TREATMENT OF DOMESTIC LAUNDRY WASTE-WATER WITH ANALAR GRADE ACTIVATED CHARCOAL AND ADSORPTION MODELS WITH TWO (LANGMUIR & FREUNDLICH) AND THREE (ELOVICH) PARAMETERS ISOTHERMS.

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Abstract

Domestic laundry wastewater (DLWW) has been remediated with activated charcoal (AC).
The physico-chemical identities of AC (pH=6.4, moisture content=1.02%, ash content=12.4%, bulk density= 1.7g/cm3, iodine number=1332, methylene blue number=322 and fixed carbon=46.9%) that were established technically enhanced the adsorption potential and treatment of laundry waste.
DLWW was characterized (Physical, chemical, and organic nutrient demand) before and after treatment.
Physical parameters in terms of pH, color, turbidity, electrical conductivity, and total dissolved solids were significantly controlled by 50, 47.5, 97.7, 82.70 and 58.02% respectively. Chemical parameters; in terms of alkalinity, phosphate, nitrate, sulfate, fluoride, chloride and calcium were controlled by 46.71, 96, 58.33, 70.15, 97.18, 99.84 and 98.46% respectively. Heavy metals with respect to copper, cadmium, nickel, iron, manganese, chromium, zinc, lead, magnesium and potassium are 83.64, 98.33, 99.46, 73.44, 38, 96.8, 24.96, 95, 15, 20, 91.5 and 29.21 % treatments respectively while organic nutrient demands in terms of biological oxygen demand and chemical oxygen demand, achieving 91.5% and 29.21% respectively with world health organization (WHO) guidelines as standard. The sorption processes were strongly supported by two parameters adsorption models of Langmuir (R2=0.9679) and three adsorption model of elovish (R2=0.9690) than to two parameters model of freundlich (R2=0.8869).Deducing from the relationship between the three adsorption models, the overall processes are predicted to be exponentially homogenous in nature.

Keyword: laundry waste water, activated charcoal, two and three parameters adsorption models, physico-chemical parameters, WHO standards

1.INTRODUCTION

Laundry is a service industry where conscious environmental regulations have not been raised and enforced . Laundry wastes emanate with the usage of detergent and soap in eliminating dirt, oil, and starch from clothing [1].The methods and techniques of washing include white-bleaching, bluing, and starching

processes [2]. Specific approaches are employed in silk woolen and other fabrics material in connection with the nature of stains and chemicals being used for the elimination of the unwanted stains. As far as dry cleaning is concerned, it is one of the vital methods of cleansing textile materials with a natural solution. The natural solvent with this method deactivates the dirt and the stain which apparently is difficult to eliminate with ordinary water. That is, dry cleaning virtually assists in successive cleaning with the type of garments that are difficult and tedious to press after they have been leached in water. The dry cleaning detergents, fluids and solvents normally find their way into the wastewater. Thus, it is not only the soap and detergent but also various dry-cleaning fluids, solvent, dry cleaning detergents, stain-removing chemicals that find a way into the wastewater. Stoddard solvent is commonly used by the laundry industry [3]. Normally, the solvent is reclaimed but some part of it definitely becomes a part of wastewater. That is why it is difficult to characterize wastewater because washing technology is not the same. The application of any technique depends upon various factors like the type of the fabric, the amount of soiling, type of stain and stain removal chemical which is the solvent for dry-cleaning [4].Since almost all houses use domestic washing machines, the nature of the wastewater from the business clothing industry and domestic laundry is clearly unique to each other and consequently would be generally challenging comparing the two. Therefore, the wastewater between the two sources will be of different identities. Commercial oleo-chemicals which are the function of complete suspended solids that are significantly considered as one of the major laundries mostly retain factors of pollutions in the wastewater [5].These debasements are gotten from the dirt which is taken off from clothes and as well from the synthetic compounds which are utilized. Insoluble components that are suspended in water give a turbid appearance with an unpleasing and unattractive appearance which is responsible for harboring unsafe microscopic organism such as coliforms bacteria [6]. These microorganisms are unsafe and can be lethal when ingested as they readily attach themselves and hide on suspended solids, and are not readily disinfected [7].In the past, the discharge of untreated wastewater from industrial processes into rivers and lakes were not taken seriously as it was perceived that the supply of fresh water was unrestricted and could somehow handle the waste [8]. That is, there was no concerned with the long-term consequences of this form of pollution, neither the available technology to remedy the situation. As bacteria consume and deplete the dissolved oxygen in the water, untreated wastewater that is released into waterways and streams; would likewise drain the dissolved oxygen and consequently endanger marine and dry vegetation [9].

A measure of water quality contamination is its demand by biological activities (BOD5) which is the proportion of the measure of oxygen that the wastewater devours within 5Days at 20oC .Most developed countries have set limits of 100-150 ppm for FOG (from vegetable or animal sources), 350 ppm for TSS and 300 ppm for BOD5[10].

Business laundries that surpass these points of limits can have extra charges applied to their water bill in relative to the level surpassed. For laundries utilizing enormous volumes of water, this additional charge can be noteworthy going from hundreds to thousands of dollars for every month thus there is a solid conservative encouragement for keeping civil by laws in treating the laundry wastes [11].For all intents and purposes, each district today has received comparable by laws determining what can and can't be released into clean sewers and the allowable degrees of each contaminant. Austere measures can be applied with additional charges when contaminant levels surpass the maximums [11].Wastewater treatment is fundamental before being released as it is typically described by a dim shading smelly scent a solids substance of around 0 1% and 99 9% water substance [12].The solids can be suspended

(about 30%) and deactivate about 70% of chemical and organic procedures that can encourage dissolved solids [13]. From a physical perspective, the suspended solids can prompt the advancement of sludge stores and anaerobic conditions when released into the accepting condition [14]. Wastewater is made out of natural and inorganic mixes just as different gases [15].Natural segments may comprise of oils surfactants oils pesticides and phenols. Inorganic components may consist of pH, sulfur, chlorides, alkalinity, and toxic compounds. In domestic wastewater, the organic and inorganic portion is approximately 50% respectively [16]. However, since wastewater contains a higher portion of dissolved solids than suspended, about 85 to 90% of the total inorganic component is dissolved and

about 55 to 60% of the total organic component is dissolved [17]. Laundries wastes originate from the domestic and commercial washing machines vary in their characteristics depend on the type of chemicals to be used [18]. The attributes of the wastewater releases will change from area to area depending on the source with household or business. This procedure is compelling in evacuating certain organics, for example, undesirable taste and smells, micro-pollutants, chlorine, fluorine or radon from drinking water or wastewater. The adsorption efficiency depends on the nature of activated carbon used, the wastewater composition, and operating parameters [19]. There are many types of activated carbon filters that can be designed for household, community and industry requirements as they are relatively easy to install but require energy and skilled labor and can have high costs due to regular replacement of the filter material [20].Hence, the sorption technique is considered to be a suitable alternative in the remediation of effluents due to its simplicity and ease of use. Furthermore, this procedure can dispose of or lessen the various kinds of natural and inorganic toxins in wastewater. The innovations that include sorption have demonstrated to be effective at removing various kinds of inorganic anions, as appeared by Wajima et al. 2009 [21]. Viswanathan and Meenakshi (2010) in the expulsion of fluorine [22].Namasivayam and Sangeetha (2005) in nitrate evacuation [23].Bhatnagar et al. (2009) in the elimination of bromate [24], Parette and Cannon (2005), in the evacuation of per chlorate [25]. The same approach is being taken to remediate domestic laundry waste-water with an organic adsorbent (Activated charcoal) with the sole objective of preventing direct pollution of surface water and terrestrial environments.

2.MATERIALS AND METHOD

Charcoal decolorizing (lab grade), distilled water and sufficient quantity of freshly generated domestic laundry waste water.

2.1. Proximate analysis of the lab grade activated charcoal

The proximate analysis with pH, moisture, ash content, bulk density, iodine number, methylene number and fixed carbons were determined with ASTM D121(ASTM 2009) methods [26].

2.2. Characterization of the untreated and treated domestic laundry wastewater

Selected physical parameters as ph, odor, turbidity, conductivity, and TDS were conducted. Chemical parameters as alkalinity, phosphate, nitrate, sulfate, fluoride, chloride, and calcium, were also conducted. Heavy metals such as Cu, Cd, Ni, Fe, Mn, Cr, Zn, Pb, Mg, and K were estimated [29]. Organic nutrient demand as biological (BOD) and chemical (COD) oxygen demands were all according to US EPA [30].

2.3. Two parameters Langmuir isotherm[qe & Ce]

The Langmuir adsorption isotherm has been used to predict the performance of different bio-sorbents which depends on the concept that uptake occurs on a homogenous surface by monolayer sorption without interaction between adsorbed particles [31]. The simple expression of Langmuir isotherm relationship is stated as follows

$$\frac{C_e}{q_e} = \frac{1}{q_m K_e} + \frac{C_e}{q_m},$$

Where Ce denotes the quantity of the sorbate in equilibrium (mg/g).Ke is Langmuir constant identified with adsorption which implies that large surface area and pore volume will result in higher adsorption capacity.

2.4. Two parameters Freundlich Isotherm. [qe & Ce]

Freundlich isotherm is relevant to adsorption forms that happen on heterogonous surfaces. The isotherm describes the surface heterogeneity and the exponential conveyance of dynamic adsorption [32].The simplest form of freundlich isotherm is as below

$$\log q_e = \log K_F + \frac{1}{n} \log C_e,$$

2.5. Three parameters elovich isotherm. [qe, Ce & qm]

The condition that characterizes this model depends on a dynamic principle that expects that adsorption sites increase exponentially [35]. The condition was first created to portray the energy of chemisorptions of gas onto solids [36]. The simplest relationship of the elovich model is expressed as follows [33].

$$\ln \frac{q_e}{C_e} = \ln K_e q_m - \frac{q_e}{q_m}.$$

3.RESULTS AND DISCUSSION

Table I. Physico-chemical properties of analytical grade activated charcoal

Parameter	Value
pH	6.4
Moisture content (%)	1.02
Ash content (%)	12.4
Bulk density (g/cm^3)	1.7
Iodine Number	1332
Methylene blue number	322
Fixed carbon (%)	46.9

Table II. Characterizations of the untreated and treated domestic laundry wastewater

Category		Untreated LWW	Activated Carbon Treated LWW	WHO Standard
Physical properties	pH	12.4	6.2	6.5-8.5
	Odor	Soapy	Odorless	Unobjectionable
	Turbidity (NTU)	133.00	32.00	5.00
	Conductivity(uS/cm)	682.00	118.00	1000
	TDS(mg/l)	767.00	322.00	1500
Chemical properties	Alkalinity(mg/$CaCO_3$/l)	85.00	45.30	100
	Phosphate(mg/l)	17.50	0.70	5
	Nitrate(mg/l)	36.00	15.00	50
	Sulphate(mg/l)	40.20	12.00	500
	Fluoride (mg/l)	21.30	0.60	1.50
	Chloride (mg/l)	135.33	0.22	200
	Calcium (mg/l)	570.00	8.79	500
Heavy metal	Cu(mg/l)	0.55	0.090	2
	Cd(mg/l)	0.06	0.001	0.003
	Ni(mg/l)	0.55	0.003	0.07
	Fe(mg/l)	0.32	0.085	0.3
	Mn (mg/l)	0.10	0.062	0.4
	Cr (mg/l)	0.25	0.008	0.05
	Zn (mg/l)	1.37	1.028	5
	Pb (mg/l)	0.12	0.006	0.01
	Mg(mg/l)	42.00	35.700	50
	K(mg/l)	1.50	1.200	2
Organic nutrient demand	BOD(mg/l)	210.00	17.00	50
	COD(mg/l)	832.00	589.00	1000

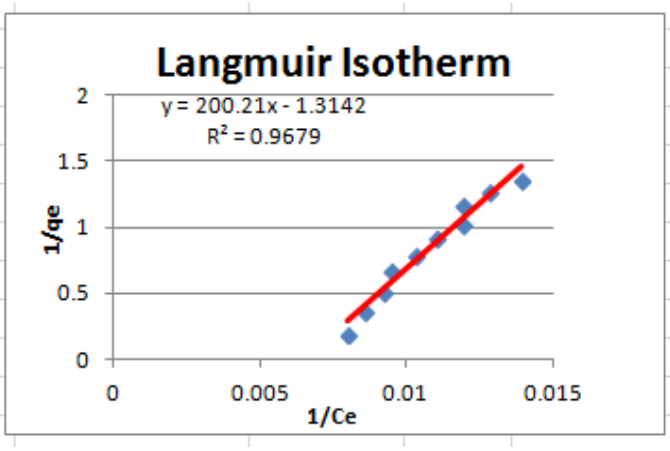

Figure I. Langmuir Isotherm of domestic laundry wastewater

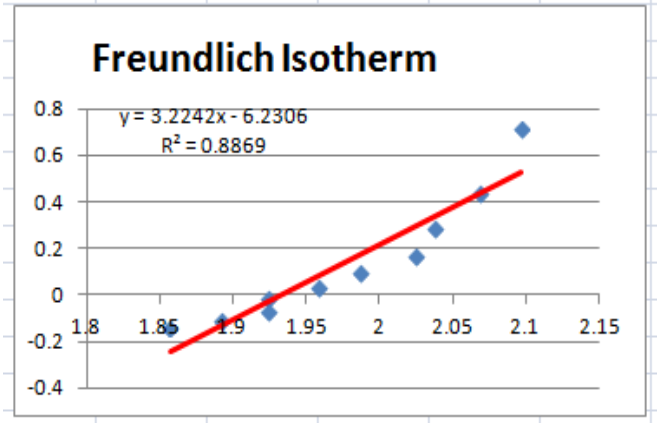

Figure II. Freundlich isotherm of domestic laundry wastewater

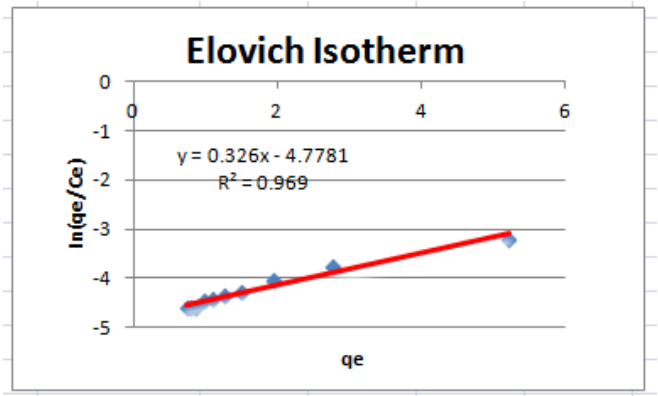

Figure III. Three parameters Elovich isotherm of domestic laundry wastewater.

The proximate evaluations for the analytical grade activated carbon prior to application are disclosed in table 1 where pH (6.4) is almost a neutral value that identifies the adsorbent not being acidic nor alkaline that might interfere with the adsorption process. The moisture content of 1.02% implies a well-activated charcoal [34].

Ash content of 12.4% describes the low content of inorganic compositions with an implication of high fixed carbon content (46.9%) [35]. Bulk density of 1.7g/cm3 expresses the mass to volume ratio which defines its stability with the adsorption process. Methylene blue number (322) presented the degree of mesoporosity of the activated adsorbent between 2-50 nanometer size and iodine number of 1332 with an indication of 2-nanometer micro-porosity [35].Table II is the physical, chemical and organic nutrient demands parameters of the domestic laundry wastewater before and after treatment. Physical parameters as pH, color, turbidity, electrical conductivity and total dissolved solids of the domestic laundry wastewater were treated and controlled by 50, 47.5, 97.7, 82.70 and 58.02% respectively below WHO standards. Chemical parameters with alkalinity, phosphate, nitrate, sulfate, fluoride, chloride and calcium were controlled by 46.71, 96, 58.33, 70.15, 97.18, 99.84 and 98.46% below WHO standards. Heavy metals in terms of copper, cadmium, nickel, iron, manganese, chromium, zinc, lead, magnesium and potassium are in the order of 83.64, 98.33, 99.46, 73.44, 38, 96.8, 24.96, 95, 15, 20, 91.5 and 29.21 % treatments below WHO standards. With organic nutrient demands in terms of biological oxygen and chemical oxygen demands, are 91.5% and 29.21% respectively and below WHO standards.

Figures I and II are two parameters adsorption isotherm of Langmuir (R2=0.9679) and Freundlich models (R2=0.8869). These models declared the adsorption process being effective with the homogenous surface by monolayer sorption and being a heterogeneous sorption process respectively. Figure III is the three parameters elovich adsorption model (R2=0.9690) that expresses the adsorption sites increases exponentially with adsorption processes. Meanwhile, it is technically expected that the passive state of adsorbent (activated charcoal) after some time will be attained due to the saturated condition with various components of the adsorbate from the wastewater. However, the advantage of reactivating the sorbent material is to subject it to high thermal conditions.

4.CONCLUSION

A low cost, organic, renewable and environmental benign activated charcoal will continue to be relevant as a good performance natural adsorbent in sorption studies. It is however observed that two parameters Langmuir and three parameters elovich supported the sorption processes. Domestic laundry wastewater should strictly be acknowledged globally as an agent of pollution both in aquatic and terrestrial environments. Naturally, the wastewater is characterized by a high state of phosphate (toxins), nitrate (blue baby diseases), sulfate (diarrhea), fluoride (fluorosis) and heavy metals which were all above WHO guidelines. Water as natural resources must be conserved and managed. Hence, this research work has successfully achieved the objectives of treating laundry wastewater with renewable material and with the mindset of recycling, especially in agricultural irrigation systems.

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