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Comparative study of adsorption characteristics of coag-flocculation performances of bio-coagulants in mechanic village seeped water medium

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Abstract

Comparative study of the adsorptive potentials of *Moringa oleifera* seed coagulant (MOSC) and *Carica papaya* leaf coagulant(CPLC) in the coag-flocculation treatment of Mechanic village seep water (MVSW) for both water portability and disposal purposes was undertaken. The coagulants were prepared accordingly and proximate compositions determined. Effluent was characterized according to AOAC (1990). Jar test procedure was used in coag-flocculation experiments and efficiencies of reactions calculated. Five adsorption isotherms were used to test the fitness of the experimental data. Results showed that turbidity, colour, total suspended solid (TSS), total dissolved solid (TDS), manganese (Mn), iron (Fe), chemical oxygen demand (COD), total solid (TS) and bio-oxygen demand (BOD) before treatment were above standards for both coagulants. After treatment, the values were within, with little exceptions. The fitness results showed remarkable differences for the various isotherms in both MOSC- and CPLC treated MVSW. Conclusively both coagulants were effective adsorbates but MOSC was more effective than CPLC. The MOSC-treated water met the portable water requirement by WHO in all the parameters except very slight differences in the values of lead (Pb) and cadmium (Cd) while CPLC-treated did not in BOD, COD, TDS, Fe, Pb and Cd. For FEPA water disposal standard, both systems met the requirements in all the parameters except colour. MOSC and CPLC-treated waters can be reasonably applied for disposal purpose while MOSC-treated could be considered for portability.

Key word: Adsorbate, Adsorbent, Adsorption isotherm, Bio-coagulant and Comparative study.

1 Introduction

Adsorption is a separation process where molecules tend to concentrate on the surface of the adsorbent as a result of Vander walls force which exists between the molecules. Liquid phase adsorption is where the molecules move from the bulk phase to the pores of the adsorbent in a semi-liquid state. The driving force here is the ratio of the concentration to the solubility of the compound (Ujile, 2014). The migration of pollutant(s) in aqueous media and subsequent development of containment measures have resulted in the use of adsorption among other techniques (Shooto et al., 2016). The adsorbability of a compound increases with: increasing molecular weight, a higher number of functional groups such as double bonds or halogen compounds (Ujile, 2014). It is applied in wastewater reuse. The adsorption capacity is affected by initial concentration of adsorbate, temperature and pH of the adsorption as well as the surface groups and surface area of adsorbents.

In the industrial processes, up-to 70%-85% of the initial raw material is transferred into solid wastes, it is necessary to know their water sorption system properties, because physical, chemical and biological changes which occur during their storage depend on water-solid interactions (Hasley, 1948). Adsorption isotherms are therefore the basic requirements for the design of adsorption systems. The purpose of the adsorption isotherms is to relate the adsorbate

concentration in the bulk and the adsorbed amount in the interface (Helmenstine, 2020). A proper understanding and interpretation of adsorption isotherms is critical for the overall improvement of adsorption mechanism pathways and effective design of adsorption system (Gopinathan et al.,2019). The significance is that they are essential for the description of how pollutant's concentration will interact with adsorbent surfaces and are useful to optimize the use of adsorbents for the removal of pollutants from aqueous solution.

The following adsorption isotherms are of interest in this study. The Langmuir Isotherm which is based on the assumption that there exists fixed individual sites on the surface of the adsorbent and that each of these sites is capable of adsorbing one molecule, culminating in a monolayer over the adsorbent surface, the thickness of which is the size of one molecule (Langmuir, 1918). The Freundlich model is based on sorption on a heterogeneous surface of varied affinities (Obiora-Okafo et al., 2014). Temkin adsorption isotherm assumes that heat of adsorption (function of temperature) of all molecules in the layer would decrease linearly rather than logarithmic with coverage. It contains a factor that explicitly takes into the account of adsorbent-adsorbate interactions (Dada et at.,2012). Henry model is the simplest adsorption isotherm in that the amount of the surface adsorbate is represented to be proportional to the concentration of the adsorptive solution. It is typically taken as valid for low surface coverage, and the adsorption energy is valid for low surface coverage (lack of inhomogeneities on the surface) Singh and Helman (2009). Finally, is the Hasley model which provides an expression for the concentration of multilayers at a relatively large distance from the surface, assuming that the potential energy of a molecule varies as the inverse nth power of its distance from the surface (Hasley, 1948).

Coagulation/flocculation is widely applied as a precursor to the disinfection stage in effluent predisposal treatment, as well as in general water treatment practice (Anagwu, et al., 2019). In this treatment reaction, coagulants neutralize the repulsive electrical charges (typically negative) surrounding particles allowing them to "stick together" creating flocs. Flocculants facilitate the agglomeration of the coagulated particles to form larger floccules and thereby hasten gravitational settling (Borchate et al., 2014). Four mechanisms are adopted in the execution of coag-flocculation: double-layer compression, adsorption and charge neutralization, enmeshment by a precipitate (sweep-floccoagulation) and inter-particle bridging (Anagwu et al., 2019). This study focuses on the adsorption as a critical aspect of the coagulation.

Bio-coagulants have emerged to be promising alternative materials to replace conventional chemical ones. Compared with the chemical types, they are safe and biodegradable polymers, fairly shear stable, easily available from reproducible agricultural resources and produce no known secondary pollution (Mohd Faiz Muaz et al., 2014). Additionally, the resulting sludge from such treatments is efficiently degraded by microorganism (Ugonabo et al.,2016). In wastewater, they aggregate dissolved contaminants and tiny particles into larger ones so that filteration, clarification, or any other solid removal process may be used to remove them. Also when in solution, they furnish ionic charges opposite to those of the colloidal turbid particles in water and thus neutralize the repelling charges (Chong, 2012). They are natural and a-times constitute waste materials. They initiate or aid an aggregating process during water and wastewater treatments.

Moringa oleifera seeds(MOS) are used as organic natural polymer containing polypeptides with cationic polyelectrolyte properties good for softening hard water by adsorption (Shahzad et al., 2014). They are excellent sources of protein but poor in carbohydrates and fats Komalafe and Aiyeleye (2017). The tree is fast growing and not very demanding as to climate and soil quality. The drum stick tree referred to as the "miracle tree" and known as "Zogale" in TV (Sengeve et al., 2013) is common throughout West African region. It is believed to be native of sub-Himalayan tracts of Northern India but it is now found worldwide in the tropics and sub-tropics.

Carica papaya leaf(CPL) is composed of lignin and cellulose as major constituents and may also contain other polar functional groups of lignin which includes alcohol, aldehydes, ketones, carboxylic, phenolic and other groups. These groups have the ability to some extent to bind heavy metals ions by donation of an electron pair from these groups to form complexes with the metal ions in solutions. The leaves are large, 50-70cm in diameter, deeply palmatedly lobed, with seven lobes (Name papaya,2018). The tree is small, sparsely branched tree, usually with a single stem growing from 5cm-10m tall, with spirally arranged leaves confined to the top of the trunk.

Mechanic village seeped water(MVSW) is usually the ground water reaching the earth's surface through the pores of the soil from underground aquifer (Seeping, 2021). Mechanic village concept has been described as a twenty first century strategy to improve upon environment quality in developing countries. The village represents several acres of land mapped out for automobile mechanics, where automobile owners must go for repairs and services of their motor vehicles (Nwachukwu et al., 2010). If the villages are well planned and built with collection and recycling of spent oil, and proper disposal of spent electrolytes, environment quality will improve.

This study therefore sets out to compare the adsorption characteristics of coagulation flocculation performances of *Moringa oleifera*seeds and *carica papaya* leaf bio-coagulants in mechanic village seeped water medium.

2.0 Materials and methods

2.1 *Carica Papaya*Leaf Coagulant (CPLC).

Green leaves of *Carica papaya*were collected from various farmlands in Owerri West Local Government Area of Imo State. The leaves were washed with water 2-3 times to remove dusts and water soluble impurities. They were then sun-dried until they became crisp. The dried leaves were powdered and washed two times with distilled water so that the washings were free of colour and turbidity. The resulting powder was dried and sieved to 0.144-0.145 micron different fractions usingWS Tyler RX-29 8''rotap sieve shaker. The size fractions were preserved in airtight container for use as a coagulant (adsorbent).

2.2 *Moringa oleifera*Seed Coagulant (MOSC)

The seeds of *Moringa oleifera*were collected from Ikoti Idom in Akwa Ibom State. The seeds were given washing with distilled water to remove impurities and dried at 65^0C for 24hrs. The seeds shells were removed and kernels ground to fine powder using a FOL-5 semi-automatic blender. The powder was sieved using 600micron stainless sieve and then put into cheese cloth sack till further use (Sharma et al., 2006).

2.3 Effluent collection

The mechanic village seeped water was collected from a shallow well within the vicinity of Nekede mechanic village along Aba Road Owerri. The shallow well water comprises of rain and surface water which seeped (infiltrate) into the well. Nekede mechanic village is located in Owerri West Local Government area in Imo State of South Eastern Nigeria.

2.4 Characterization of Effluent

This was done to ascertain the contaminants levels of the effluent. The physiochemical characterization of the effluent was carried out before and after treatment. The waste water samples were collected using sterilized polyethylene Gerry-cans. That for heavy metal analysis was preserved by acidifying with conc.H_2N0_3 (at 0.20ml/100ml effluent). This is intended to forestall the adsorption of elements on the container wall. The other samples were preserved with ice-block bearing cooler to forestall degradation at 3^0C prior to analysis Afuye and Mogaji (2015). They were then subjected to characterization for some major pollution causative factors using standard methods according to (APHA-AWWA-WEF, 2005).

2.5 Proximate composition of *Moringa oleifera* seed and *Carica papaya* leaf coagulants.

This was done mainly to establish that the coagulants have sufficient protein for the process coagulation. This was done using the standard methods of (AOAC,1990).

2.6 Coag-flocculation Experiment

Experiments were conducted using conventional jar test apparatus. Appropriate dosage of the coagulants in the range 100-400mg/l was added directly to 200ml of MVSW. The suspension, turned to pH range 2-10 by application of H_2S0_4/Na0H was subjected to 2 minutes of rapid mixing (40rpm), 20minutes of slow mixing (20rpm) and followed by 30minutes of settling (Obiora-Okafo et. al.,2020). During settling, samples were

withdrawn from 2cm dept at settling time intervals of5, 10,15,20,25,30,35,40,45 and 50minutes. The efficiency of the coag-flocculation process was calculated using the equation:

Contaminant removal (%) $=\frac{C_r - C_t}{C_r}$ x 100 (1)

Where C_r(mg/l)= contaminant concentration in raw water, C_t(mg/l) = contaminant concentration in treated water.

2.7 Adsorption Studies

Five adsorption isotherms were used to test the fitness of the experimental data. The significance is that the isotherms describe how pollutants' concentrations interact with adsorbent surfaces and are useful to optimize the use of adsorbents for the removal of pollutants from aqueous solutions Emmanuel and Rao (2008).

2.7.1 Langmuir Isotherm Testing:

The linearized Langmuir equation is given as: $\frac{C_i}{q}=\frac{I}{q_\infty \ Kg}+\frac{C_1}{q_\infty}$ (2)

Where C_1 (mg/L) is the equilibrium concentration of the adsorbate, q(mg/l) is the amount of adsorbate adsorbed per unit mass of adsorbent. q∝(mg/g) and Kg (^{L}/mg) are Langmuir constants which are related to adsorption capacity and rate of adsorption, respectively.

A plot of C_1/q against C_1 will yield $\frac{1}{q_\infty}$ as slope and $\frac{I}{q_\infty \ Kg}$ as intercept.

A dimensionless separation factor, R_L is used to further describe the adsorption process given by Obiora – Okafo et al., (2014)

$$R_L = \frac{1}{1+Kg\ C_o} \quad (3)$$

Where C_o (mg/l) is the initial concentration of the adsorbent. The favourability of the adsorption process could be affirmed from R_L of the Langmuir isotherm.

If R_L> I, adsorption process is unfavourable.

If R_L = 1, it is linear.

If 0<R_L<I, adsorption is favourable.

and if R_L = 0, process is irreversible.

2.7.2Freundlich Isotherm

The linearized form is: $\log q_\infty = \log K_f + \frac{1}{n}\log C_1$ (4)

where K_F(mg/g $((\frac{L}{mg})^{1/n})$ is a Freundlich equation constant that indicates the adsorption capacity of the adsorbent (Obiora-Okafo et al., 2014). n is also a Freundlich equation constant that represents the parameter characterizing Quasi-Gaussian energetic heterogeneity of the adsorption surface. In general, n>I suggest that adsorbate is favourably adsorbed on the adsorbent. The higher then value the stronger the adsorption intensity (Obiora-Okafo et al., 2014). A plot of log q against log C_1will give a slope = 1/n and intercept of log K_F.

2.7.3 Temkin Model

The linear form is: $q = \frac{2.303RT}{b_T}\log A + \frac{2.303RT}{b_T}\log C_1$ (5)

Where $^{RT}/_{b_{T=B}}$ (J/mol), which is the Temkin constant related to the heat of sorption, whereas A ($^l/_g$) is the equilibrium binding constant corresponding to the maximum binding energy (Obiora-Okafo et al., 2014). R (8.314) (j/mol.K) is the universal gas constant and T (K) is the absolute temperature of the solution.

A plot of q versus log C_1will give slope $=\frac{2.303RT}{b_T}$ while the intercept is $=\frac{2.303RT}{b_T}\log A$.

2.7.4 Henry's Isotherm

It is expressed as: q = KC_1 (6)

Where K is the Henry constant (moles/cm^3.atm.) Singh and Heldman (2009).

A plot of q against C_1 gives slope = K.

2.7.5 Hasley Isotherm

The form is: q = $\frac{1}{n_H} lnK_H - \frac{1}{n_H} lnC_1$ (7)

Where K_H is the Hasley dimensionless constant representing adsorption tendency. n_H is the exponent based upon the decay of surface forces with distance.

A plot of q versus lnC_1 gives slope = $\frac{1}{n_H}$ andIntercept = $\frac{1}{n_H} lnK_H$

3.0 Results and discussion

3.1 Proximate compositions of *Carica Papaya* leaf and *Moringa Oleifera* Seed coagulants

This was done mainly to establish that the coagulants have sufficient proteins for the process coagulation. The compositions are shown in table 3.1 for MOSC and CPLC

Table 1: Result of the proximate composition of MOS and CPL coagulants

	Moisture (%)	Ash (%)	Crude protein (%)	Crude fat (%)	Crude fibre (%)	Carbohydrate (%)	Dry matter %
MOSC	6.72 ± 0.26	3.26 ± 0.16	33.25± 0.21	32.24 ± 0.20	8.40 ± 0.31	16.13± 0.08	93.28±0.26
CPLC	13.02±0.09	10.69±0.27	12.23±0.12	3.15±0.09	1.70 ± 0.46	59.21± 0.11	86.98±0.34

Note: These values are the means of triplicate determinations. Moisture content + dry matter = 100%

Effluent

Crude protein + fat + ash + fibre + carbohydrate = dry matter.

'Table 3.1' contains the results of the proximate compositions of *Moringa oleifera* seed (MOS) and *Carica papaya* leave (CPL) coagulants. The results show that MOS has more protein content than the CPL. Protein content is responsible for the coag-flocculation characteristics of organic materials (Muhammad et al., 2015). Both MOS and CPL have been established to be efficient in waste water treatment (Nwofia, et al., 2012).

From the above reports, it can therefore be informed that the higher the protein content, the higher the coag-flocculation characteristics through adsorption. From the foregoing, it indicates that the MOS and CPL are good adsorbates for waste water treatment.

3.2 Characterization of Effluent.

This was done to ascertain the contaminants levels of the effluent. The results of physiochemical characterization of the effluent before and after treatment are shown in 'table 3.2'. The results indicate that turbidity, TDS, TSS, TS, Mn, Fe, COD, colour and BOD are the factors of interest. They were reduced by adsorptive coag-flocculation at 37^{0}C temperature to permissible level as shown in the table.

Table 3.2: Result of physiochemical characteristics of the mechanic village seeped water before and after treatment using MOSC & CPLC in comparison with WHO & FEPA

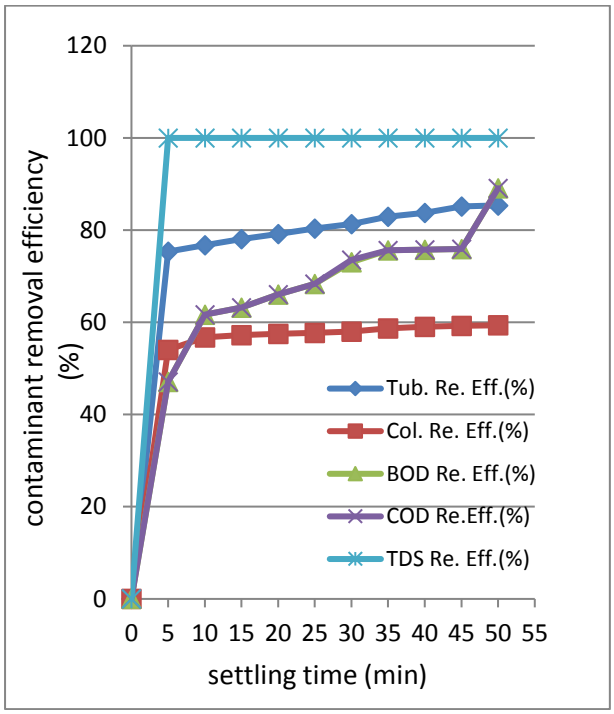
S/N	Parameter	WHO (2006, 2011)	FEPA (Ekanem et al., 2016)	Before Treatment	After Treatment with MOC	After Treatment with CPLC
1.	Temperature (^{0}C)	25.0	< 40	30.1	37.0	37.0
2.	Ph	6.5-8.5	6-9	7.3	7.5	7.5
3	Conductivity ($_{US}$/cm)	8-10,000	1000	4322.86	132.0	193.50
4	Turbidity (NTU)	<5.0	6.8	8.20	0.52	0.98
5	Colour (CPU)	≤15	7.0	31.10	10.36	12.43
6	BOD (mg/l)	5	30	39.60	3.41	9.36
7	COD(mg/l)	10	80	85.14	6.56	26.66
8	SO_4^{2-}(mg/l)	<500	500	0.111	0.013	0.021
9	PO_4^{3-}(mg/l)	6.5	5.0	0.128	0.031	0.084
10	NO^-_3(mg/l)	50	20	1.281	0.077	0.142
11	TS (mg/l)	500	250	2857.13	11.76	22.73
12	TDS (mg/l)	300	2000	2809.86	176.40	439.93
13	TSS (mg/l)	30	30	47.27	11.75	22.43
14	C_u (mg/l)	2	1.5	0.512	0.058	0.17
15	M_n (mg/l)	0.4	0.2	0.697	0.088	0.23
16	C_r (mg/l)	0.05(P)	0.05	0.0321	0.0039	0.0095
17	Z_n (mg/l)	≤ 3.0	≤1.0	0.351	0.041	0.11
18	Fe (mg/l)	0.3	20	1.077	0.095	0.37
19	Ni(mg/l)	0.07	0-2	0.0115	0.0010	0.0039
20	Pb	0.01(A,T)	<1	0.804	0.083	0.26
21	Cd	0.003	0.01	0.0394	0.0048	0.013

Note A: *provisional guideline value because calculated guideline value is below the achievable quantification level; P: Provisional guideline value because calculated guideline value is below the level that can be achieved through practical treatment methods, source protection, etc.*

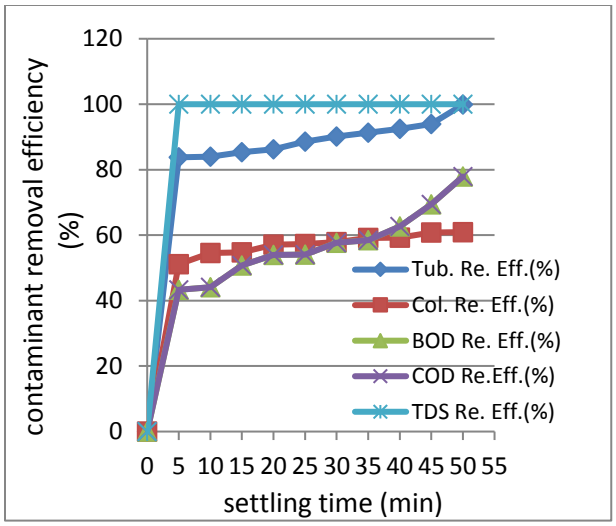
3.3 Coagulation/Flocculation Efficiency Studies

From the physiochemical result (Table 3.2), it indicates that the factors of interest: turbidity, colour TS, TDS, TSS, Mn, Fe, COD and BOD values before treatment are clearly above the WHO and FEPA standards for portable water and water disposal purposes respectively, thus indicating their pollution tendencies and need of treatment to combat the consequences of pollution. After treatment, values of turbidity, colour TS, TDS, TSS, COD, Mn, Fe and BOD are 0.52NTU, 10.36CPU, 11.76mg/l, 176.40, 11.75, 6.56, 0.088, 0.095 and 3.41 respectively for MOSC-treatment MVSW and 0.98NTU, 12.43NTU, 22.73mg/l, 439.93, 22.43, 26.66, 0.23, 0.37 and 9.36 for CPLC-treated MVSW. For the MOSC-treated, the values are within the acceptable range of values by WHO for potable water in all the

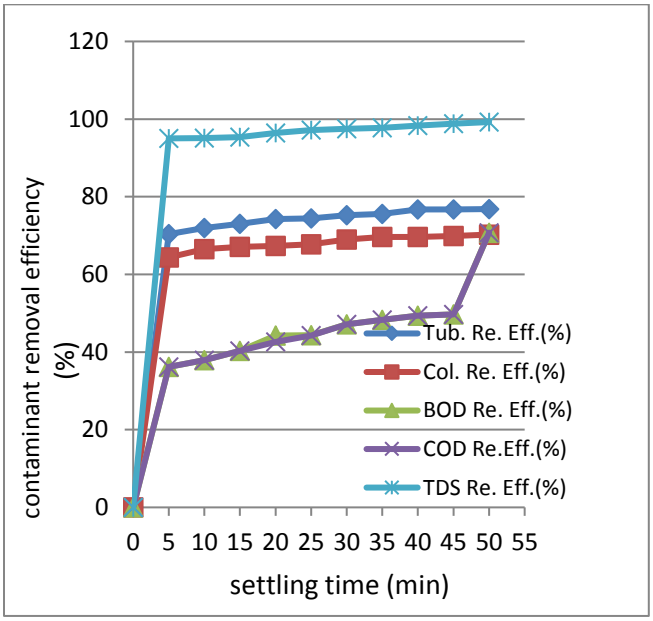
pollutants except slight differences in the values of Pb and Cd, while CPLC-treated did not meet in BOD, COD, TDS, Fe, Pb and Cr. For the FEPA standard for water disposal purpose, both systems met the requirement in all the pollutants except in colour. The removal efficiencies for these contaminants are 93.66, 66.69, 99.59, 93.72, 75.14, 92.30, 87.37, 91.18 and 91.39% for turbidity, colour TS, TDS, TSS, COD, Mn, Fe and BOD respectively in the MOSC-treated MVSW (some of which are illustrated in figures 3.1 – 3.3) while they are 88.05, 60.03, 99.20, 84.34, 52.55, 68.69, 67.00, 65.65 and 76.36% respectively in the CPLC-treated (Figures 3.4 – 3.6). This implies that the adsorption process in the MOSC-treated is higher than in the CPLC-treated system. This is as a result of the protein contents of the coagulants which has been reportedto be responsible for the coagulation/flocculation characteristics of organic materials (Muhammad et al., 2015) and (Nwofia et al., 2012).



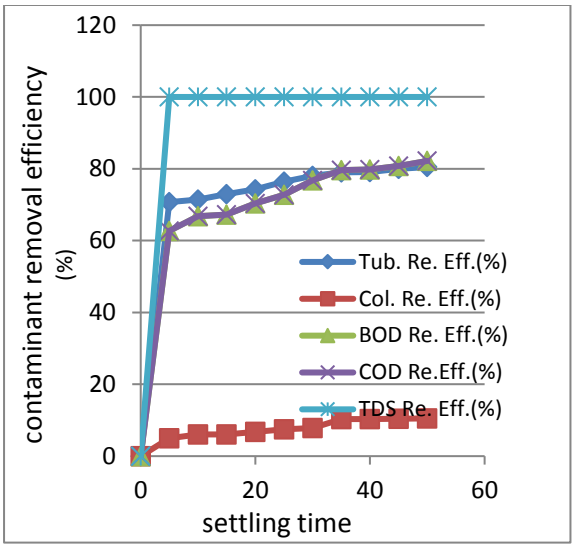
'Figure 3.1': Contaminants removal efficiency vs settling time at pH of 6.0, for MOC dose of 300mg/l and temperature of 30ºC for WVSW



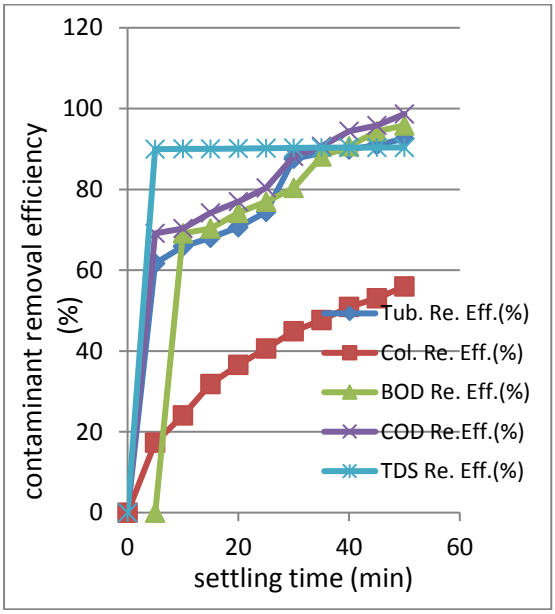
'Figure 3.2:' Contaminants removal efficiency vs settling time at pH of 80.0, for MOC dose of 400mg/l and temperature of 30°C for MVSW



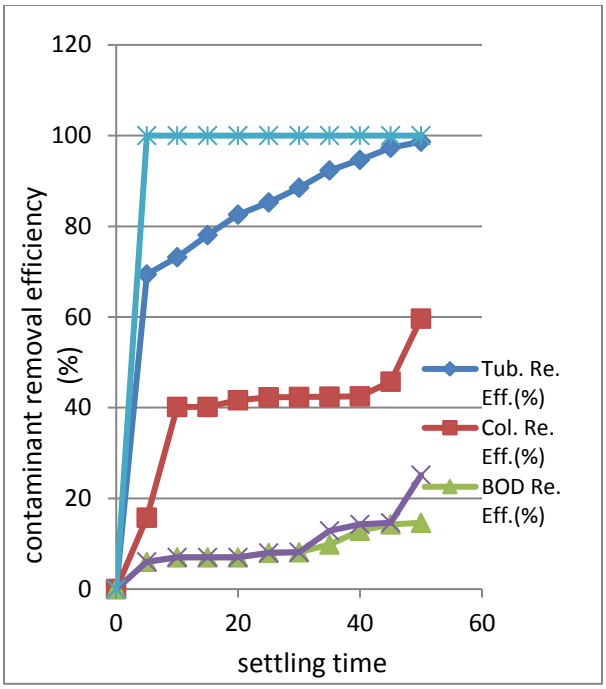
'Figure 3.3:' Contaminants removal efficiency vs settling time at pH of 10.0, for MOC dose of 300mg/l and temperature of 40°C for MVSW



'Fig 3.4:' Contaminant against time at pH of 4.0., paw-paw leave dose of 400mg/l and temperature of 30^{0}C for MVSW



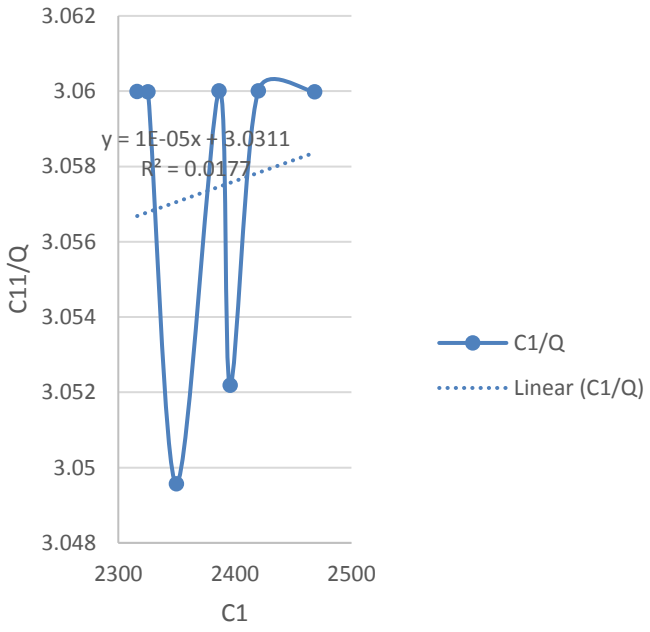
'**Fig 3.5:' Contaminant against time at pH of 6.0, paw-paw leave dose of 400mg/l and temperature of 30^{0}C for MVSW**



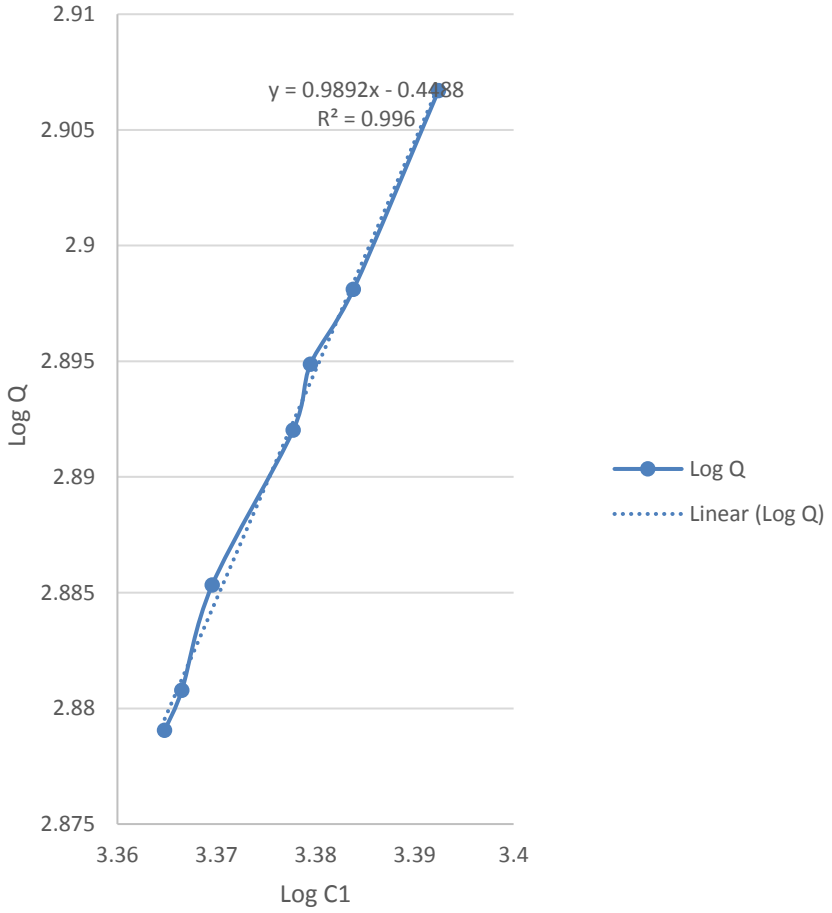
'Fig 3.6:' Contaminant against time at pH of 10.0, paw-paw leave dose of 200mg/l and temperature of 30^{0}C for MVSW

3.4 Adsorption Studies

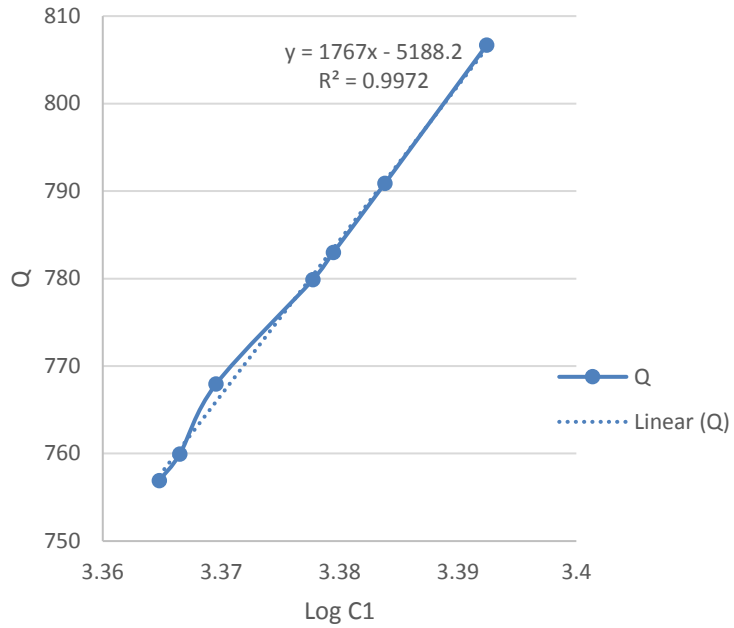
Five adsorption isotherms –Langmuir, Freundlick, Temkin, Henry and Hasley isotherms were tested in this study to exploy the fitness of the experimental data



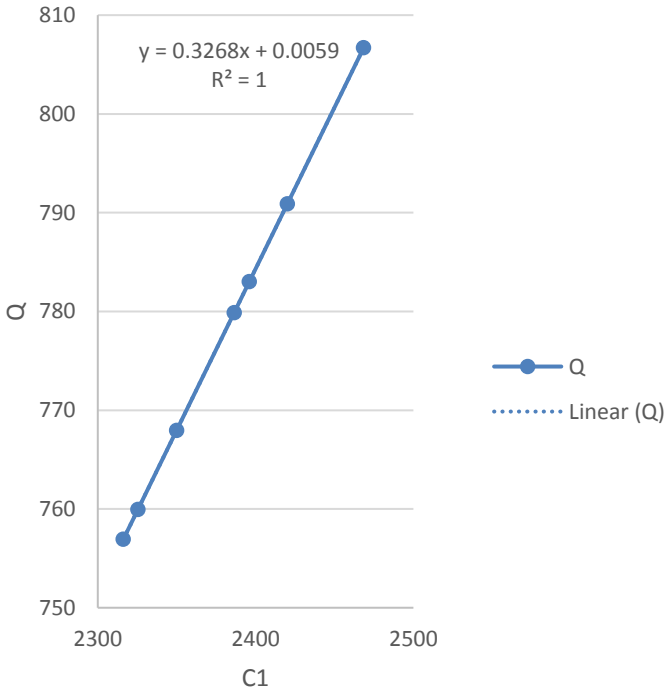
'Fig 3.7' Langmuir isotherm for MOC-treated MVSW



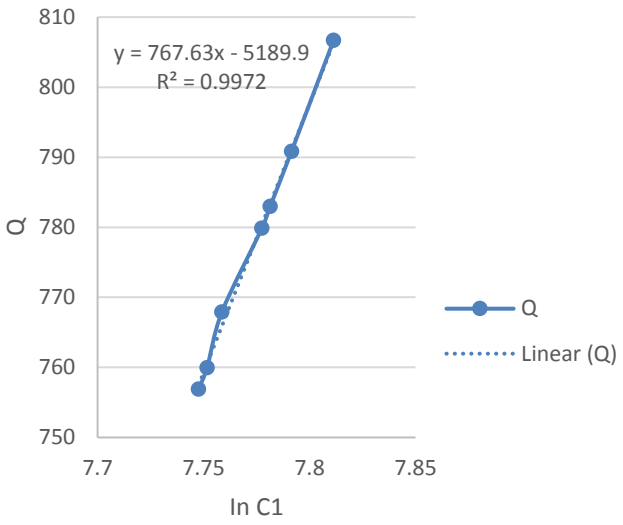
'Fig 3.8' Freundlich isotherm for MOC-treated MVSW



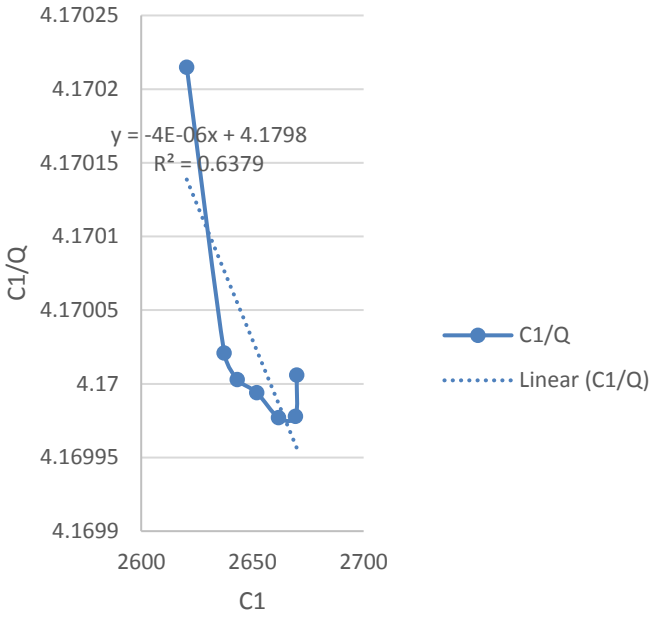
'Fig 3.9' Temkin isotherm for MOC-treated MVSW



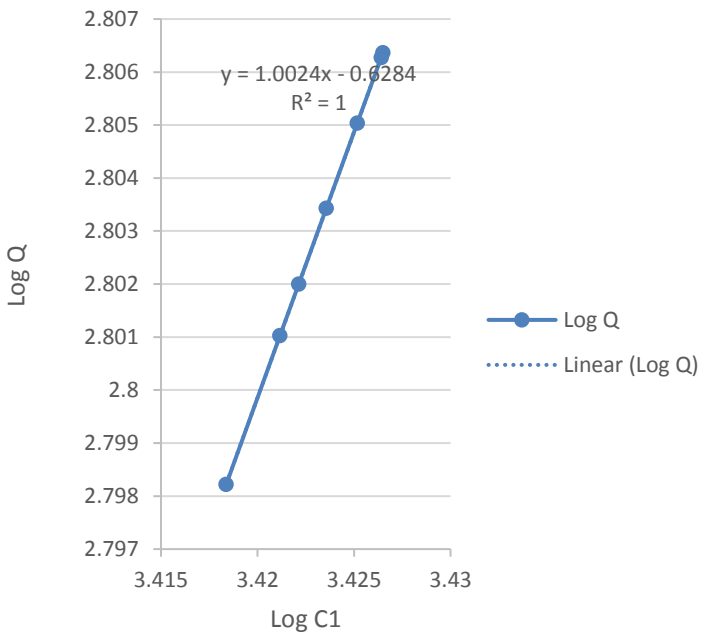
'Fig 3.10' Henry isotherm for MOSC-treated MVSW



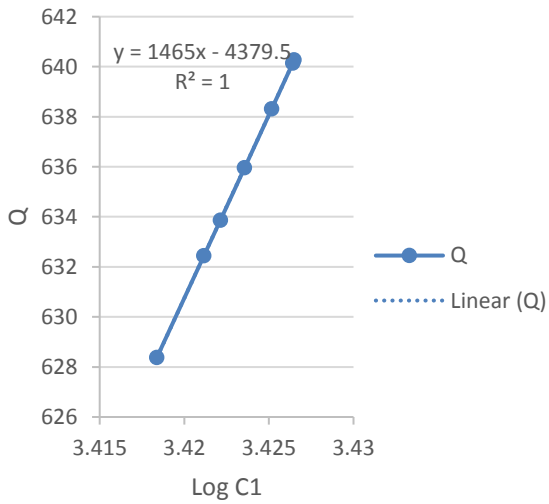
'Fig 3.11' Hasley isotherm for MOSC-treated MVSW



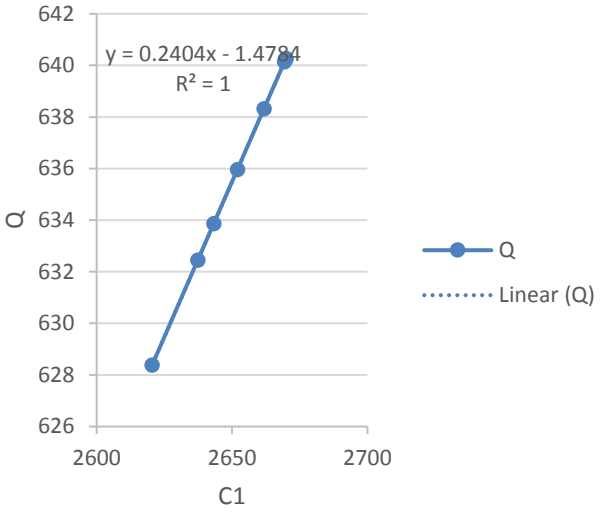
'Fig 3.12' Langmuir isotherm for PPLC- treated MVSW



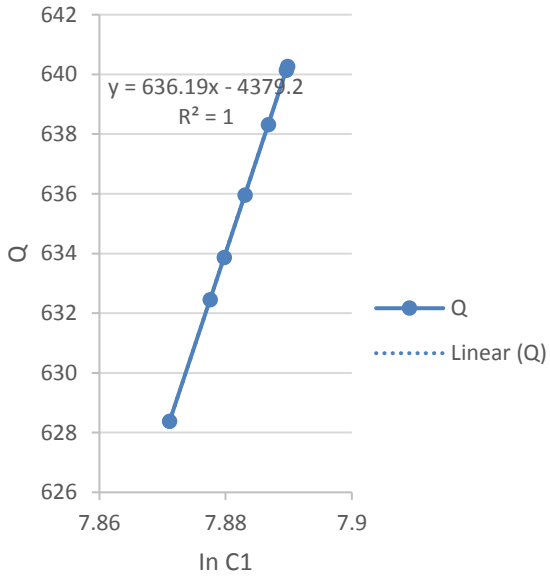
'Fig 3.13' Freundlich isotherm for PPLC - treated MVSW



'Fig 3.14' Temkin isotherm for PPLC- treated MVSW



'Fig 3.15' Henry isotherm for PPLC- treated MVSW



'Fig 3.16' Hasley isotherm forPPLC - treated MVSW

Table 3.3 Result of the adsorption kinetic parameters for adsorption of MOSC and CPLC onto colloidal particles

	Langmuir isotherm				Freundlch isotherm			Temkin isotherm				Henry isotherm		Hasley		
	$q\infty$	K_g	R_L	R^2	K_F	n	R^2	A	B	b_T	R^2	K	R^2	K_H	n_H	R^2
MOSC	1.64	0.20	0.0018	0.017	0.80	1.01	0.996	1.08	767.45	3.25	0.997	0.326	1	850.39	0.001 3	0.997
CPLC	0.55	0.59	0.0006	0.7745	0.72	1.0	1	0.89	245.	0 10.8	1	0.324	1	284	0.004 1	1

'Table 3.3' contains the results of the adsorption Kinetic parameters for adsorption of MOS and CPL coagulants onto colloidal particles. These results are depicted in figures 3.7-3.16. From the result, the Langmuir adsorption constants q^{∞} and Kg, separation factor R_L, and coefficient of determination R^2 for MOSC-treated MVSW are respectively 1.64mg/g, 0.20l/mg, 0.0018, and 0.017. Similarly, those of CPLC-treated MVSW are 0.55mg/g, 0.59l/mg, 0.00060 and 0.7745 respectively. Langmuir constant q^{∞} is related to the adsorption capacity of the adsorbent. From the result and following the definition of $q\infty$, it implies that the adsorption capacity of MOSC is higher than that of CPLC.

This is probably due to the differences in their protein contents which according to (Muhammad et al., 2015) is responsible for the coagulation-flocculation characteristic of organic materials. Langmuir constant Kg on the other hand is related to the rate of adsorption and from the result in the table, that of CPLC is higher than MOSC. This implies that adsorption in CPLC-treated MVSW is faster than MOSC-treated MVSW. The separation factor R_L results show that for both MOSC and CPLC, the values lie between 0 and 1($0<R_L<I$). This therefore shows that the adsorption processes for the two systems are favourable. The experimental values of R_L of the Langmuir compared favourably with the results obtained by (Dada et al., 2013). From the coefficient of determination R^2 results, Langmuir isotherm could explain the experimental results to upto 1.7 and 77.45% for MOSC and CPLC-MVSW systems respectively. Goodness of fit of an adsorption isotherm is expressed by the coefficient of determination R^2. From the result therefore, Langmuir isotherm does not fit the experiment data well in both systems (Menkiti et al., 2012). On the comparative basis, Langmuir isotherm relatively explained the CPLC data more than it did for MOSC experimental data. For the Freundlich model, the results show that Freundlich equation constants K_F, n and coefficient of determination R^2 for both the MOSC and CPSC systems are 0.80 $(mg/(L/g)^{1/n}$ and 0.72; 1.01 and 1.0; and 0.996 and I respectively. Freundlich constant K_F indicates the adsorption capacity of the adsorbent (Obiora-Okafo et al., 2014). From the result, it therefore implies that MOSC-treated MVSW exhibited higher adsorption capacity than CPLC system. Freundlich constant n represents the parameter characterizing Quasi-Gucissian energetic heterogeneity of the adsorption surface Roop and Meenakshi (2005b).

Both K_F and n are parameters characteristics of the sorbent-sorbate system. The reciprocal of n is a function of the strength of adsorption in the adsorption process (Voudrias et al., 2002). The reciprocal of n values for the two systems are 0.990 and I respectively for MOSC-treated and CPLC-system. According to (Voudrias et al., 2002), the smaller $^1/_n$, the greater the expected energetic heterogeneity. From the explanation, it implies that MOSC- treated MVSW has more energetic heterogeneity than CPLC-in-MVSW. If n lies between 1-10, this indicates a favourable sorption process (Goldberg, 2005). Following this view therefore, both systems have favourable adsorption processes. The coefficient of determination R^2 results show that Freundlich isotherm is adequate to explain the experimental results of both systems. In the Temkin Isotherm, the results of the equilibrium binding constant A, Temkin constant $B = RT/b_T$, b_T and coefficient of determination R^2 are 1.08l/g, 767.45 ^{J}/mol, 3.25 and 0.997 for MOSC system; and 0.89^l/g, 245.01^J/mol, 10.18 and I for the CPLC system. A is the equilibrium binding constant relating to the maximum binding energy (Obiora-Okafo et al.,2014). Following the above opinion, it implies that the MOSC-in-MVSW has more equilibrium binding energy than the CPLC system. In terms of the heat of adsorption process B, MOSC-in-MVSW exhibited much more heat of sorption with 76 7.45j/mol. than CPLC-treated MVSW with 245.01j/mol. In the b_T results, following the relationship between B and b_T, it can be seen that the higher the value of b_T, the lower the sorption energy B since the product RT is a constant. This implies that CPLC system with b_T of 10.18 exhibits less sorption energy than the MOSC system with b_T value of 3.25. For the R^2 results, both systems are ably explained by the Temkin Isotherm since the R^2 values in both systems are close to and equal to unity. In the Henry's model fitness to experiment data, the results show that for MOSC and CPLC-in-MVSW, Henry's constant K are 0.326 and 0.334 moles/cm^3.atm. respectively. Henry's constant K, indicate solubility (Singh and Heldman 2009). From the result, it can be clearly seen that both systems have almost equal solubility.

Considering the results for the coefficient of determination R^2, the Henry's isotherm fits both systems experimental data and therefore can explain them very well. Finally, is the Hasley fitness results which show that the Hasley constant K_H, Hasley's exponent n and coefficient of determination R^2 are 850.3,0.0013 and 0.997; and 284.30, 0.0041 and 1 respectively for the MOSC and CPLC systems. Hasley constant K_H is the dimensionless coefficient of heteroporosity and multilayer adsorption tendency of the adsorption process (Hasley, 1948). From the results therefore, MOSC system has higher heteroporosity and multilayer adsorption tendency than the CPLC system. In the Hasley exponent n_H results, the CPLC system has higher value than the MOSC system. n_H is a Hasley exponent based upon the decay of surface forces with distance (Conway, 1960). Since n_H is an exponent, it implies that the higher the value, the higher the decay of surface forces with distance. This implies then that MOSC system has more concentration of multilayer at a relatively large distance from the surface than the CPLC system. Finally, is the fitness result expressed by the R^2 values. Both systems have R^2 values of unity implying that the linearity of the plots are very high (>0.99). From the Hasley's point of view, the high possibilities of MOSC and CPLC surfaces being heteroporous are expressed because the data obtained from the study are ably explained by Hasley Isotherm equation. Some works such as (Ayawei et al., 2017) has also reported the good of fit of experimental data to Hasley Isotherm model. The good fit attests to the heterogeneous distribution of active sites and multilayer on the MOSC and CPLC adsorbents.

4. Conclusions

Conclusively, it is ably affirmed that both the MOSC and CPLC are effective adsorbates applicable in adsorptive treatment of Mechanic village seeped water prior to disposal. On the comparative basis, MOSC is more effective than CPLC in the MVSW adsorptive treatment. The experimental data obtained for both the MOSC and CPLC-treated MVSW are well represented by Freundlich, Temkin, Henry and Hasley Isotherms. For the Langmuir Isotherm, the CPLC data was 77.45% explained than the MOSC with 1.7% explanation. The MVSW adsorptively treated by MOSC can be said to have met the portable water requirement by WHO while for water disposal purpose by FEPA, both waters could be used.

5 Recommendations

In view of the fact that MOSC and CPLC are confirmed to be effective adsorbates, they are recommended in the adsorptive treatment of water and wastewater from other sources. Considering the fact that these coagulants can be locally produced, their use in water purification should be encouraged. This is likely to reduce the high cost of the current water treatment systems using the inorganic coagulants. Finally, because these coagulants are eco-friendly, omnipresent, inexpensive, bio-renewable and susceptible to modification (Mohd Faiz Muaz et al.,2014), purification of water utilizing them may provide cheaper cost of treatment that can be used in the rural areas where no facilities are available for the treatment of drinking water and the resulting sludge used as bio-fertilizers by farmers.

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Conflict of interest statement

We declare that we have no conflict of interest.

Nomenclature

H_2No_3: Nitric acid

H_2No_4: Sulphuric acid

NaoH: Sodium hydroxide

Cr: Contaminant concentration in raw water (mg/l)

Ct: Contaminant concentration in treated water (mg/l)

Ci: Equilibrium concentration of adsorbate (mg/l)

q: Amount of adsorbate adsorbed per unit mass of adsorbent

q_∞: Langmuir constant relating to adsorption capacity (mg/g)

kg: Langmuir constant relating to rate of adsorption (l/mg)
co: Initial concentration of adsorbent (mg/l)
R_L: Langmuir dimensionless separation factor
Kf: Freundlich equation constant (mg/g)
n: Freundlich constant for Quasi-Guassian energetic heterogeneity of adsorption surface
B: Temkin constant related to heat of sorption (J/mol).
A: Tempkin equilibrium constant relating to maximum binding energy (L/g)
R: Universal gas constant (J/mol.K)
K: Henry's constant (moles.cm^3 atm.)
H_H: Hasley dimensionless constant representing adsorption tendency
n_H: Hasley exponent based open decay of surfaces forces with distance.

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