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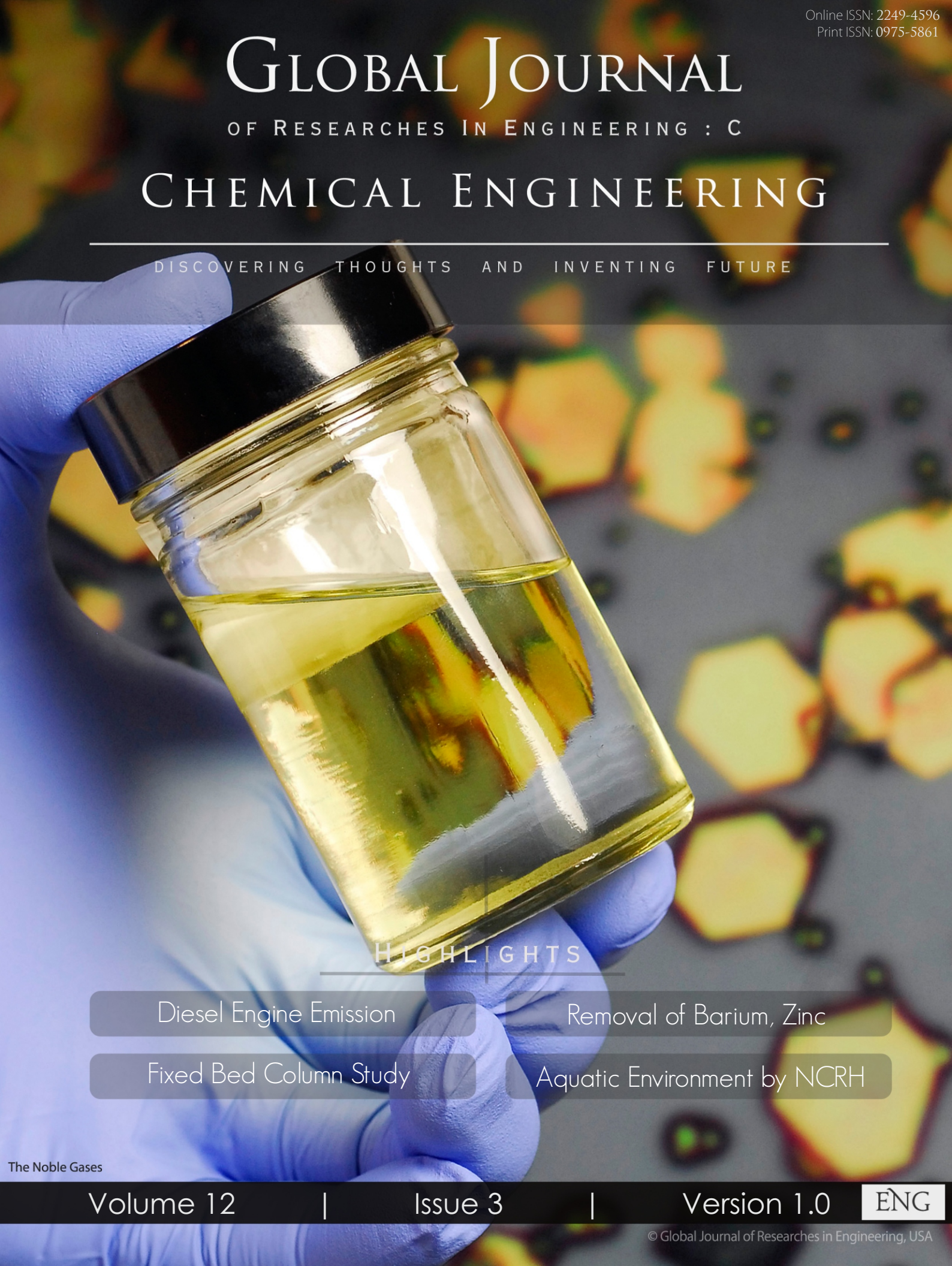

Highlights

- Diesel Engine Emission
- Removal of Barium, Zinc
- Fixed Bed Column Study
- Aquatic Environment by NCRH

The Noble Gases

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Fixed Bed Column Study for the Removal of Copper from Aquatic Environment by NCRH

By Upendra Kumar & Jyotikusum Acharya
National Institute of Technology, Silchar Assam, India

Abstract - This paper reports the results of the study on the performance of low-cost adsorbent such as NCRH in removing copper. The adsorbent materials adopted were found to be an efficient media for the removal of heavy metals in continuous mode using fixed bed column. The fixed bed column experiment was conducted in a column having a diameter of 2 cm with 10 mg/l Cu(II) solution at a bed depth of 10 cm maintaining a constant flow rate of 10 ml/min. The breakthrough and exhaust time were found to be 3.583 and 10.500 h, respectively. Height of adsorption zone was found to be 10.21 cm and the rate at which the adsorption zone was moving through the bed was 1.48 cm/h. The percentage of the total column saturated at breakthrough was found 44.95%. The value of adsorption rate coefficient (K) and adsorption capacity coefficient (N) were obtained as 0.056 l/(mg h) and 1623 mg/l, respectively.

Keywords : *copper, NCRH, breakthrough curve, adsorption rate coefficient, adsorption capacity coefficient.*

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I. Introduction

Water pollution due to toxic heavy metals has been a major cause of concern. The industrial and domestic wastewater is responsible for causing several damages to the environment and adversely affecting the health of the people. Metals can be distinguished from other toxic pollutants, since they are nonbiodegradable and can accumulate in living tissues, thus becoming concentrated throughout the food chain [1]. As one of the important toxic heavy metals, copper finds its way to the water stream from industries like electroplating, mining, electrical and electronics, iron and steel production, the non-ferrous metal industry, the printing and photographic industries and metalworking and finishing processes [2, 3]. Moreover, copper sulfate has been used in eutrophic lakes to kill the algae since the early 1990s and is still widely used today. Trace amounts of copper are essential to human and many other living species. However, the intake of excessively large doses of Cu(II) by human may lead to severe mucosal irritation, a central nervous system irritation, possible necrotic changes in the liver and kidney, etc., and the recommended maximum acceptable concentration of Cu(II) in drinking water by the World Health Organization(WHO) is 1.5 mg/L. As per U.S. Environmental Protection Agency (EPA) maximum acceptable concentration in drinking water is 1.3 mg/L [4].

Various treatment techniques have been employed to eliminate or reduce heavy metals in wastewater including precipitation, adsorption, ion exchange and reverse osmosis. As of now, adsorption by activated carbon is accepted to be the best available technology for the reduction of heavy metals, except that its manufacturing cost is quite high. Hence, a search is on worldwide for a low-cost alternative. Research in the recent years has indicated that some natural biomaterials including agricultural products and by-products can accumulate high concentration of heavy metals. Adsorbent generated from these biomass are cost effective and efficient. Low-cost agricultural products and by-products have been reported to be effective in removing heavy metals[5]. Adsorption process of heavy metals present in aqueous solution by low-cost adsorbents from plant wastes can be carried out with or without chemical modifications. In general, chemically modified plant wastes exhibit higher adsorption capacities than unmodified forms [6].

In our continued study on the use of lowcost material for the removal of organic and organic pollutants from water and wastewater we investigated rice husk as a sorbent for the removal of Cu(II). Some simple and low-cost chemical modifications resulted in increasing the sorption capacity of raw rice husk. The highly efficient low cost and the rapid uptake of Cd(II) by NCRH indicated that it could be an excellent alternative for the removal of heavy metal by sorption process [1, 7].

Agricultural products and by-products have been reported to be effective in removing copper. Rice husk consists of cellulose (32.24%), hemicelluloses (21.34%), lignin (21.44%) and mineral ash (15.05%) as well as high percentage of silica in its mineral ash, which is approximately 96.34%. Rice husk is insoluble in water, has good chemical stability, has high mechanical strength and possesses a granular structure, making it a good adsorbent material for treating heavy metals from wastewater [6]. Rice husk, an abundant agricultural product, is capable of removing heavy metals and can be considered as an efficient and low-cost adsorbent for heavy metals. The present study has been undertaken to report the Cu(II) adsorption in the fixed bed column process. In recent years, attention has been taken on the utilization of unmodified or modified rice husk as a sorbent for the removal of pollutants [8, 9, 10].

II. Materials and Methods

a) Equipments and Chemicals

All chemicals used were of analytical grade (BDH, India). Stock solutions of 100 mg/l were prepared

using metal nitrate salts, which were diluted with distilled water to prepare working solutions. Cyberscan 510 model pH meter was used for the measurement of pH of the solution. A peristaltic pump (Miclins India Limited, PP 30) was also used for providing constant flow of metal and desorbing solution in fixed bed column. The metal ion concentrations in the solution were analyzed using atomic absorption spectrophotometer (AA-6650, Shimadzu).

b) Preparation of adsorbent

Fresh rice husk was obtained from a local rice mill and was passed through different sieve size. The fraction of particle between 425 and 600 micron (geometric mean size: 505 micron) was selected. The rice husk was washed thoroughly with distilled water. It was dried at 60°C. The sorbent thus obtained was designated Raw Rice Husk (RRH). Rice husk was treated with 0.1 M sodium carbonate solution at room temperature for 4 h. Excess of sodium carbonate was removed with distilled water and the material was dried at 40oC. This material was designated as sodium carbonate treated rice husk (NCRH) [1].

c) Experimental Studies

Fixed bed column study for Cu(II) removal from wastewater by NCRH was conducted using a column of 2 cm diameter and 55 cm length. The column was packed with NCRH between two supporting layers of pre-equilibrated glass wool. The bulk density of NCRH packed in the column was 0.267 g/cm^3. The column bed depth was kept 10 cm. The schematic diagram of column study is shown in Fig. 1. The study was conducted at temperature of 28 ± 2oC and the pH of the Cu(II) solution as 6.0 ± 0.2 for the present study. The column was charged with Cu(II) bearing wastewater with a volumetric flow rate of 10 ml/min (~ 2.10 m^3/m^2/h). The initial concentration of Cu(II) was 10 mg/l. The samples were collected at certain time intervals and were analyzed for Cu(II) using atomic absorption spectrophotometer (AA-6650, Shimadzu).

III. Results And Discussions

a) Behavior of adsorption column

The fixed bed column experiment was conducted with 10 mg/l Cu(II) solution at a bed depth of 10 cm maintaining a constant flow rate of 10 ml/min. The breakthrough curve of S-shaped was obtained as shown in Fig. 2. The breakthrough

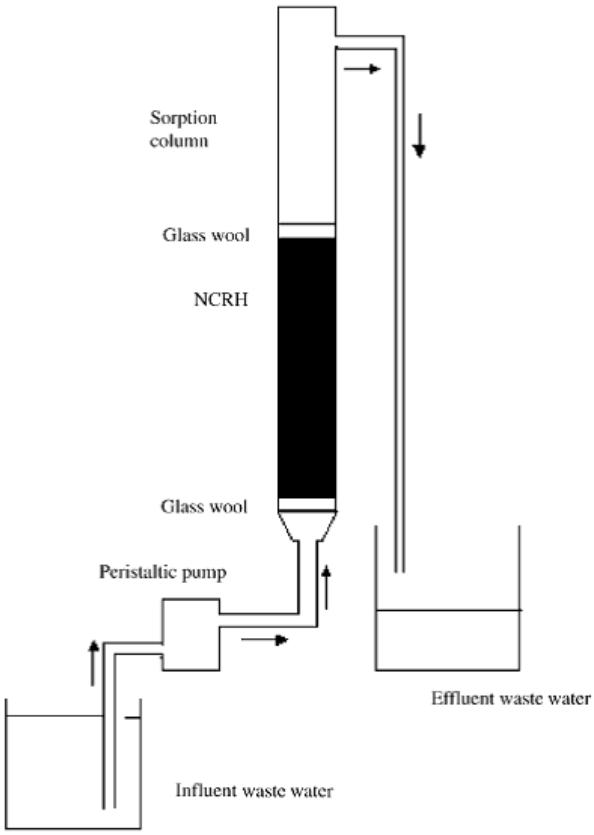

Fig. 1 : Schematic diagram fixed bed column experimental set up

time (corresponding to C/Co = 0.1) and exhaust time (corresponding to C/Co = 0.9) were found to be 3.583 and 10.500 h respectively. The corresponding volumes of wastewater treated were 2.15 and 6.30 liters respectively. About 8.39 gm of NCRH were used in the 10 cm column. The volume of metal effluent treated and the requirement of NCRH up to breakpoint have b shown in Table 1. The market price of activated carbon for industrial grade is US $ 20-22 (Rs. 1000 – 1100) per kg depending on the quality[11]. The cost of NCRH is in India was estimated as only Rs. 4 per Kg (US $ 0.08). Hence, by cost comparison the cost, NCRH is about 250 times cheaper than activated carbon. Cost for volume of metal effluent treated up to breakpoint per kg of NCRH has been calculated and has been presented in Table 6.2.

The formation and movement of the adsorption zone has been described mathematically [12, 13]. The time required for the exchange zone to move the length of its own height up/down the column once it has become established is

$$t_z = \frac{V_E - V_B}{Q_w} \quad (1)$$

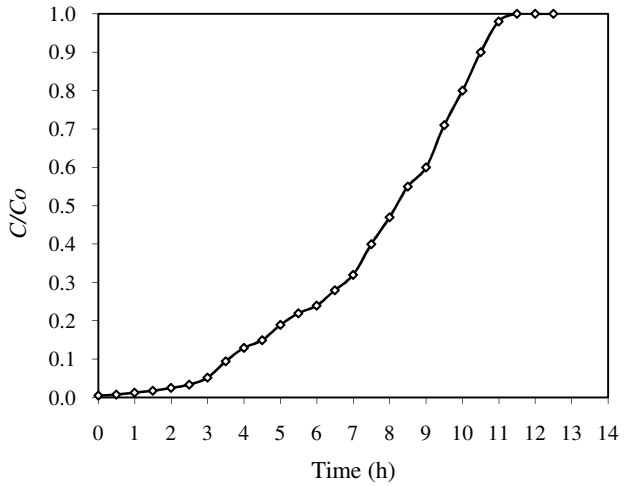

Fig. 2 : Breakthrough curve for Cu(II) using NCRH.

Where,

V_E = volume of wastewater treated to the point of exhaustion (l)

V_B = volume of wastewater treated to the point of breakthrough (l)

Q_w = wastewater flow rate (l/h)

The time required for the exchange zone to become established and move completely out of the bed is

$$t_E = \frac{V_E}{Q_w} \tag{2}$$

Rate at which the exchange zone is moving up or down through the bed is

$$U_z = \frac{h_z}{t_z} = \frac{h}{t_E - t_f} \tag{3}$$

Where,

h = height of exchange zone (cm)

h = total bed depth (cm)

t_f = time required for the initially form (h)

Rearranging Eq. 3 provides an expression for the height of the exchange zone as given below.

$$h_z = \frac{h(t_z)}{t_E - t_f} \tag{4}$$

The value of t_f can be calculated as follows.

$$t_f = (1 - F)t_z \tag{5}$$

At breakthrough the fraction of adsorbate present in the adsorption zone still possessing ability to remove solute is

$$F = \frac{S_z}{S_{\max}} = \frac{\int_{V_B}^{V_E} (C_o - C)dV}{C_o(V_E - V_B)} \tag{6}$$

Where,

C_0 = initial solute concentration (mg/l)

S_z = amount of solute that has been removed by the adsorption zone from breakthrough to exhaustion

S_{max} = amount of solute removed by the adsorption zone if completely exhausted

The percentage of the total column saturated at breakthrough is

$$\% \, saturation = \frac{h + (F-1)h_z}{h} \text{X } 100 \tag{7}$$

The values of the important design parameters were calculated using the data from breakthrough curve. Height of adsorption zone was found to be 10.21 cm and the rate at which the adsorption zone was moving through the bed was 1.48 cm/h. The percentage of the total column saturated at breakthrough was found to be 44.95 %.

b) Evaluation of adsorption column design parameters

Data collected during laboratory and pilot plant tests serve as the basis for the design of fullscale adsorption columns. A number of mathematical models have been developed for the use in design. In the present research work the fixed bed column was designed by logit method [14, 15]. The logit equation can be written as:

$$\ln\left[\frac{C/C_o}{1 - C/C_o}\right] = -\frac{KN_oX}{V} + KC_ot \tag{8}$$

Where,

C = concentration at any time t

C_o = initial Cu(II) concentration (10 mg/l)

V = approach velocity (210 cm/h)

X = bed depth (10 cm)

K = adsorption rate constant (l/mg-h)

N_o = adsorption capacity constant (mg/l)

Rearranging Eq. 8

$$\ln\left[\frac{C}{C_o - C}\right] = -\frac{KN_oX}{V} + KC_ot \tag{9}$$

Plot of ln $C/(C_0 - C)$ vs. t gives a straight line with slope KC_o and intercept – KN_0 X /V from which K and N_o could be calculated. Plot of ln $C/(C_0 - C)$ vs. t was shown in Fig. 3. The values of adsorption rate constant (K) and adsorption capacity constant (N_o) were obtained as 0.056 l/mg.h and 1623 mg/l (1.623 kg/m^3) respectively. These values could be used for the design of adsorption columns. The adsorption capacity was found to be good. Hence, it could be concluded that NCRH is effective for Cu(II) removal.

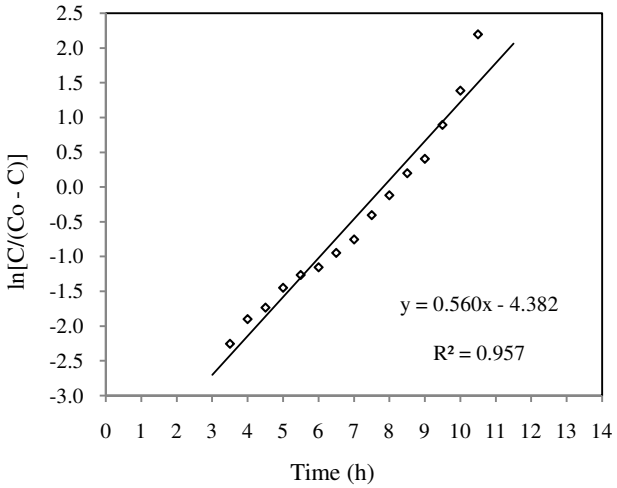

Fig. 3 : Linearized form of logit model.

IV. Conclusions

NCRH was found to be efficient media for the removal of Cu(II) from aquatic environment. The column with 2 cm diameter, and bed depth 10 cm could treat 2.15 liters of Cu(II) at breakthrough, at initial concentration 10 mg/l. About 3.90 g of NCRH was required per liter of Cu(II) treatment. Height of adsorption zone was found to be 10.21 cm and the rate at which the adsorption zone was moving through the bed was 1.48 cm/h. The values of adsorption rate constant (K) and adsorption capacity constant (N_o) were obtained as 0.056 l/mg.h and 1623 mg/l respectively.

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Table 1 : Volume of effluent treated and the mass of NCRH required up to breakthrough

Bed depth (cm)	10% Breakthrough time (hr)	Treated volume (lts)	Total mass of NCRH (gm)	Mass per litre (gm/l)
10	3.583	2.15	8.39	3.90 gm

Table 2 : Cost for volume of metal effluent treated up to breakpoint per kg of NCRH

Metal	Volume of metal effluent treated per kg of NCRH	Cost per kg NCRH @ Rs. 4	Cost per kg NCRH @ US $ 0.08
Cu(II)	256 litres	64 litres / Rs.	3200 litres / US $

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Removal of Barium, Zinc and Mercury from Drill Cuttings Using Activated Palm Kernel Shell and Husk

By Ijeoma. A. Chukwu & Elijah T. Iyagba
University of Port Harcourt, Nigeria

Abstract - Palm kernel shell and Palm kernel husk have been used to remove Barium, Zinc and Mercury from drill cuttings. Batch adsorption studies were carried out as function of pH, contact time and Carbon dosage. Barium, Zinc and Mercury were found to be pH dependent with optimum pH of 9 for all activated Carbon materials. Barium and Zinc APKS was 150mins, while Barium and Zinc APKH was 120mins. For Mercury both APKS and APKH attained maximum adsorption at 60mins. For maximum adsorption, the adsorbent loading was 5g for Barium and Mercury APKS, 3g for Zinc and 4g for Barium, Zinc and mercury APKH. Although Barium and Zinc did not exceed the regulatory limit, the equilibrium experimental data were found to best fit the Freundlich Isotherm model for APKH with R2 = 99.84% for Ba, 85.66% for Zinc and 89.92% for Mercury. The intensity of adsorption for Barium was 0.9420, 0.0710 for Zinc and 0.2935 for Mercury. Although their was ion adsorption of heavy metal ions at low concentration, the low intensity values below unity indicates that adsorption using Palm kernel shell and husk is not very favorable for the removal of Barium, Zinc and Mercury from drill cutting.

Keywords : *drill cuttings, heavy metals removal, palm kernel shell, palm kernel husk, adsorption.*

GJRE-C Classification : *FOR Code: 030301, 030304*

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Ijeoma. A. Chukwu [α] & Elijah T. Iyagba [σ]

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Keywords : drill cuttings, heavy metals removal, palm kernel shell, palm kernel husk, adsorption.

I. Introduction

In many operations of gas or oil wells, the drill cuttings give rise to an increasing problem with respect to their handling and disposal. If oil and gas exploration rigs and production installations are allowed to dump drilling wastes unchecked, the effects on marine life can be widespread (Frode and Gray, 1995, Okpokwasili and Nnubia, 1996, Wills, 2000). The ecological effects extend for several kilometers, smothering seabed life and remaining toxic for many years.

Cuttings that contain significant levels of heavy metals require special handling since repeated disposal can lead to accumulation of high molecular weight compounds. At high concentrations, these non-biodegradable constituents can increase soil water repellency and render the land unfit without treatment or amendment (Callahan et al, 2002, Cordah, 2001). In a review Bell et. Al., 1998, underlined the dangers of allowing cuttings to accumulate. Various measures to obtain zero discharge have called for appropriate drill cutting treatments prior to disposal in order to meet standard conditions. Treatment of drill cuttings is vital because it has lots of application (Page et al., 2003, Reuben and Miebaka, 2008, Opete et al., 2010).

Living organisms require varying amounts of heavy metals, while excessive levels can be damaging to organisms. Some are dangerous to health (e.g: Hg, Cd, As, Pb, Cr) and some cause corrosion (eg:Zn, Pb) (Sullivan, 1991, Ayotamuno et al., 2007). Numerous processes exist for removing dissolved heavy metals. The use of alternative low cost materials as potential sorbents for the removal of heavy metals is very important (Abel-Ghania and El-Chaghaby, 2007, Ademuluyi et. al., 2009). Disposal of agricultural wastes is currently a major economic and ecological issue, and the conversion of these agro-products to adsorbents such as activated carbon represents an alternative (Itodo et al., 2010).

To reduce the hazardous nature of these drill cuttings, international legislations have been imposed. The oil and gas exploration and production activities inevitably generate these drill cuttings which must be treated prior to disposal. Drill cuttings are treated thermally in Nigeria. This only takes care of hydrocarbons leaving heavy metals above regulatory limits. The heavy metal, if considerably reduced to a tolerable level reduces the hazardous effects to the environment (Okporanma and Ayotamuno, 2008).

In an earlier study, the feasibility of using activated carbon from two readily available agricultural wastes, namely; Palm Kernel Shell (PKS) and Palm Kernel Husk (PKH) to remove chromium and lead from drill cuttings was carried out (Iyagba and Opete, 2009). This work is a continuation of the previous study and is aimed at the removal of Barium, Zinc and Mercury from drill cuttings, using PKS and PKH as well.

II. Materials and Methods

a) Preparation of adsorbent

Palm kernel shell and husk were collected, washed with clean water and sun dried for 48 hours. They were crushed in mortar, sieved and carbonized at 300°C and 250°C for palm kernel shell and husk

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respectively. They were subsequently activated using concentrated H_3PO_4 and oven dried.

b) Preparation of heavy metal extract

Heavy metal extract from the thermally treated drill cuttings were prepared using the ASTM-D-3974 method.

c) Batch equilibrium studies

Batch equilibrium experiments were conducted by adding a known quantity of activated carbon shell and husk to 20 ml of the heavy metal extract and shaken vigorously.

d) pH

20ml of the heavy metal extract was adjusted to different pH values of 1,3,5,7 and 9 by adding 0.1M HCl or NaOH accordingly. The resulting solution at different pH levels were treated with 1.5g of APKS and APKH each and shaken. These were shaken and filtered and their concentrations determined using the Atomic Adsorption Spectrophotometer (GBC AVANTA Model).

e) Contact time

1g of the APKS and APKH each was weighed into a beaker. 20ml of the heavy metal extract was added to the activated carbon and shaken. This was allowed to stand for 30, 60, 90,120 and 150 mins and filtered. The filtrate was analyzed for Barium, Zinc and Mercury using an Atomic Adsorption Spectrophotometer

f) Carbon Dosage

Keeping the pH of the heavy metal extract constant (pH of 9) following the earlier results obtained, 1,2,3,4 and 5g of APKS and APKH were each added to 30ml of the heavy metal extract and allowed to stand for 60mins-Mercury, 120 mins-Barium and Zinc for APKH and 150 mins-Barium and Zinc for APKS. The resultant solution with the adsorbents was shaken and filtered. The Barium, Zinc and Mercury concentrations were determined spectrophotometrically.

The mass of Barium, Zinc and Mercury adsorbed were calculated using the formulae;

$$X = (c_i - c_f)V$$

where c_i and c_f are initial and final Barium, Zinc and Mercury concentrations, while V is the volume of extract used.

III. Results And Discussion

Analysis of the experimental data obtained from the batch studies were carried out. The study showed the following;

a) Effect of pH

The optimal pH of Barium, Zinc and Mercury is 9 (Figures 1,2 and 3). At these pH values, Barium removal for APKS and APKH both attained over 94%, Zinc removal for APKS and APKH were both 97% while for Mercury APKS and APKH were both 89%. At low pH, the removal of Ba^{2+}, Zn^{2+} and Hg^{2+} was low. This finding is at variance with chromium and lead removal that took place optimally at 3 and 5 with APKS and APKH, respectively (Iyagba and Opete, 2009). Metals have small number of electrons in excess of a stable, closed-shell electronic configuration and as such have tendency to loose these extra ions to attain stability (Wikipedia). This should favour increased metal uptake at low pH. More metal removal at low pH may also be due to high proton present making metal bonding sites become positively charged thereby repelling the cations e.g. Cr^{3+} and Pb^{2+} and attracting anions such as Cl^- and OH^-. However, oxides of Barium and Zinc are well known solid bases whereas oxides of trivalent Al^{3+}, Cr^{3+} tend to be acidic (Iyagba and Schutz, 2007). The result therefore shows that although neutral or highly acidic conditions are favorable for metals uptake, Ba^{2+}, Zn^{2+} and Hg^{2+} uptake is enhanced in relatively strong alkaline media, as supported by Ansari and Raofie, 2006.

b) Effect of contact time

For APKS, varying the contact time of the adsorbent with the adsorbate shows a gradual increase in Barium and Zinc APKS, while there was a rapid increase for Barium and Zinc uptake for APKH. The highest adsorption for the uptake of Barium and Zinc in APKS occurred at 120 mins. These can be seen in figures 4 and 5, while the adsorption of Mercury on APKS and APKH was highest at 60 mins.(Figure 6).

From the plot, further increase in contact time for Barium and Zinc increases with rate of adsorption while for Mercury, further increase in contact time after 60 mins reduces the rate of adsorption; this may be attributed to the volatile nature of Mercury.

c) Effect of carbon dosage

The amount of carbon used in the process was found to affect the adsorption process. Figures 7 to 9 show that percentage removal of Barium, Zinc and Mercury increased with increasing carbon dosage.

The maximum adsorption of APKH in Barium, zinc and Mercury was attained at a particular dose (4g) of the adsorbent, whereas the maximum for APKS varied. Barium and Mercury uptake on APKS attained maximum adsorption at 5g, while Zinc adsorption attained the maximum at 3g. The variations in carbon dosage and rates of adsorptions are due to ability of contaminants to be adsorbed on the exterior carbon surface; move into the carbon powder and be adsorbed into the interior walls of carbon. These variations are due to varying iodine number, surface area, pore space and particle size distribution in APKS and APKH.

d) Adsorption Isotherm Studies

The Langmuir isotherm model is expressed as (Henderson et al., 2009, Igoni et al., 2009):

$$\frac{c}{(q)} = \frac{1}{ab} + \frac{1}{a}(c)$$

where q = mass of solutes adsorbed per mass of adsorbent, c = concentration of adsorbate in solution in equilibrium with the adsorbate adsorbed, a and b are constants obtained by plotting c/q against c. The slope is 1/a while the intercept is 1/ab. Figures 10 to 15 show the Langmuir isotherm plots for the adsorption of Barium, Zinc and Mercury in Palm kernel shell and husk respectively.

The Freundlich isotherm model is given by the following equation:

$$q = K_f c^{\frac{1}{n}}$$

where K_f and n are constants. The linearised form of this equation becomes:

$$\ln q = \ln K_f + \frac{1}{n} \ln c$$

By plotting ln q versus ln C, the constants K_f and n are obtained. The slope a=1/n while the vertical axis intercept b=ln K_f, therefore n=1/a and $K_f = e^b$ The plot of ln q versus ln c are given in figures 16 to 21 for the adsorption of Barium, Zinc and Mercury using palm kernel shell and husk respectively.

Table 1 shows the comparison between the Langmuir and Freundlich regression coefficients. It was observed that the experimental data fitted the Freundlich APKH isotherm model best. The Langmuir model was far from unity while the Freundlich isotherm model was closer to unity, with the Freundlich APKH better than Freundlich APKS.

Table 2 shows the comparison in values of regression coefficient, adsorption intensity and adsorption constant (k) for various studies; Ayotamuno and others (2007), Opete. (2008) and this study. The adsorption intensities of Barium, Zinc and mercury were the lowest, showing that low amounts of heavy metals are adsorbed at low concentrations of adsorbate and this varies with its regression coefficients and their constants respectively.

IV. Conclusion

Palm kernel shell and husk have been shown to have an average capacity for the removal of Barium, zinc and mercury present in thermally treated drill cuttings used in the oil and gas industry. This is with respect to its low values of n and k^f. Removal of Barium zinc and mercury are pH, contact time and carbon dosage dependent with optimal pH for Barium, zinc and mercury being 9. For APKS, maximum percentage adsorption for Barium and Zinc uptake occurred at 150 mins, while Barium and Zinc APKH occurred at 120 mins. Mercury APKS and APKH maximum occurred at 60 minutes. The maximum carbon dosage for Barium, zinc and mercury uptake in APKH were attained with 4g, whereas Barium and Mercury uptake in APKS was 5g and zinc uptake in APKS 3g. The equilibrium adsorption data obtained showed moderate adsorption favorable to Freundlich Isotherm for palm kernel husk preferably. This work showed that with futher research, the readily available agricultural waste –Palm Kernel shell and Husk can be used to effectively adsorb Barium, zinc and mercury, thereby curbing disposal of toxic heavy metals.

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Tables

Table 1 : A Comparism of the Langmuir and Freundlich Regression Coefficients.

	BARIUM		ZINC		MERCURY	
	1	2	1	2	1	2
Langmuir	36.16	71.47	45.53	65.14	4.41	81.12
Freundlich	61.34	99.84	70.09	85.66	25.1	89.92

- **1: APKS*
- **2: APKH*

Table 2 : A Comparism of the Langmuir and Freundlich Regression Coefficients for various studies.

	Heavy Metal	Adsorbent	R^2(%)	n	K
1.	Cr	PAC	98.1	1.3200	7.68×10^{-1}
2.	,,	APKS	91.94	1.3755	1.372×10^{-1}
	,,	APKH	86.39	1.5511	2.056×10^{-1}
	Pb	APKS	89.37	1.5087	9.2×10^{-2}
	,,	APKH	96.74	1.6199	1.2×10^{-1}
3.	Ba	APKS	61.34	0.0683	2.72×10^{-1}
	,,	APKH	99.84	0.9420	6.727×10^{-1}
	Zn	APKS	70.09	0.6249	2.408×10^{-1}
	,,	APKH	85.66	0.0710	7.055×10^{-16}
	Hg	APKS	25.1	0.4421	2.8×10^{-4}
	,,	APKH	89.92	0.2935	4.059×10^{-6}

** Ayotamuno and others (2007)*
** Opete O. (2008)*
** This study*

Figures

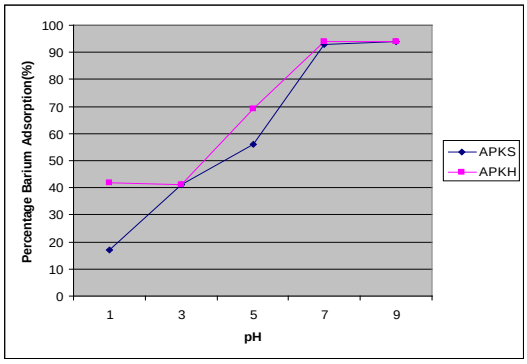

Figure 1 : Plot of pH against percentage Barium adsorption with APKS and APKH

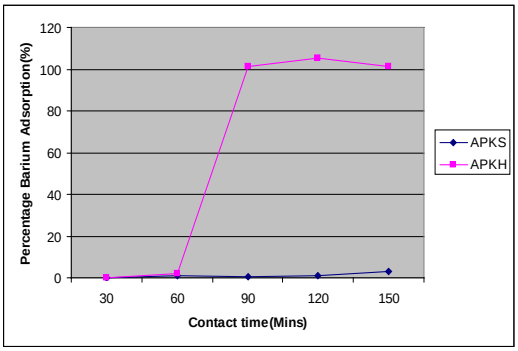

Figure 4 : Plot of contact time against percentage Barium adsorption with APKS and APKH

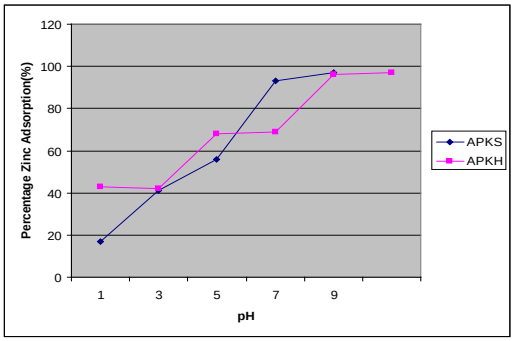

Figure 2 : Plot of pH against percentage Zinc adsorption with APKS and APKH

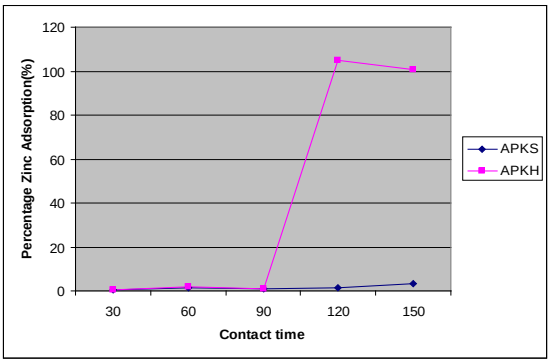

Figure 5 : Plot of contact time against percentage Zinc adsorption with APKS and APKH

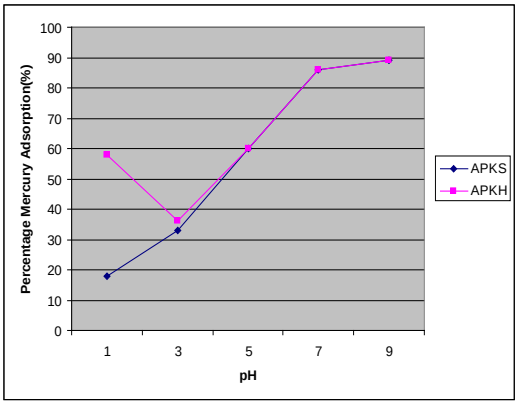

Figure 3 : Plot of pH against percentage Mercury adsorption with APKS and APKH

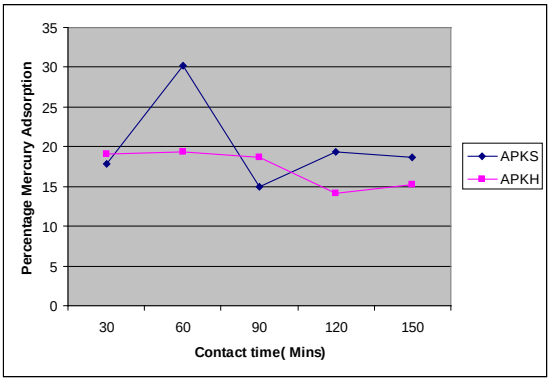

Figure 6 : Plot of contact time against percentage Mercury adsorption with APKS and APKH

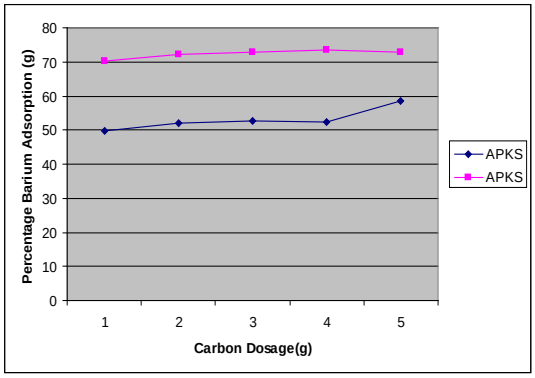

Figure 7 : Plot of Carbon Dosage against percentage Barium adsorption with APKS and APKH

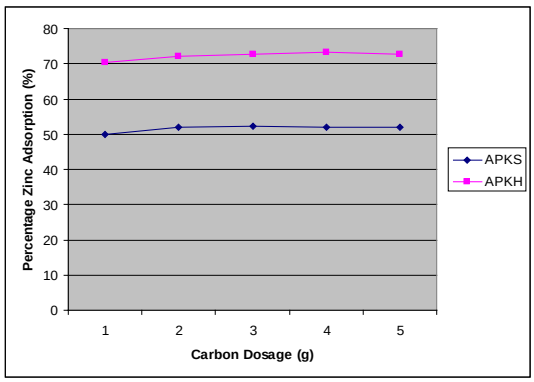

Figure 8 : Plot of Carbon Dosage against percentage Zinc adsorption with APKS and APKH

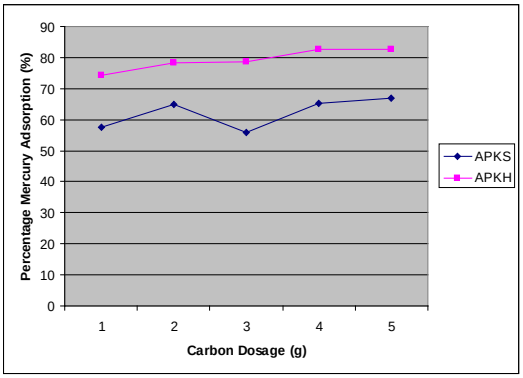

Figure 9 : Plot of Carbon Dosage against percentage Mercury adsorption with APKS and APKH

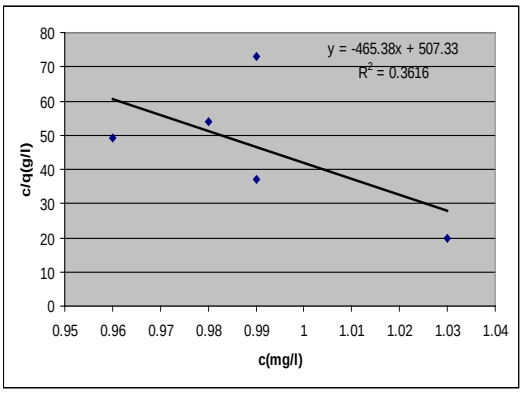

Figure 10 : Plot of Langmuir Isotherm for Barium Adsorption with APKS

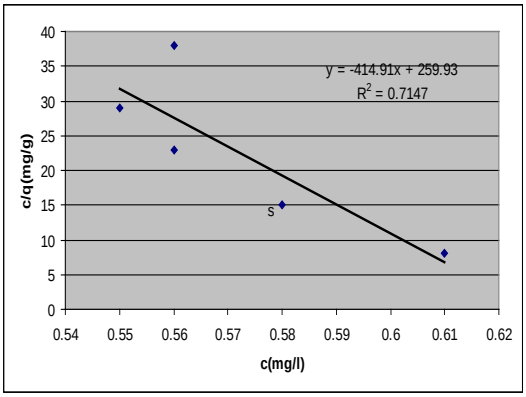

Figure 11 : Plot of Langmuir Isotherm for Barium Adsorption with APKH

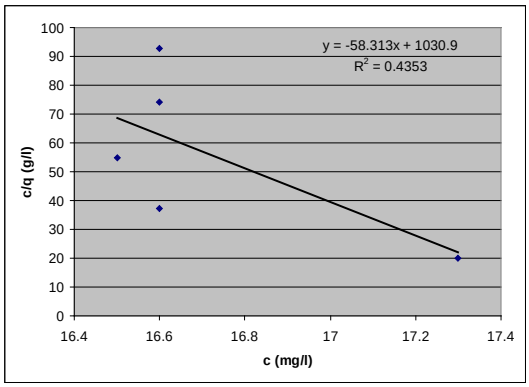

Figure 12 : Plot of Langmuir Isotherm for Zinc Adsorption with APKS

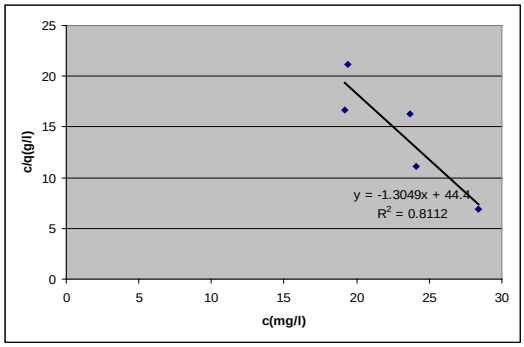

Figure 15 : Plot of Langmuir Isotherm for Mercury Adsorption with APKH

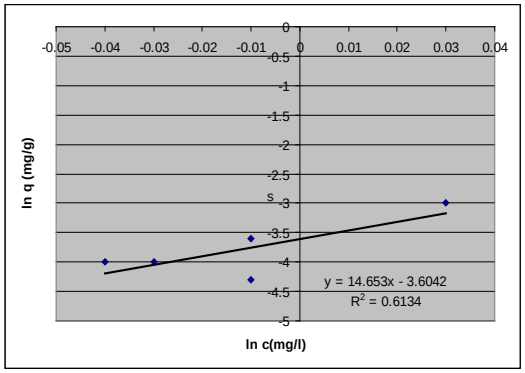

Figure 16 : Plot of Freundlich Isotherm for Barium Adsorption with APKS

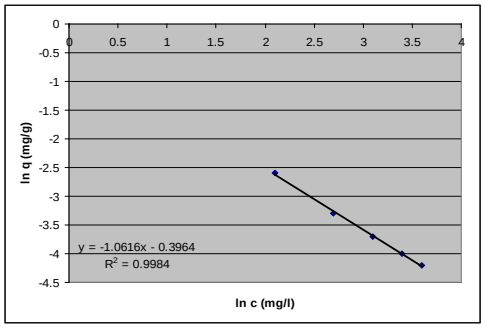

Figure 17 : Plot of Freundlich Isotherm for Barium Adsorption with APKH

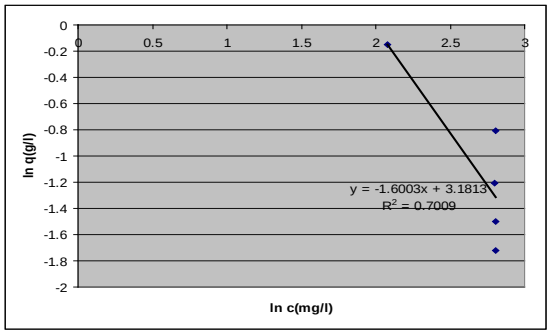

Figure 18 : Plot of Freundlich Isotherm for Zinc Adsorption with APKS

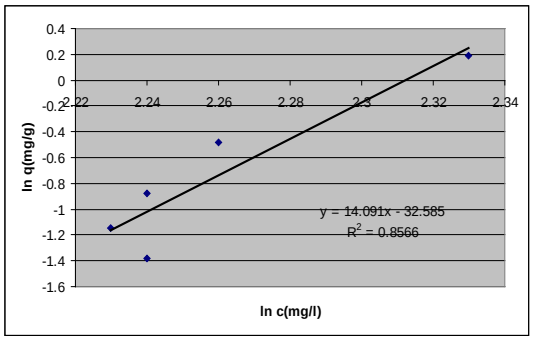

Figure 19 : Plot of Freundlich Isotherm for Zinc Adsorption with APKH

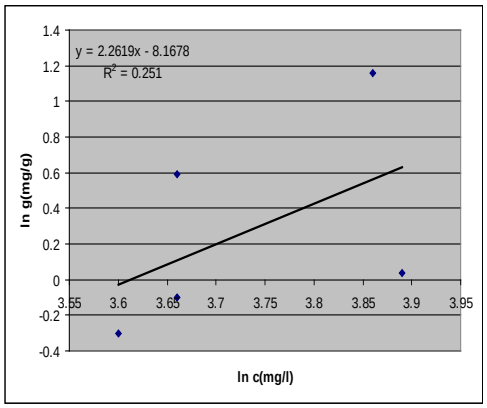

Figure 20 : Plot of Freundlich Isotherm for Mercury Adsorption with APKS

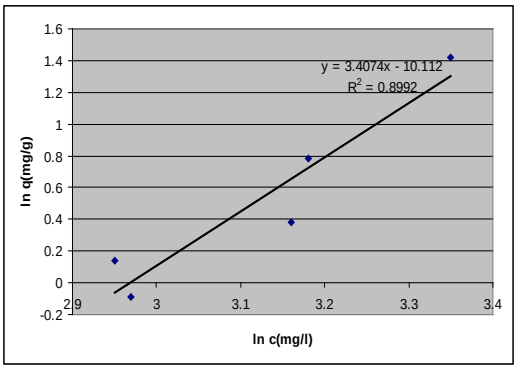

Figure 21 : Plot of Freundlich Isotherm for Barium Adsorption with APKS

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The Effect of High Water Content of Fuel on Diesel Engine Emission

By Abdulaziz H. El-Sinawi, Kifah Takrouri, Omar Osta & No'man Haimour
King Faisal University

Abstract - Introducing water with fuel in diesel engines has been proved to be powerful and economical method for reducing combustion pollutant emissions from the engine. Most studies available in literature discuss the effect of adding water to the fuel in the range 5 to 10% water. In this paper, results of modeling study are presented where the effect of relatively high water content in fuel has been investigated. The fuel used was a surrogate mixture composed of 70% n-Heptane and 30% Toluene with two water contents of 25% and 35% by volume. The modeling study was performed using the commercially available software CHEMKIN at diesel engine-relevant conditions. The results show that water, even at high percentages, still has the tendency to reduce pollutant emissions as its concentration increases. Also, fuel consumption was found to decrease by increasing water content. However, the tradeoff with CO and Unburned Hydrocarbons UHC emissions was maintained.

Keywords : *water-in-fuel emulsion, pollutants reduction, diesel, surrogate fuel, combustion.*

GJRE-C Classification : *FOR Code: 030599*

Strictly as per the compliance and regulations of :

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I. Introduction

The exhausted gaseous phase from diesel engines is usually composed of hundreds of chemical compounds and pollutants. High engine temperatures are usually involved in the exothermic reactions of fuel with air. With the existence of nitrogen and oxygen from air or fuel, nitrogen oxides NO_x and carbon oxides CO_x are among the major pollutants emitted by the combustion process. To a lesser extent, Unburned Hydrocarbons UHC and Volatile Organic Compounds VOC can also be emitted as well as many trace amounts of hazardous air pollutants. Due to the impact of these emissions on the environment, many countries are gradually strengthening the regulations related to these emissions. As a result, diesel engine designers are challenged with two often conflicting goals: reducing the engine emissions and at the same time improving its efficiency.

Recently, intensive research has been done worldwide on developing methodologies that reduce the diesel engine pollutant emissions. Many of these methodologies are focused on improvements in engine design. However, such improvements are usually costly and difficult to apply.

One method for pollutants reduction is to decrease the engine high temperature by bringing water into the combustion chamber. Water can be injected to the engine inlet manifold, directly injected to the combustion zone or can be injected in the form of water-in-diesel emulsion. Among these technologies, the use of water-in-diesel emulsions was reported to be the most efficient to reduce pollutant emissions as, in addition to other effects, water is injected directly into the combustion zone causing a larger decrease of the combustion temperature [1, 2]. Water-in-diesel emulsions can also be applied with virtually no additional costs.

The main reason for the reduction in pollutants emission in the use of water-in-diesel emulsion is the reduction in the combustion temperature. The reduction in the temperature itself is due to (1) vaporization of liquid water which decreases the internal energy and (2) increasing heat capacity due to having higher trapped mass of vapor. Moreover, water provides its improvements physically by enhancing mixing within the engine and chemically by reacting with the combustion gases. Also, water, which has a much lower boiling point than that of the surrounding diesel in the emulsion, suddenly and dramatically expands upon vaporization. This expansion increases turbulence and enhances the mixing between oxygen and fuel. This process is usually referred to as the micro-explosion process. Several researches reported that the emulsion combustion reactions are not simply kinetically controlled, but the turbulence inside the combustor has a considerable effect.

The water-in-diesel emulsions emit reduced amounts of particulate matters and soot. These emulsions also show better burning efficiency and therefore reduce fuel consumption without engine modifications. However, one limitation is the potential increase in CO and UHC production.

In practice, extensive research has been done on the use of water-in-fuel emulsions. Some water-in-fuel emulsions, such as the Aquazole formulation developed by TOTAL, are already in use today on a large number of vehicles in France and other countries in Europe. It has been claimed that this formulation brings about a reduction of up to 30% in NO_x and of up to 80% in soot [3]. Water-in-fuel emulsions have also been used on autobuses in some areas of China.

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In literature, high water content in diesel emulsions (more than 10%) was rarely discussed and needs to be thoroughly investigated [4, 5].

This study provides modeling analysis of emissions reduction obtained by using water-in-fuel emulsions with water ratios of 25% and 35% in volume. Surrogate fuel was used in this study as detailed kinetic and thermodynamic data can be available for selected surrogate fuels but not available for conventional diesel. Conventional diesel fuels are blends of several hundreds of individual components [6]. Surrogate fuels can be reasonably considered as simpler representatives of the chemically complex conventional diesel fuel in terms of performance and emissions behavior [6]. As one-component surrogate fuel may not accurately reflect the behavior of real diesel, surrogate fuels of more than one component are usually employed. However, a surrogate fuel should be prepared with the smallest possible number of components that provide the desired representation of the conventional diesel. Surrogate fuel composed of 70% n-Heptane and 30% Toluene was used in this study.

In most of the studies conducted with regard to water-in-fuel emulsions only NO_x and particulate matter were the emissions of concern [7]. Some recent studies investigated the CO and UHC emissions. In this study, emissions of CO, UHC, VOC and other compounds like propargyl, benzene and others were looked at as well as emissions of n-Heptane; one component of the surrogate fuel used.

II. Literature Review

This literature review is focused on the combustion studies where relatively high water content in fuel (20% and above) was used. There are inconsistent results reported in different studies where high water contents were used which reveal the need for further research on combustion of such emulsions. Lif et al. [3] reported that the typical water content of a diesel emulsion is between 10 and 20%. However, Nazha et al. increased the amount of water up to 50% and reported a 60% reduction in NO_x but noticed a slight increase in smoke emissions [9].

Park et al. [8] used water up to 40% in combustion tests and the general picture of pollutants reduction was maintained. However, small effects on CO and UHC emissions were reported. In another study [3], the NO_x and soot levels were significantly reduced for water contents between 15–45% but the CO and UHC emissions increased. Canfield [10] reported a significant pollutant emissions reduction with up to 45% water, by volume, in diesel. He reported that of six technologies evaluated for pollutants reduction, the water-in-diesel emulsion promises the easiest solution.

Matheaus et al. [6] used diesel having 20% water by mass in an experimental study to investigate the effect of water on the engine emissions and fuel consumption rate. He reported a 19% reduction in NO_x and 16% reduction in particulate matter. However, there was 42% increase in CO and 28% increase in UHC.

III. Modeling, Results and Discussion

In this study, the commercially available code CHEMKIN was used to investigate the combustion of the selected surrogate fuel (70% n-Heptane and 30% Toluene) with water content of 25 and 35% by volume. CHEMKIN contains an extensive database of temperature dependent properties and a built-in chemical reaction kinetics solver which is appropriate for detailed combustion calculations. CHEMKIN computation is performed using 393 species and 1,925 reactions. The Partially Stirred Reactor PaSR modeling approach was used in this analysis. PaSR can assess the extent of interactions between turbulence and chemical kinetics and therefore can provide information on how turbulence intensity inside a combustor will affect combustion [11].

The initial temperature and pressure for the computations are 900 K and 39 bar; respectively, with air as the oxidizer. The temperature and pressure values agree with the actual parameters of a real engine [6]. The fuel/air equivalence ratio was 0.8.

Fig. 1 shows typical profiles of some major exhaust emissions resulting upon combustion of the surrogate fuel with 25% water. Fig. 2 shows the emissions plotted against water mole fraction. Most of the data of this paper are plotted against water mole fraction in the exhaust gaseous phase being a better representing parameter.

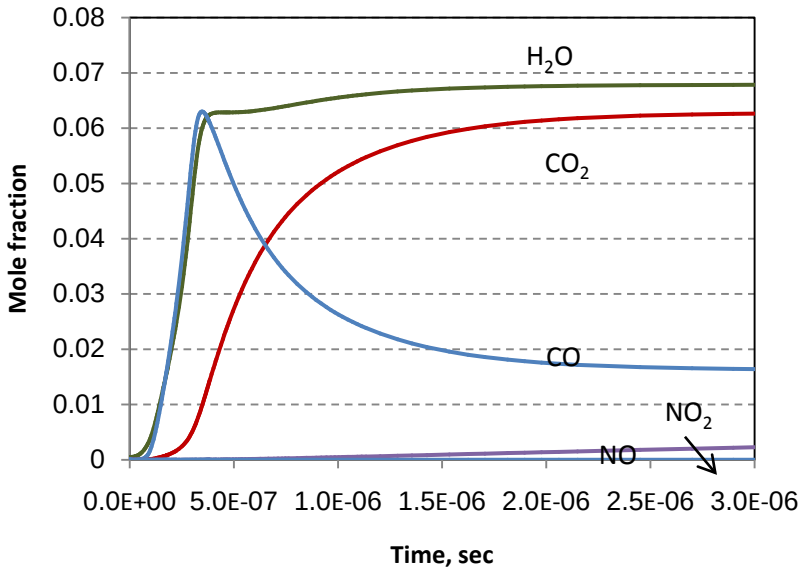

Fig. 1 : Typical NO_x, CO_x and water mole fraction profiles for 25% water content in emulsion of 70% n-Heptane and 30% Toluene.

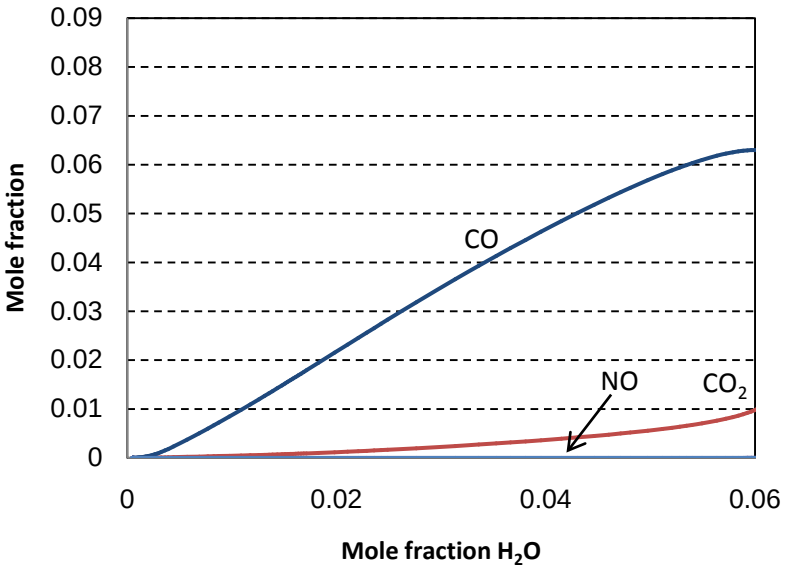

Fig. 2 : Typical plots of CO_x and NO mole fractions for 25% water content in emulsion of 70% n-Heptane and 30% Toluene.

Fig. 3 shows the calculated combustion temperature for the two water contents. As shown in the figure, the peak temperature decreases with increasing water content.

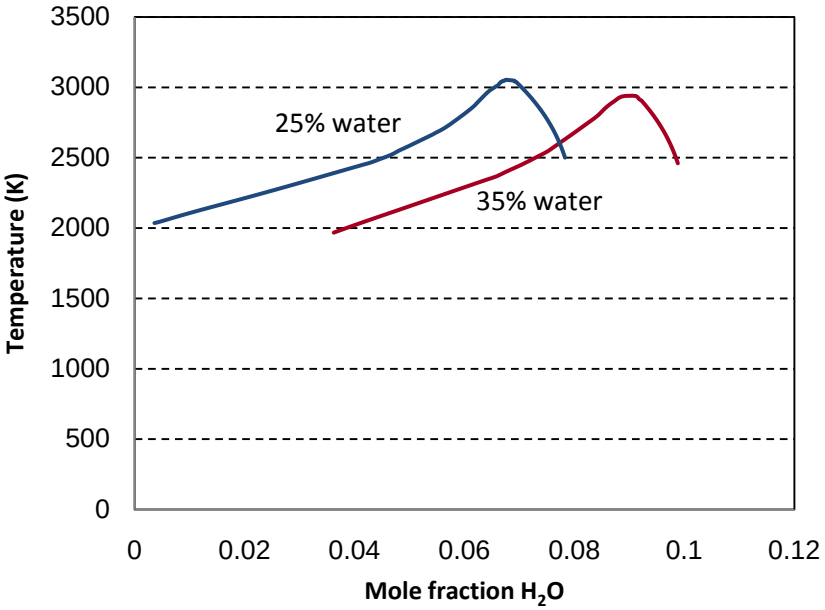

Fig. 3 : Calculated temperatures for 25% and 35% water in a surrogate fuel of 70% n-Heptane and 30% Toluene.

Fig. 4 shows the water mole fraction profile for the two emulsions. As expected, the water concentration in the exhaust gas is higher for the emulsion with higher water content.

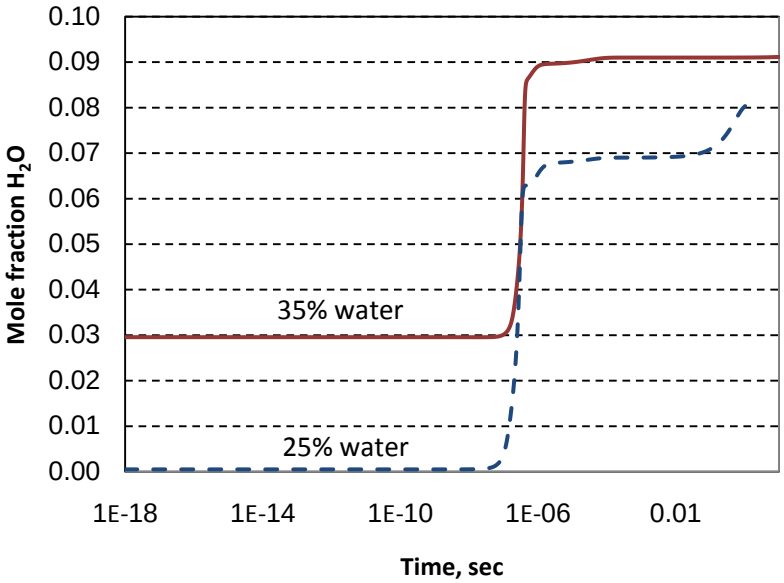

Fig. 4 : Water mole fraction profile for emulsions with water contents of 25% and 35% in a surrogate fuel of 70% n-Heptane and 30% Toluene.

Fig. 5 shows the mole fraction of n-Heptane for the two emulsions. The emulsion with the higher water content results in a higher n-Heptane concentration which is consistent with findings of other studies that increasing the water content may decrease the fuel consumption [3, 10, 12].

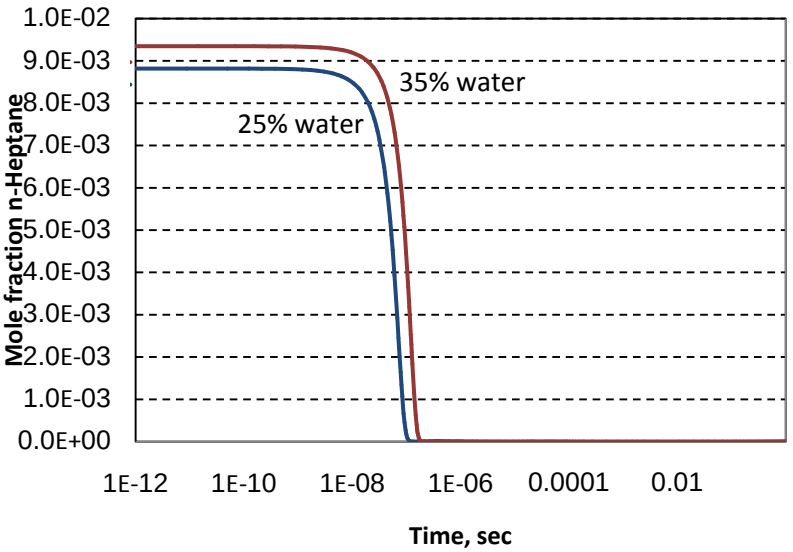

Fig. 5 : n-Haptane mole fraction for emulsions with water contents of 25% and 35% in a surrogate fuel of 70% n-Heptane and 30% Toluene.

Fig. 6 shows the effect of water content on CO, where CO and UHC are produced as a result of incomplete combustion. At high temperatures with more sufficient time, these two products further oxidize and form carbon dioxide and water.

As shown in Fig. 6, the final CO concentration increases with increasing water content in the emulsion. Water reduces the temperature inside the combustion chamber to a level where CO oxidation is inhibited. The reaction rates of CO with O, O_2 and OH decrease with decreasing temperature. Therefore the production rate of CO is increased. CO production rates for the two water contents are shown in Fig. 7 where the peak CO production rate increases as the water content increases.

The increase of CO level with increasing water content was experimentally validated by several researchers [13].

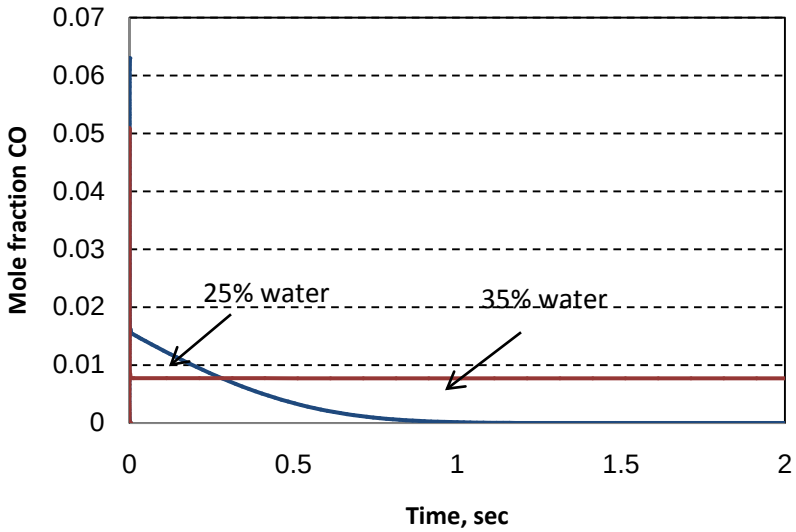

Fig. 6 : CO mole fraction for 25% and 35% water content in emulsion with 70% n-Heptane and 30% Toluene.

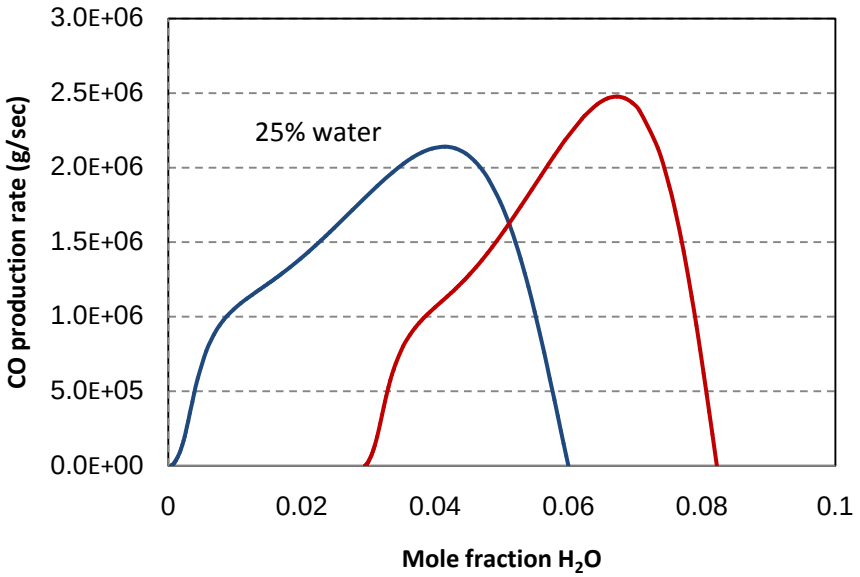

Fig. 7 : CO production rate (g/sec) for 25% and 35% water content in emulsion with 70% n-Heptane and 30% Toluene.

Fig. 8 shows the effect of water content on the UHC and VOC. As shown in the figure the amount of UHC increases as the water content increases. This result agrees with the findings of Milton and Carter, who showed for tests simulating a typical city driving cycle that UHC tend to increase by water injection [14], and with the findings of Prakash et al. [16].

UHC emissions are direct result of incomplete combustion of fuel. As water content in the emulsion increases, longer ignition delay and lower combustion temperature are usually experienced which may lead to the emission of more partially oxidized hydrocarbons [14, 16].

Therefore, while benefits to several pollutant emissions occur as a result of water addition to the fuel, these may be offset by the increase in CO and UHC emissions. However, researchers used emulsions of water with heavy oil [13] and biodiesel [2] reported a decrease in UHC emissions with increasing water content and thus the effect of water on UHC emissions needs further thorough investigation. Fig. 8 also shows the effect of water content on VOC emissions which like the UHC, increase with increasing water content. VOC are typically not acutely toxic, but instead may have compounding long-term health effects.

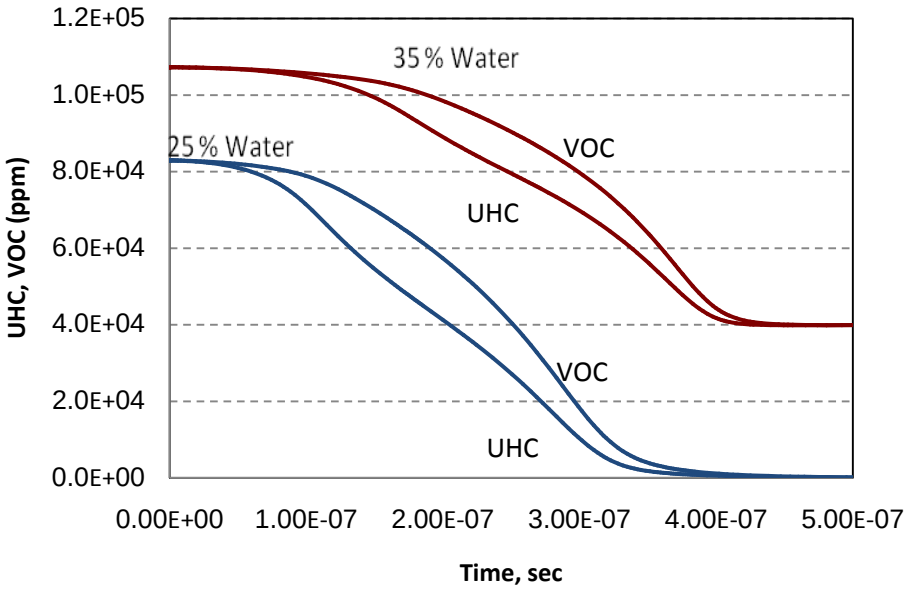

Fig. 8 : UHC and VOC for 25% and 35% water content in emulsion with 70% n-Heptane and 30% Toluene.

The effect of water content on propargyl C_3H_3 formation is shown in Fig. 9. C_3H_3 concentration decreases with increasing water content. C_3H_3 is a major precursor to form Polycyclic Aromatic Hydrocarbons PAH as two molecules of C_3H_3 can combine together to form Benzene ring C_6H_6. For low water contents, El-Sinawi [15] found that the formation of C_3H_3 decreases with increasing water content up to 5% then it increases when higher amounts of water were added with surrogate fuel composed of 80% n-Heptane and 20% Toluene.

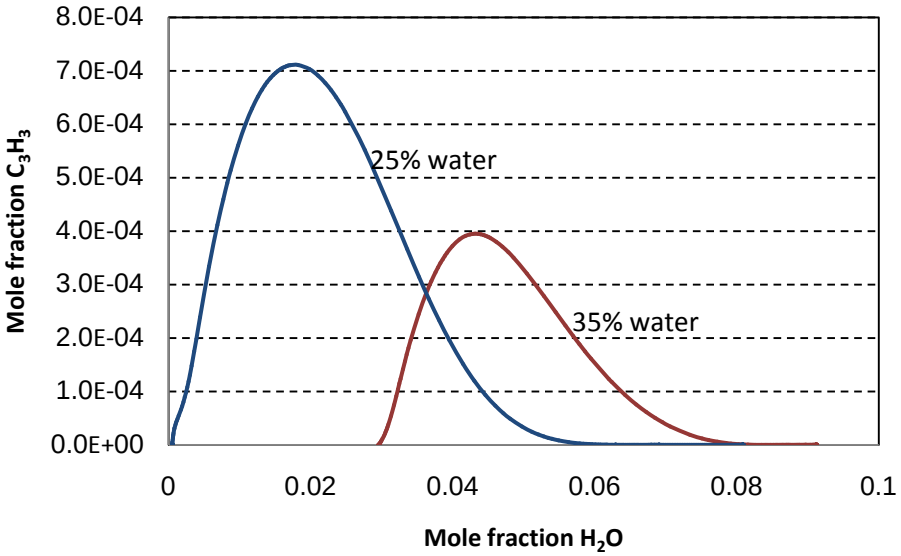

Fig. 9 : C_3H_3 mole fraction for 25% and 35% water contents in emulsion with 70% n-Heptane and 30% Toluene.

The effect of water content on Benzene formation is shown in Fig. 10. Benzene concentration decreases with increasing water content. Benzene can combine with Toluene and therefore has an important role in PAH and soot formation [4].

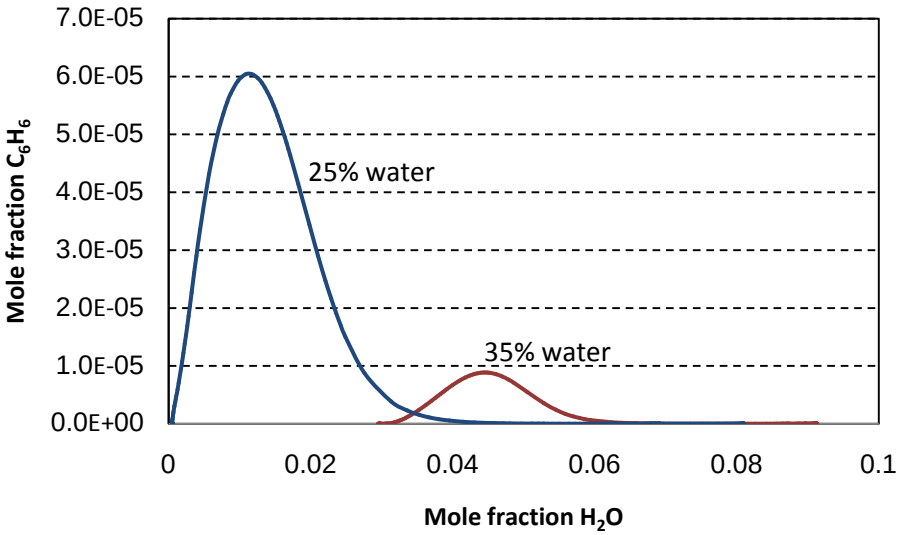

Fig. 10 : Benzene mole fraction for 25% and 35% water contents in emulsion with 70% n-Heptane and 30% Toluene.

Fig. 11 shows the effect of water content on the concentration of fulvene, which is a toxic compound. Increasing water content decreases fulvene emissions.

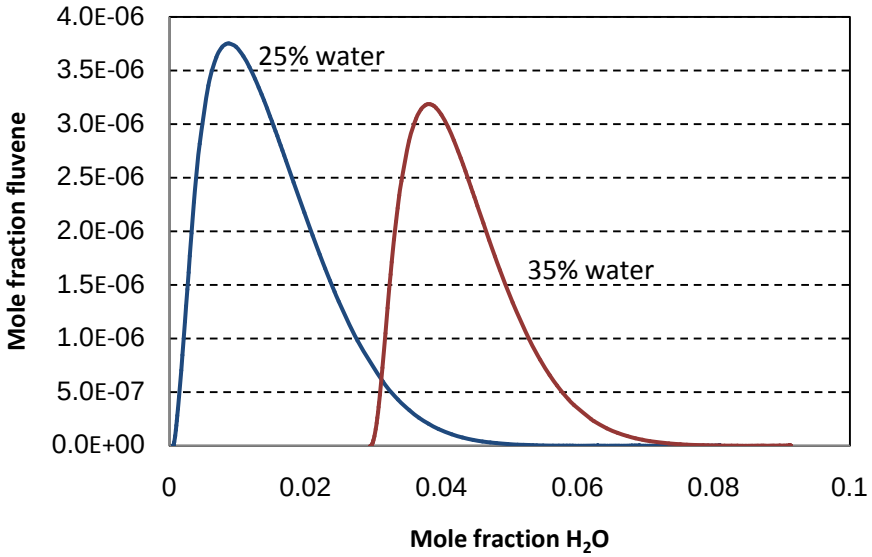

Fig. 11 : Fulvene mole fraction for 25% and 35% water contents in emulsion with 70% n-Heptane and 30% Toluene.

The concentration of nC_3H_7 group is shown in Fig. 12. nC_3H_7 can lead to the formation of formaldehyde which is very toxic and corrosive. The concentration of nC_3H_7 decreases as water content in the emulsion increases.

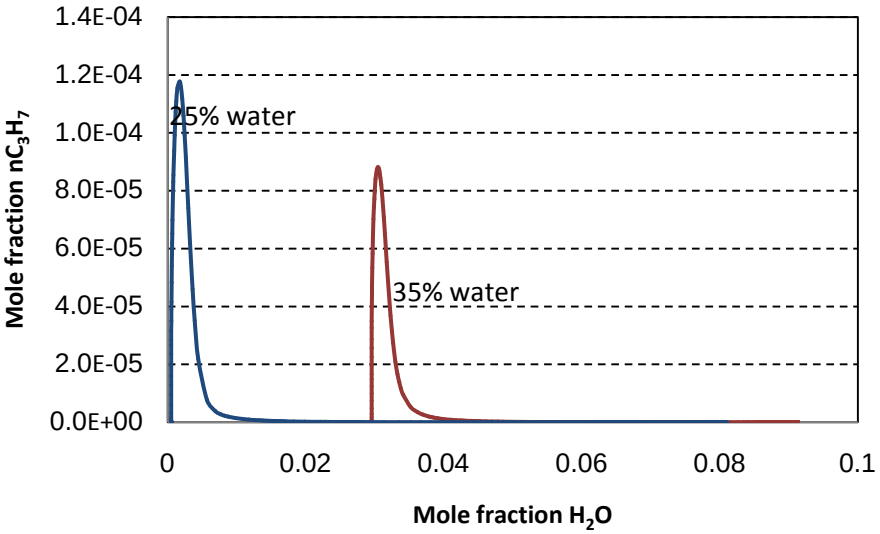

Fig. 12 : nC_3H_7 mole fraction for 25% and 35% water content in emulsion with 70% n-Heptane and 30% Toluene.

IV. Conclusions

The effect of adding a relatively high percentage of water to surrogate fuel composed of 70% n-Heptane and 30% Toluene on the formation of pollutants was discussed. The use of water-in-fuel emulsion is an effective technique to reduce pollutant emissions from surrogate fuel even at relatively high water contents of 25% and 35%. It was found that as water content increases the reduction of the emissions studied increases and the fuel consumption slightly decreases. However, the tradeoff with CO and UHC emissions was maintained.

V. Abbreviations

CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_x	Carbon Oxides
NO	Nitrogen Monoxide
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
PAH	Polycyclic Aromatic Hydrocarbons
UHC	Unburned Hydrocarbons
VOC	Volatile Organic Compounds

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Review papers: These are concise, significant but helpful and decisive topics for young researchers.

Research articles: These are handled with small investigation and applications

Research letters: The letters are small and concise comments on previously published matters.

5.STRUCTURE AND FORMAT OF MANUSCRIPT

The recommended size of original research paper is less than seven thousand words, review papers fewer than seven thousands words also.Preparation of research paper or how to write research paper, are major hurdle, while writing manuscript. The research articles and research letters should be fewer than three thousand words, the structure original research paper; sometime review paper should be as follows:

Papers: These are reports of significant research (typically less than 7000 words equivalent, including tables, figures, references), and comprise:

(a)Title should be relevant and commensurate with the theme of the paper.

(b) A brief Summary, "Abstract" (less than 150 words) containing the major results and conclusions.

(c) Up to ten keywords, that precisely identifies the paper's subject, purpose, and focus.

(d) An Introduction, giving necessary background excluding subheadings; objectives must be clearly declared.

(e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition; sources of information must be given and numerical methods must be specified by reference, unless non-standard.

(f) Results should be presented concisely, by well-designed tables and/or figures; the same data may not be used in both; suitable statistical data should be given. All data must be obtained with attention to numerical detail in the planning stage. As reproduced design has been recognized to be important to experiments for a considerable time, the Editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned un-refereed;

(g) Discussion should cover the implications and consequences, not just recapitulating the results; conclusions should be summarizing.

(h) Brief Acknowledgements.

(i) References in the proper form.

Authors should very cautiously consider the preparation of papers to ensure that they communicate efficiently. Papers are much more likely to be accepted, if they are cautiously designed and laid out, contain few or no errors, are summarizing, and be conventional to the approach and instructions. They will in addition, be published with much less delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and to make suggestions to improve briefness.

It is vital, that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

Format

Language: The language of publication is UK English. Authors, for whom English is a second language, must have their manuscript efficiently edited by an English-speaking person before submission to make sure that, the English is of high excellence. It is preferable, that manuscripts should be professionally edited.

Standard Usage, Abbreviations, and Units: Spelling and hyphenation should be conventional to The Concise Oxford English Dictionary. Statistics and measurements should at all times be given in figures, e.g. 16 min, except for when the number begins a sentence. When the number does not refer to a unit of measurement it should be spelt in full unless, it is 160 or greater.

Abbreviations supposed to be used carefully. The abbreviated name or expression is supposed to be cited in full at first usage, followed by the conventional abbreviation in parentheses.

Metric SI units are supposed to generally be used excluding where they conflict with current practice or are confusing. For illustration, 1.4 l rather than 1.4 × 10-3 m3, or 4 mm somewhat than 4 × 10-3 m. Chemical formula and solutions must identify the form used, e.g. anhydrous or hydrated, and the concentration must be in clearly defined units. Common species names should be followed by underlines at the first mention. For following use the generic name should be constricted to a single letter, if it is clear.

Structure

All manuscripts submitted to Global Journals Inc. (US), ought to include:

Title: The title page must carry an instructive title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) wherever the work was carried out. The full postal address in addition with the e-mail address of related author must be given. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining and indexing.

Abstract, used in Original Papers and Reviews:

Optimizing Abstract for Search Engines

Many researchers searching for information online will use search engines such as Google, Yahoo or similar. By optimizing your paper for search engines, you will amplify the chance of someone finding it. This in turn will make it more likely to be viewed and/or cited in a further work. Global Journals Inc. (US) have compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Key Words

A major linchpin in research work for the writing research paper is the keyword search, which one will employ to find both library and Internet resources.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy and planning a list of possible keywords and phrases to try.

Search engines for most searches, use Boolean searching, which is somewhat different from Internet searches. The Boolean search uses "operators," words (and, or, not, and near) that enable you to expand or narrow your affords. Tips for research paper while preparing research paper are very helpful guideline of research paper.

Choice of key words is first tool of tips to write research paper. Research paper writing is an art.A few tips for deciding as strategically as possible about keyword search:

- One should start brainstorming lists of possible keywords before even begin searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in research paper?" Then consider synonyms for the important words.
- It may take the discovery of only one relevant paper to let steer in the right keyword direction because in most databases, the keywords under which a research paper is abstracted are listed with the paper.
- One should avoid outdated words.

Keywords are the key that opens a door to research work sources. Keyword searching is an art in which researcher's skills are bound to improve with experience and time.

Numerical Methods: Numerical methods used should be clear and, where appropriate, supported by references.

Acknowledgements: Please make these as concise as possible.

References

References follow the Harvard scheme of referencing. References in the text should cite the authors' names followed by the time of their publication, unless there are three or more authors when simply the first author's name is quoted followed by et al. unpublished work has to only be cited where necessary, and only in the text. Copies of references in press in other journals have to be supplied with submitted typescripts. It is necessary that all citations and references be carefully checked before submission, as mistakes or omissions will cause delays.

References to information on the World Wide Web can be given, but only if the information is available without charge to readers on an official site. Wikipedia and Similar websites are not allowed where anyone can change the information. Authors will be asked to make available electronic copies of the cited information for inclusion on the Global Journals Inc. (US) homepage at the judgment of the Editorial Board.

The Editorial Board and Global Journals Inc. (US) recommend that, citation of online-published papers and other material should be done via a DOI (digital object identifier). If an author cites anything, which does not have a DOI, they run the risk of the cited material not being noticeable.

The Editorial Board and Global Journals Inc. (US) recommend the use of a tool such as Reference Manager for reference management and formatting.

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Tables: Tables should be few in number, cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g. Table 4, a self-explanatory caption and be on a separate sheet. Vertical lines should not be used.

Figures: Figures are supposed to be submitted as separate files. Always take in a citation in the text for each figure using Arabic numbers, e.g. Fig. 4. Artwork must be submitted online in electronic form by e-mailing them.

Preparation of Electronic Figures for Publication

Even though low quality images are sufficient for review purposes, print publication requires high quality images to prevent the final product being blurred or fuzzy. Submit (or e-mail) EPS (line art) or TIFF (halftone/photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Do not use pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings) in relation to the imitation size. Please give the data for figures in black and white or submit a Color Work Agreement Form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution (at final image size) ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs) : >350 dpi; figures containing both halftone and line images: >650 dpi.

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6. AFTER ACCEPTANCE

Upon approval of a paper for publication, the manuscript will be forwarded to the dean, who is responsible for the publication of the Global Journals Inc. (US).

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(Free of charge) from the following website:

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the search? Will I be able to find all information in this field area? If the answer of these types of questions will be "Yes" then you can choose that topic. In most of the cases, you may have to conduct the surveys and have to visit several places because this field is related to Computer Science and Information Technology. Also, you may have to do a lot of work to find all rise and falls regarding the various data of that subject. Sometimes, detailed information plays a vital role, instead of short information.

2. Evaluators are human: First thing to remember that evaluators are also human being. They are not only meant for rejecting a paper. They are here to evaluate your paper. So, present your Best.

3. Think Like Evaluators: If you are in a confusion or getting demotivated that your paper will be accepted by evaluators or not, then think and try to evaluate your paper like an Evaluator. Try to understand that what an evaluator wants in your research paper and automatically you will have your answer.

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10. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right! It is a good habit, which helps to not to lose your continuity. You should always use bookmarks while searching on Internet also, which will make your search easier.

11. Revise what you wrote: When you write anything, always read it, summarize it and then finalize it.

12. Make all efforts: Make all efforts to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in introduction, that what is the need of a particular research paper. Polish your work by good skill of writing and always give an evaluator, what he wants.

13. Have backups: When you are going to do any important thing like making research paper, you should always have backup copies of it either in your computer or in paper. This will help you to not to lose any of your important.

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15. Use of direct quotes: When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

16. Use proper verb tense: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

17. Never use online paper: If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

18. **Pick a good study spot:** To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

19. Know what you know: Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

20. Use good quality grammar: Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

21. Arrangement of information: Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

23. Multitasking in research is not good: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. **Think technically:** Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be

sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page

- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

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Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

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The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to

shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

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The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

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- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

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- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

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- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

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- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

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- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.

- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

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- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

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The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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