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EXPERIMENTAL STUDY ON WASTEWATER TREATEMNT FROM AIR CONDITIONER PLANT OF CALEDONIAN COLLEGE OF ENGINEERING, OMAN

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Abstract

Purpose of the study: Treatment of the wastewater coming from households, laboratories, big AC plants etc. is very important. For this the use of low cost activated carbon is highly preferable and eco-friendly making great improvements in the quality of wastewater also. The aim of this study is to clean the wastewater collected from Air Port Height Campus of Caledonian College of Engineering, by the use of activated carbon in batch process.

Methodology: Wastewater sample is collected from Airport height campus of CCE, Oman. It was treated using activated carbon in batch study, and the quality of water is tested in terms of % variation in COD in the college laboratory. Time, activated carbon dose, pH, and temperature variation were conducted on 50 ml batch size.

Main Findings: Maximum COD removal was 88% at carbon dose 0.2g, time 30 min, pH 5 and temperature 55^{0}C.The results obtained from experiments were also analysed by Langmuir and Freundlich isotherm. Results shows that the process fit well with Freundlich isotherm because R^2 values are higher for the linear relationships.

Applications of this study: The results obtained from the experiments clearly indicate that the quality of the treated water has improved and if some more parameters that are concerned with the purity factor can be introduced, this water can be made available in form of non-potable usage also. So, this study is highly beneficial for our earth as well as human beings.

Novelty/Originality of this study: The experiment performed is very eco-friendly as low cost and easily available chemicals and activated carbon is used here, so it will relieve us from the expensive and complicated methods for wastewater treatment.

Keywords: activated carbon, wastewater treatment, adsorbents, BOD, COD, isotherms

INTRODUCTION

Water pollution is one of the most appalling problems which can lead the world to destruction. Because of the easy solvent nature of water, most of the solvents get easily dissolved and so contaminate it and those organisms and also the vegetation including amphibians, which survive in water are the most affected ones. It must be also noted that human beings are also highly affected, so they die due to consumption of polluted and infected water. The main reason for the pollution of water is the discharge of various types of pollutants either directly or indirectly into the water bodies without prior treatment for the removal of the harmful substances or compounds. So in few words water pollution is defined as "the addition of harmful chemicals to natural water".

Various examples of the wastewater pollution in Oman: The domestic use of water by humans for examples water from toilets flush, washing, laundry, food preparation, and cleaning of kitchen utensils is transferred to the treatment plants. i.e., Muscat projects Environmental services (MPES) is one of the companies which uses the domestic waste water for treatment of the water than use for the garden.

Because of the improper wastewater treatment in Oman (Khaliq et al, 2017), are being affected by improper disposal of wastewater and thus findings say that most areas of the Oman are still suffering from the presence of large quantities of untreated wastewater and this water is has been disposed of in unsuitable ways, such as in dumping in holes in the ground and landfills. With this some other factors are also responsible for the land contamination (Baawain et al, 2014), example; there are some districts in Oman (Miklos et al, 2018) which still do not have their own treatment stations despite high population density.

There are also some districts with high industrial output but they are not having their own treatment resources. For an example Barka in the North Batina of Oman has problem with the sea water, because of the sea water Salinization enter to the fresh water, the northern part of Barka is more vulnerable to pollution than southern part and the central part of Barka also shows high relative vulnerability which is mostly related to the high conductivity values.

Also the changes in water level due to the high abstraction rate of groundwater reflect the vulnerability maps. The problem of salinization of water in Barka is a big problem faced in Oman and this will lead to the death of agricultural crops and animals, and there will be shortage of fresh water also.

The water produced from the industries is industrial wastewater. Three types of samples are collected for characterization in Oman as shown in the following table 1.

Table 1: Basic information on STPs in Oman

STP	Capacity	Treated effluent (m^3/day)	Sludge (ton/month)	Sludge conditioning
RSLIE	1200	800	3.6	Drying Beds
RIE	470	125	0.58	Drying Beds
SIE	700	300	0.7	Drying Beds

Wastewater Technologies used in Oman: For the water treatment (Lubbecke et al, 1995) many different technologies are used in Oman. One of the best examples is Haya Company. Haya Water has met these challenges through the use of innovative tunnelling technology and other modern techniques to minimize disruption and thus ensures the effective implementation of the project, and also uses technology such as membrane bioreactor systems that are far beyond the quality normally required.

Research problem: In Oman there are two main types of water resources; the (natural) including surface and ground water that is present about 87% and nonconventional water resources including desalination water and treated wastewater that is present about 13%. Oman is one of the country in world having water pollution for example in the coastal plains and desert areas it is relatively low even less than 40mm. However the rain fall is greater up to 350mm, and this provides a source of natural recharge to a number of aquifers including those in the interior and coastal areas. Three types of water sources are in Oman; surface water like the aflaj, springs, represents over 70% of the total water usage. There is severe shortage of water in some places, like Al-Batinah and Salalah coastal areas due to the desalination of sea water which becomes an important contributor to water supply in places where natural water resources are unavailable or inadequate. Water collected from wash rooms, labs, workshops, big A. C. plants is in big volume but is a waste and thus thrown, as it is not hygienic and so is a great opportunity as this water can be easily treated, recycled and reused for cleaning, gardening etc. purposes in CCE

Activated carbon and Adsorption: Activated carbon (Streicher et al, 2016) is a carbonaceous, highly porous adsorptive medium that has a complex structure composed primarily of carbon atoms. The networks of pores in activated carbons are channels created within a rigid skeleton of disordered layers of carbon atoms, linked together by chemical bonds, stacked unevenly, creating a highly porous structure of nooks, crannies, cracks and crevices between the carbon layers. It is manufactured from coconut shell, peat, hard and soft wood, lignite coal, bituminous coal, olive pits and various carbonaceous specialty materials. Chemical activation or high temperature steam activation mechanisms are used in the production of activated carbons from all these raw materials.

Mainly there are two types of adsorption as given below:

Physical Adsorption: In this type of adsorption, the adsorbents are held on the surface of the adsorbate that is the pore walls by weak forces of attraction known as van der Waals forces or London dispersion forces.

Chemisorption: In this type of adsorption, the adsorbents are held on the surface of the adsorbate by relatively stronger forces of attraction, that is actual chemical bonds between adsorbents and chemical complexes on the pore wall of the activated carbon are there.

A number of adsorption studies for dye removal (Mittal et al., 2009) have been carried out using activated carbon made from nonconventional source adsorbents. In general, these carbons will be efficient in the adsorption of both organic and inorganic as the commercial activated carbons. There are a number of applications of commercially activated carbon. If low cost nonconventional sources are used to prepare activated carbons for a specific purpose, then they will be economical for wastewater treatment. There are different types of activated carbon. It is mainly available in three forms, powder, granular and extruded and every form is available in different size range so a specific form and size are recommended depending upon the application and requirements.

Aim of the study: The aim of this study is to clean the wastewater collected from Air Port Height Campus CCE, by the use of activated carbon in batch process.

LITERATURE REVIEW

The amount of water consumed per day plays a very crucial role in the maintenance of a healthy body and with this plants and animals also need water for their survival. Apart from drinking, the water which is used in other types activities and the left over water which is a type of waste water is adversely affected in quality in a combination by anthropogenic influence, so in simple words the waste water can originate from any of the domestic, industrial (Meas et al., 2010) commercial or agricultural activities.

For obtaining safe drinking water monitoring and control technologies are important. It helps in observing the quality of water source and the detection of biological cell and chemical threats, all this will in turn provide the boundary conditions for the respective water treatment and also gives an early warning in case of unexpected contaminations. So these parameters are very important for monitoring process. The analytical tools applied for this purpose are highly dependent on the nature of the supply system considered

Sampling is a key step in the wastewater monitoring (Daughton et al., 2018), whatever may be the objectives- regulation compliance, t- compliance or discharge impact, and it is always the first step of the classical analytical process prior to laboratory analysis or online measurement. Before considering analytical methods for wastewater quality monitoring, based on either standard or alternative procedures, the sampling step must be considered because of the importance as a source of possible errors (Akpor et al., 2011)

Evan et al., in 2013 has discussed in his article about the laboratory tests, focused on four major categories: first category includes the analysis of the wastewater, this will help in determination (Metcalf et al., 2003, Apha, 2005) of the concentration of carbon-based compounds aimed at establishing the relative "strength" of wastewater i.e., Biochemical oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Organic Carbon (TOC). Second category includes the solids, this gives the measurement of the concentration of particulate solids that can dissolve or suspend in wastewater e.g., Total Solids (TS),Total Suspended Solids (TSS), Total Dissolved solids (TDS), Total volatile solids(TVS), and Total Fixed Solids(TFS), third category includes the nutrients, this gives the measurement of the concentration of targeted nutrients e.g., nitrogen and phosphorus that can contribute to the acceleration of eutrophication (the natural aging of water bodies), and finally the fourth category includes the physical properties and other parameters. It is very important to note that analytical tests are designed to measure a varied group of constituents and they directly affect waste water treatment e.g., temperature, color, pH. Turbidity, odor.

Rengarajet al., in 1999mentioned in his research article that the activated carbons (Rengaraj et al., 1999) will be highly efficient in the adsorption of both organic and inorganic as the commercial activated carbons Commercial activated carbon are sophisticated in the sense that they are designed for a variety of applications. If low cost, non-conventional sources are used to prepare activated carbons for a specific purpose, then they will be economical for wastewater treatment. So activated carbon is very important wastewater treatment.

Mohamed et al. in 2014, discussed about the coagulants, alum and regular natural *Moringa oleifera* and *Strychnos* Potatorum (Mohamed et al. 2014) are also assessed for various measure of doses, running from 30 mg/l to 200 mg/L .These are also assessed for pH. The effectiveness of regular natural range 30 was much more powerful in contrast with dose of synthetic coagulants that is 80mg/L. *Moringa oleifera* demonstrated 90% turbidity, 60% and 75 COD phosphorus, strychnos indicated removal of 96% y, 55% COD 65% while Potatorum phosphorus Information demonstrated that the *Moringa oleifera* seed and *Strychnos Potatorum* contained coagulating substances suitable for removing turbidity up to 99%. The materials and methodology are as follows:

The carwash wastewater was collected on weekdays and weekends at three different times, 11.00 am, 2.00 pm and 4.00 pm samples. The result shows that the raw carwash wastewater is characteristics of different samples. Those data are considered which were collected on the weekend and weekdays and When the comparison is done on the basis of all parameters between the weekdays and the weekends, the result shows that the samples collected on the weekends showed higher turbidity, pH in sample 1and in sample 2 was found to be 8.68 and 7.85 respectively on weekends, COD in sample 1 and in sample 2 was found to be 105 458 mg/l and -27.392 mg/L respectively, TSS in sample 1 and sample 2 was found to be 83.72 mg and 82 mg respectively, and oil and grease in sample was found to be 1 1.78x10 s whereas no oil and grease were found in sample 2.

F. Rigas, et al., 2000, excellently discussed in his article about an alternative separation device which depends on the focus concentrations, flocculent and water pH (Difusa et al., 2015) reading resulting from the process of dewatering of oil tanks in the a leading wasp treatment interval for effective joint action of a blood clot and the flocculent, the central used compound of experiences designed to build the response surfaces of the second degree of turbidity. For this purpose, proved intervals are taken for fast and reliable investigation of multivariate systems and to search the optimum state through statistical design of experiments.

Howlader et al. in 2004, mentioned in their article that the use of conventional water and wastewater treatment processes are becoming day by day challenging (Van Koerten et al, 2000) because of the identification of more and more contaminants, rapid growth of population and industrial activities, and diminishing availability of water resources. So three emerging treatment technologies, including membrane filtration, advanced oxidation processes (AOPs), and UV irradiation, provide alternatives for better protection of public health and the environment and therefore the main emphasis is on their basic principles, the main applications, and new developments. With this the advantages and disadvantages of these new emerging technologies are compared to highlight their current limitations and future research needs. Thus it is concluded that, with the growing knowledge and advances in manufacturing industry, the applications of these technologies are also increasing at an unprecedented scale.

The hazardous nature of the oil contents present in the water has significant amount of threats to the soil, water, air and human beings. One of the main objectives of this review paper is to highlight the currently developed methods for oily wastewater treatment which will help in removal of contaminants such as oil, fats, grease, and inorganic. These methods include electrochemical treatment, membrane filtration, biological treatment, hybrid technologies. The methodology and materials used in this study include electrochemical method and it is one of the most effective oily wastewater treatment techniques employed recently. Several electrochemical technologies have been applied to treat oily wastewater from different sources. The electrochemical technologies include electrochemical oxidation processes and electro-Fenton achieved using several electrodes. Electrode materials such as iron, aluminum, boron doped diamond, platinum-iridium, and titanium- rubidium have been tested. A summary of the treatment efficiencies of electrochemical technologies obtained in some works aimed at removing pollutants from different sources of oily wastewater are presented here. The results show that the optimum removal of COD at a current density of 100 mA/cm and a temperature of 50 'C reached 40% after 12 h and 57% after 70 h. This work was carried out on batch electrocoagulation experiments in the treatment of petroleum refinery wastewater and they assessed the removal of COD and sulfate by using different types of electrodes such as of aluminum, stainless steel and iron at 25 'C and different current densities in the range of 2-13 m. The results show that the aluminum electrode was the most effective, with the removal of 93% of sulfate, and this is more than 2.5 times as compared to the other electrodes. It was also found that as the current density increases, the sulfate removal also increases.

It has also been noticed that there are a lot of pollutants and wastes in the wastewater such as nutrients, inorganic salts, pathogens, coarse solids etc. which are really dangerous for ecology and human so for removal of these pollutants, diff erent processes are to be employed which aim to reduce the pollution of the water. There are specific processes and unit operations in sewage, one is Chemical unit processes and physical processes. The Chemical processes plays an important role in advanced cleansing. There are a number of other chemical processes, such as precipitation, coagulation, neutralization and stabilization, ion exchange, oxidation and advanced oxidation which may be added to sewage water during the purifying procedure. The physical process is mainly used in wastewater treatment methods which cleanse the wastewater, such as flocculating, floatation, mixing, filtration, screening and gas transfer.

METHODOLOGY

In this work, waste water sample is collected from airport height campus and then it is treated using activated carbon (Cecen et al., 2011) in batch study, and the quality of water is tested in the laboratory. The steps and factors required in the process are listed below. LR grade Activated carbon, Hydrochloric acid (HCl), Sodium hydroxide, (NaOH), COD Vials were collected from CCE lab.

Experiment performed with different dose concentrations:

In this step, the dose variation for four different sample is tested. Firstly 50 ml of sample is taken. Then it is mixed with different value of active carbon ranging from 0.1g , 0.2g , 0.3g , 0.4g ,and 0.5g in the beaker for a fixed time of 30 min for each sample. After 30 min the sample is filtered using paper filtration, funnel and beaker. Then 0.2 ml of each of the test sample is taken for COD analysis, this will take 2 hours.

Experiment performed at different time intervals:

In this step, the time variation of four different sample is analyzed. Firstly 50ml of sample is taken and mixed with 0.2 g value of activated carbon [Fares et al., 2018] in the beaker. Then the sample is tested for the different time range (15 min, 30min, 40min, and 60 min) at fixed room temperature. After this the sample is filtered and 0.2 ml of each of the test sample is taken to test COD, this testing will take 2 hrs.

Experiment performed at different temperatures:

In this step, the effect of variation of temperature is studied for the process. Firstly 50ml of the sample is taken in the beaker and then 0.2 g value of activated carbon is mixed. After this the sample is tested for the different temperature ranges (25'C, 35'C, 45'C, 55'C) using Magnetic stirrer for 30 min. After 30 min the sample is filtered and then in the final step 0.2 ml of each of the sample is taken for testing COD, this testing will take 2 hrs.

Experiment performed at different pH values:

In this step, pH variation of four different samples is analysed. 50ml of sample is taken, firstly pH is tested, then it is mixed with different value of activated carbon start from (0.1g , 0.2g , 0.3g , 0.4g ,and 0.5g) in the beaker and the time is fixed for 30 min for each test and then Magnetic stirrer is used (at room temperature), after 30 min the sample is filtered using paper filtration, funnel and beaker. After filtration, 0.2 ml of each of the sample is taken for testing COD.

RESULTS/FINDINGS

Waste water collected from airport campus in CCE Oman. And following properties were recorded.

Table 2: Comparison of parameters between waste water and pure water

Parameters	Waste water	Pure water
pH	8	7.4
COD	88 ppm	10 ppm
BOD	2.27 ppm	1.2 ppm
TDS	139.5 ppm	102 ppm

Table 2 shows a comparison between waste water and pure water and it is clear that the values of the parameters such as pH, COD, BOD and TDS is much higher as compared to that obtained in the case of pure water.

Experiment performed with different dose concentrations:

50 ml of waste water is taken at different values of activated carbon at room temperature, with fixed time 30 min, pH 7.8 (as shown in table 3)

Table 3: COD removal with activated carbon variation

Activated Carbon (g)	COD ppm	% Removal	C_e	q_e	C_e/q_e	log C_e	log q_e
0.1	43	51.10	43	450	0.095	1.633	2.65
0.2	40	54.50	40	240	0.166	1.602	2.38
0.3	39.5	55.11	39.5	161.6	0.244	1.596	2.2
0.4	38.6	56.13	38.6	123.5	0.312	1.586	2.09
0.5	36.3	58.75	36.3	103.4	0.531	1.559	2.01

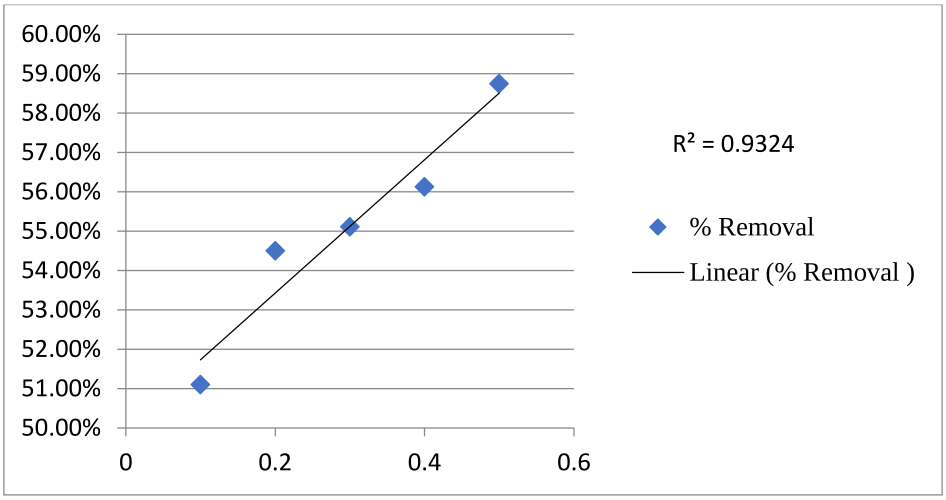

Figure 1: % COD removal in activated carbon variation

It is clear from the Figure 1 that % removal increases as the dose of activated carbon is increasing. This is due to the fact that with the addition of activated carbon (Ismadji et al, 2001) in batches, there occurs decrease in the value of COD.

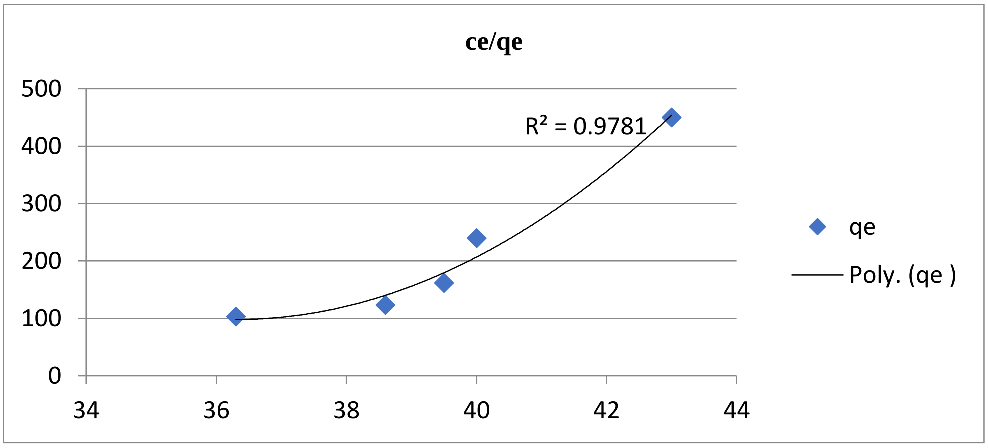

Figure 2: Freundlich isotherm for activated carbon variation

Langmuir and Freundlich isotherms were plotted for activated carbon dose variation. From the figures 2 and 3, it is clear that the results well fit with Freundlich isotherm because R^2 values are higher for the linear relationships (Rege et al. 1991).

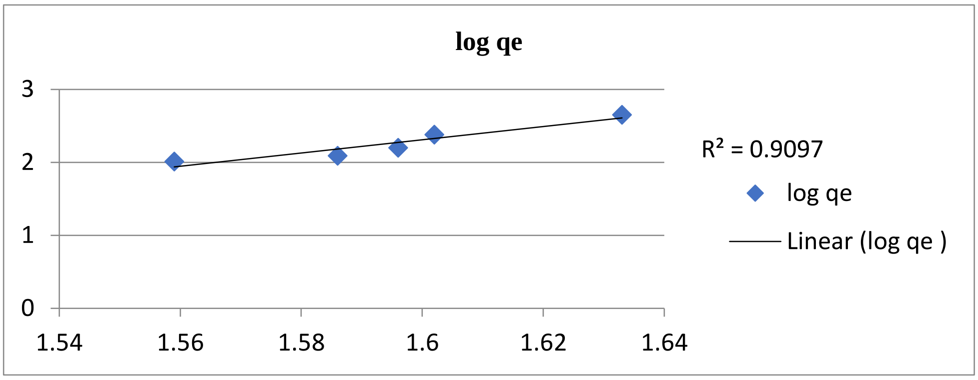

Figure 3: Langmuir isotherm for activated carbon variation

Experiment performed at different time intervals:

50ml of wastewater is taken with 0.2 g of activated carbon (Shukla et al., 2020) at room temperature at different time intervals (Ibrahim et al., 2017), as shown in table 4,

Table 4: COD removal with variation of time

Time min	COD ppm	% Removal	C_e	Q_e	C_e/Q_e	log C_e	log Q_e
15	33.2	62.20%	33.2	3.65	9.09	1.52	0.56
30	30	65.90%	30	1.93	15.54	1.47	0.28
40	28.1	68.00%	28.1	1.49	18.85	1.44	0.17
60	20	77.20%	20	1.13	17.69	1.3	0.05

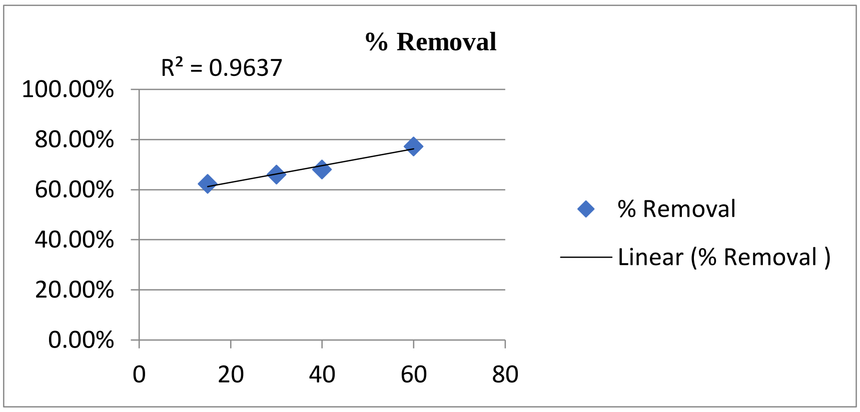

Figure 4: Isotherm showing COD removal with time

From the figure 4, it is clear that % removal increases as the time is increasing because of value of COD decreases (Mulyani et al., 2018) with increase in time intervals.

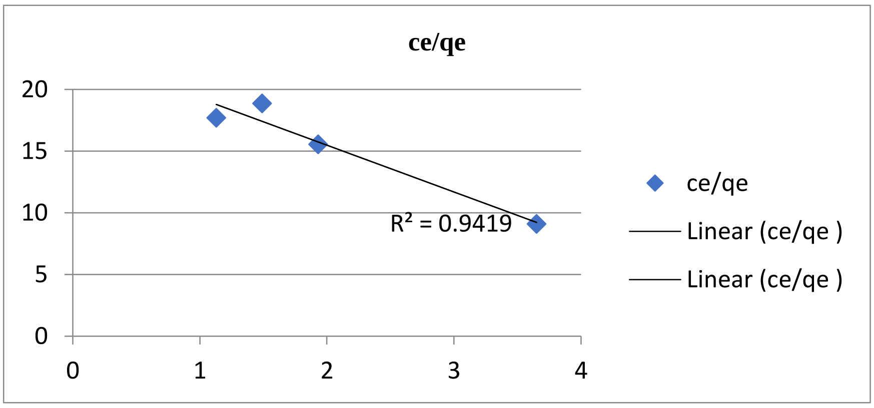

Figure 5: Freundlich isotherm for time variation

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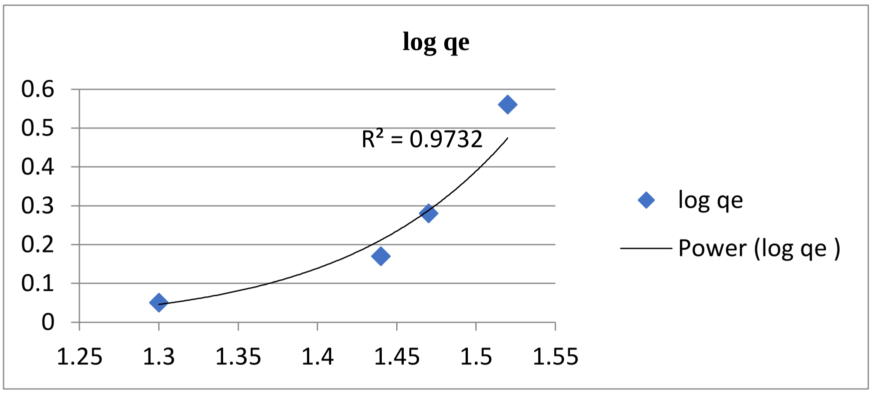

Figure 6: Langmuir isotherm for variation of time

All the above obtained results were also analyzed by Langmuir and Freundlich isotherm. From the figures 5 and 6, it is clear that the results well fit with Freundlich isotherm because R^2 values are higher for the linear relationships.

Experiment performed at different temperatures:

50ml of wastewater is taken with 0.2 g of activated Carbon (Jiang et al, 2019) at different temperatures with fixed time intervals (as shown in table 5)

Table 5: COD removal with temperature variation

Temperature 'C	COD ppm	% Removal	C_e	Q_e	C_e/Q_e	log C_e	log Q_e
25	30.3	65.50%	30.3	2.308	13.12	1.48	0.36
35	22.4	74.50%	22.4	1.874	11.95	1.35	0.27
45	15.5	82.30%	15.5	1.611	9.62	1.19	0.2
55	10	88.60%	10	1.418	7.05	1	0.15

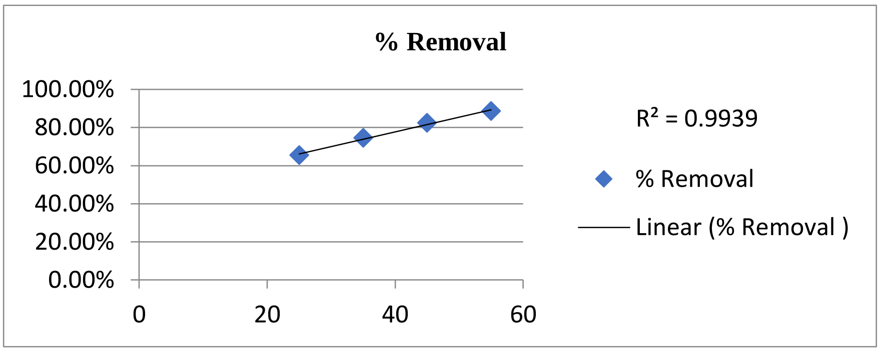

Figure 7: Isotherm showing COD removal with temperature

From the figure 7, it is clear that with the increase in temperature, the % removal also increases because of the decrease in the COD value as the time increases.

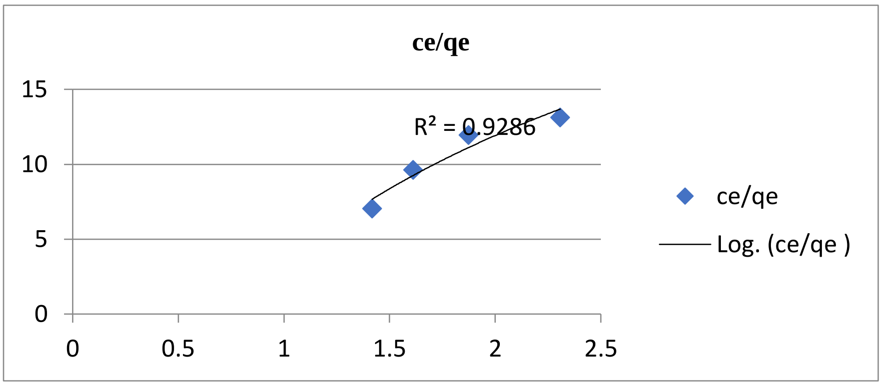

Figure 8: Freundlich isotherm for temperature variation

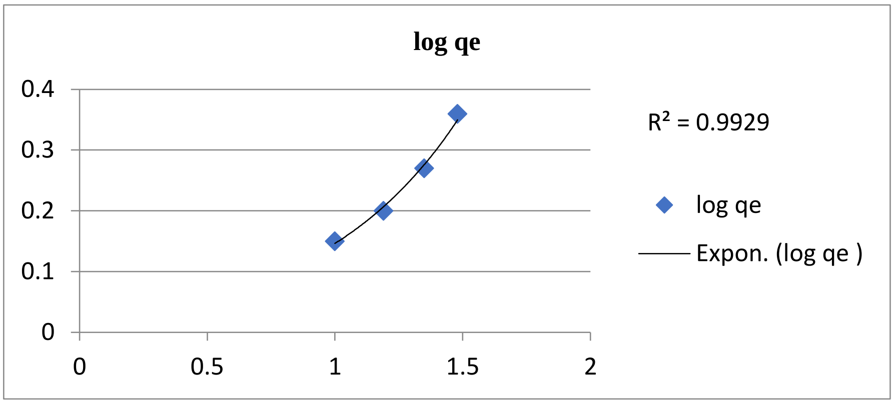

Figure 9: Langmuir isotherm for temperature variation

All the above obtained results were also analyzed by Langmuir and Freundlich isotherm. From the figures 8 and 9, it is clear that the results well fit with Freundlich isotherm because R^2 values are higher for the linear relationships.

Experiment performed at different pH values:

50ml of wastewater is taken with 0.2g of activated Carbon at different pH values, at fixed temperature and time (as shown in table 6).

Table 6: **COD removal with pH variation**

pH	COD	% Removal	ce	eq	ce/qe	log ce	log qe
3	23	73.80%	23	21.6	1.06	1.36	1.33
4	18	79.50%	18	17.5	1.02	1.25	1.24
5	10	88.60%	10	15.6	0.64	1	1.19
7.8	15	82.90%	15	9.7	1.23	1.07	0.98
8	22.5	74.40%	22.5	7.2	3.09	1.35	0.86
10	30	65.90%	30	5.8	5.17	1.47	0.76

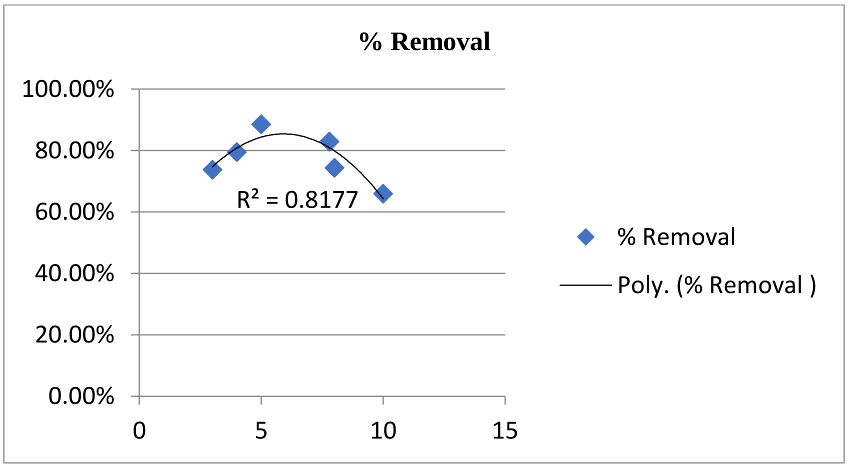

Figure 10: Isotherm showing COD removal with pH variation

From the figure 10, it is clear that with the increase in pH value, there is increase in the % removal but at the maximum value of pH (=7.8), there occurs decrease in the % removal. This is actually due to the decrease in COD value when time increases in batches (Dyan et al., 2015)

CONCLUSION

Water is life, so it has become one of the greatest need of the hour to treat the waste water coming from households, laboratories, big A. C. plants etc. For this important treatment process a number of methods are employed which are very expensive. Here in this project, it is well explained as how the waste water treatment can be safely and cheaply done by the use of activated carbon in batch reactors and also with some easily available chemicals like hydrochloric acid (HCl), and Sodium hydroxide (NaOH). In this treatment process, first of all, the impurities in water sample are tested, the results are obtained with Dose variation, time variation, temperature variation, and pH variation. Secondly, the optimization of physical and chemical parameters is done using activated carbon in batch process. It is important to note that this water is discarded and not utilized due to hygienic reasons but it is in big volume so it comes as a biggest opportunity for us to again treat, recycle and reuse this water so as to make it fit for cleaning, gardening etc. purposes in CCE.

FUTURE SCOPE OF THE STUDY

A number of methods are employed for the waste water treatment but they are highly complicated and expensive as well. On the other side, the use of low cost activated carbon for the treatment is highly preferable and eco-friendly also. With this other adsorbents for example- biosand filters can also be used for the waste water treatment. The results obtained from the experiments clearly indicate that the quality of the treated water has improved and if some more parameters that are concerned with the purity factor can be introduced, this water can be made available in form of non-potable usage also. Therefore, College should provide more fund in support of the research.

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