, nickel and hexavalent chromium was considered by adsorption tests, which were carried out at specific temperature utilizing disparate metal ion concentration. From different units the waste water samples are gathered to elect the metal ion concentration. The Freundlich isotherm constants and their correlation coefficients (R^2) for various adsorbents with heavy metals are recorded in underneath table 4.

Table 4. Freundlich Isotherm for Adsorbent on Removal of Heavy metals

SI.No	Heavy metals	Adsorbent	Freundlich model		
			K_F (mg/g)	n (g/l)	R^2
1	Copper	Sawdust	3.629	3.940	0.9243
		Eucalyptus Leaves	2.814	3.670	0.9550
		Citrus Limetta	2.604	3.604	0.9534
2	Nickel	Sawdust	1.221	15.948	0.8782
		Eucalyptus Leaves	1.732	7.203	0.8990
		Citrus Limetta	1.873	7.513	0.9012
3	Zinc	Sawdust	1.139	15.848	0.8982
		Eucalyptus Leaves	1.632	7.102	0.9166
		Citrus Limetta	1.773	7.413	0.9038
4	Hexavalent Chromium	Sawdust	3.521	3.840	0.9221
		Eucalyptus Leaves	2.201	3.770	0.9351
		Citrus Limetta	2.302	3.504	0.9138

By utilizing the correlation coefficients and Freundlich isotherm constants the efficiency of sawdust, eucalyptus leaves and citrus limetta with heavy metals are plotted of q_e against C_e are delineated in figure. 6. The adsorption of copper and hexavalent chromium metals onto the distinctive adsorbents gave a bend for estimations of "n" between 2 (g/l) to 5 (g/l) which is exposed in fig. 6 (a) and 6 (d). In fig. 6 (b) and (c), it can be contemplated that the adsorption of nickel and zinc metals is performed for "n" values between 7 (g/l) and 16 (g/l). Therefore the concentrated material (sawdust, eucalyptus leaves and citrus limetta) indicates great adsorbent for heavy metals (n>2).

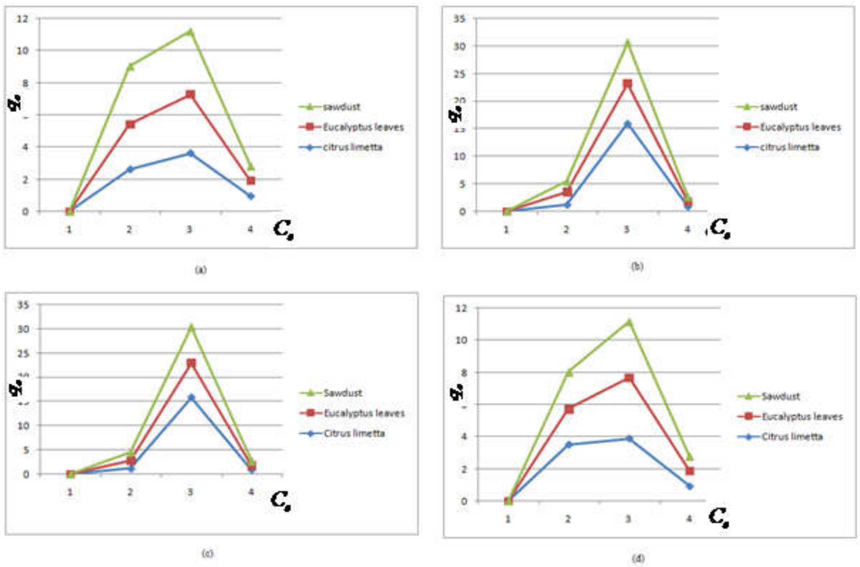

Figure 6. Freundlich plot of different adsorbents on removal of (a) Copper (b) Nickel (c) Zinc (d) Hexavalent Chromium

4.1.2. Performance of Langmuir Adsorption Isotherm: The performance of Langmuir constants identified with the sorption capacity and sorption energy respectively. On deportation of heavy metals like copper, nickel, zinc and hexavalent chromium alongside sawdust, eucalyptus leaves and citrus limetta as adsorbents; Langmuir isotherm constants and their correlation coefficients are listed in table 5. From the values in regression correlation coefficient that are regarded as a measure of the integrity of fit of experimental data on the isotherms model. Table 5 illustrates that the correlation coefficients (R^2) values are less than 0.999, which demonstrates a very good mathematical fit.

Table 5. Langmuir Isotherm for Adsorbent on Removal of Heavy metals

SI.No	Heavy metals	Adsorbent	Langmuir model		
			a_L (L/mmol)	$q_{\max}$	R^2
1	Copper	Sawdust	21.124	0.1825	0.9999
		Eucalyptus Leaves	6.123	1.223	0.9854
		Citrus Limetta	8.660	1.118	0.9778
2	Nickel	Sawdust	19.134	0.1835	0.9879
		Eucalyptus Leaves	5.071	1.233	0.9844
		Citrus Limetta	7.341	1.128	0.9788
3	Zinc	Sawdust	16.453	0.1806	0.9713
		Eucalyptus Leaves	3.968	0.3681	0.9850
		Citrus Limetta	5.432	1.3189	0.9668
4	Hexavalent Chromium	Sawdust	20.124	0.1815	0.9889
		Eucalyptus Leaves	5.123	1.213	0.9844
		Citrus Limetta	7.660	1.108	0.9768

By utilizing the correlation coefficients and Langmuir isotherm constants the efficiency of adsorbents with heavy metals is plotted of q_e against C_e are shown in figure. 7. The adsorption of copper in fig. 7 (a), nickel in fig. 7 (b), zinc metal in fig. 7 (c), and hexavalent chromium in fig. 7 (d) as heavy metals onto the distinctive adsorbents gave a curve. Unmistakably the linear fit is genuinely great and empowers the appropriateness of the Langmuir isotherm.

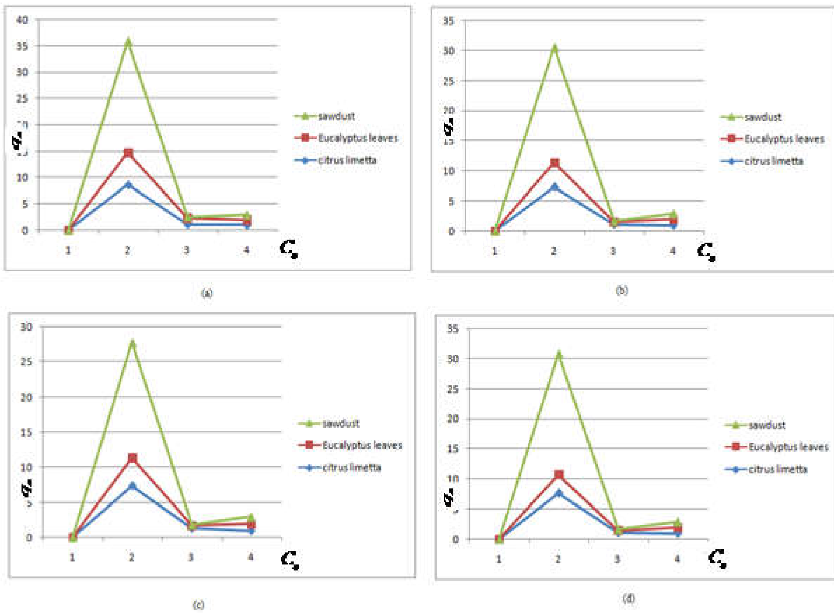

Figure 7: Langmuir plot of different adsorbents on removal of (a) Copper (b) Nickel (c) Zinc (d) Hexavalent Chromium

While correlating the Langmuir and Freundlich isotherm; it can be watched, that the experimental data of Langmuir model is fitted better. Subsequently the correlation coefficient esteems for the Langmuir isotherm model were higher than that of the Freundlich isotherm of heavy metals. Both results exhibit the maximum adsorption capacity in sawdust are utilized for deporting the heavy metals.

4.2. Performance of Soil Samples

The performance of SAT system on the distinctive soil samples with adsorbents is examined and resolved in the succeeding section.

4.2.1. Performance of the SAT System on MI-Sand with Adsorbents: To expel the heavy metals from the noxious wastewater the distinctive adsorbents for example, eucalyptus leaves, sawdust and Mosambi peel were performed with SAT system. Table 6 expos the comparative performance of different types of adsorbents on heavy metals adsorption. It is found that the MI-sand sample utilized in this study has comparable adsorption capacity. Thus, the introductory concentration of wastewater is dwindled after the treatment of SAT, and the removal efficiency is figured. The removal efficiency of copper for eucalyptus leaves as adsorbents is 97.32%, efficiency of nickel for sawdust as adsorbents is 84.92%, efficiency of zinc for eucalyptus leaves is 85.71% and the removal efficiency of hexavalent chromium for sawdust is 78.75% respectively.

Table 6. Performance of MI-Sand for the Removal of Heavy Metals with Adsorbents

MI-sand (inorganic silt with sand)					
SI.No	Adsorbents	Heavy metals			
		Removal Efficiency (%)			
		copper	nickel	zinc	Hexavalent chromium
1	Eucalyptus Leaves	97.32	64.4	85.71	50
2	Sawdust	94	84.92	69.57	78.75
3	Citrus Limetta	88.8	68	75.27	63.75

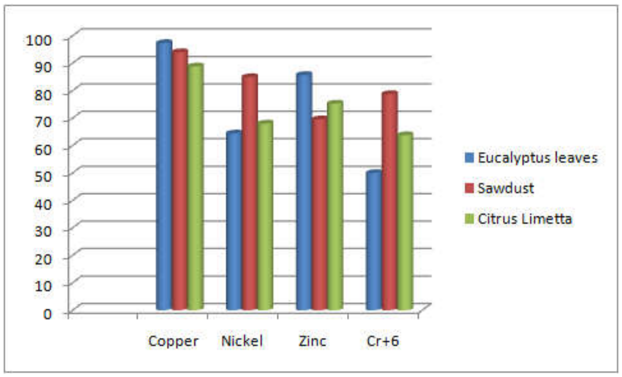

Figure 8. Removal efficiency of heavy metals with adsorbents in MI-Sand

Figure 8 affirms the efficiency correlation graph for various metals with respect to the three disparate adsorbents. It is plainly noted from the figure, that the removal efficiency for the adsorption of copper metal by adsorbents is higher in MI-sand soil (inorganic silt with sand) when contrasted with other heavy metals.

4.2.2. Performance of the SAT System on Silty Sand with Adsorbents: The removal efficiency of copper, nickel, zinc and hexavalent chromium by the investigated sorbents were determined and their results are depicted in table 7. The removal efficiency of copper 98.2% and nickel 80.92% in silty sand with adsorbent (sawdust) is illustrated in beneath table.

Table 7. Performance of Silty Sand for the Removal of Heavy Metals with Adsorbents

Silty sand (SM)					
SI.No	Adsorbents	Heavy metals			
		Removal Efficiency (%)			
		copper	nickel	zinc	Hexavalent chromium
1	Eucalyptus Leaves	96.2	66.80	81.45	68.75
2	Sawdust	98.2	80.92	71.421	74.75
3	Citrus Limetta	94	72	88.57	85

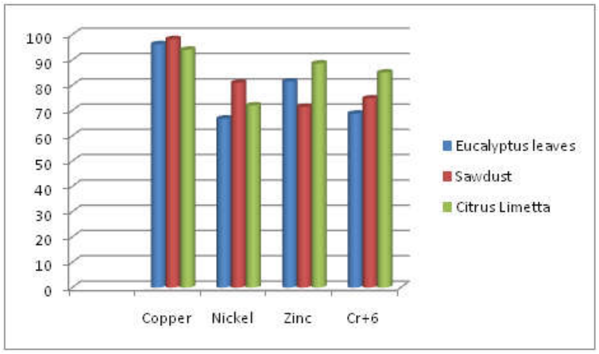

Figure 9. Removal efficiency of heavy metals with adsorbents in silty sand

The percentage removed of copper, nickel, zinc and hexavalent chromium from wastewater by various adsorbents is showed in figure 9. From the figure and table 7 the removal efficiency in silty sand of zinc 88.57% and hexavalent chromium 85% with adsorbent (citrus limetta) is designed.

4.2.3. Performance of the SAT System on Clayey Sand with Adsorbents: The clayey sand is utilized to expel the parameters such as TDS, TS, Chloride, COD, and TKN, potassium, phosphate, copper, nickel, zinc and hexavalent chromium which are available in noxious wastewater. The table 8 demonstrates the execution of clayey sand with adsorbents (eucalyptus leaves, sawdust and citrus limetta) for the expulsion of heavy metals. From the table, it can be seen that the removal efficiency of copper with adsorbents of eucalyptus leaves, sawdust and citrus limetta to be 80%, 98.2%, 63% separately.

Table 8. Performance of Clayey Sand for the Removal of Heavy Metals with Adsorbents

Clayey sand (SC)					
SI.No	Adsorbents	Heavy metals			
		Removal Efficiency (%)			
		copper	nickel	zinc	Hexavalent chromium
1	Eucalyptus Leaves	80	74	71.42	72.75
2	Sawdust	98.20	87	95	92.5
3	Citrus Limetta	63	80.8	94.28	80

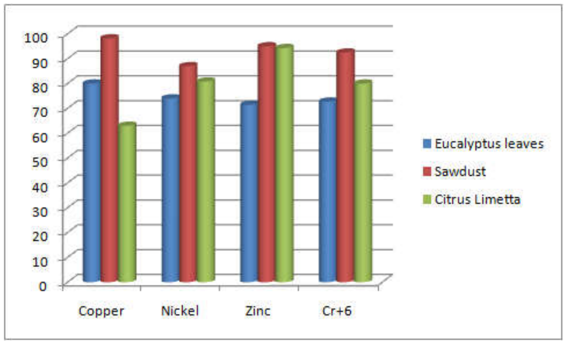

Figure 10. Removal efficiency of heavy metals with adsorbents in clayey sand

Figure 10 illustrates the execution of clayey sand with adsorbents. The removal efficiency of zinc with adsorbents was observed to be eucalyptus leaves of 71.42%, sawdust of 95% and citrus limetta of 94.28% respectively. Similarly, the chart is drawn for removal efficiency of nickel, copper and hexavalent chromium with adsorbents in clayey sand. The expulsion efficiency of all metals in noxious wastewater was recorded without great difference with practical limitation. From this, it is clear that the removal efficiency of clayey sand (SC) soil is better when contrasted to the silty sand and MI-sand soil.

5. Conclusion

Low-cost sawdust is an effective adsorbent for the removal of heavy metals from aqueous solution. The batch method was employed for parameters and metal concentration was studied. The removal efficiency increases with the increase of adsorbent dose, while the adsorption capacity decreases with increasing of adsorbent dose. The adsorbents are tested on SAT system of different soil samples (MI-sand, silty sand and clayey sand) to find the removal efficiency. Langmuir and Freundlich isotherms are used to find the maximum adsorption capacity of the adsorbents for removing the heavy metals. The adsorption isotherms are support the mechanism and favor the order of removal. The Langmuir isotherm better fitted the experimental data since the correlation coefficient for the Langmuir isotherm was higher than that of the Freundlich isotherm for metals. Also, the sawdust with clayey sand (SC) removes the heavy metals and the removal efficiency was copper of 98.20%, nickel of 87%, zinc of 95% and Hexavalent chromium of 92.5% when compared with other adsorbents.

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