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Research Article

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Treatment of Dairy Wastewater using Orange and Banana Peels

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ABSTRACT

An experimental investigation was carried out for the treatment of diary wastewater using low cost adsorbents. The peels of orange and banana were used as adsorbents in this study by carbonization and dehydration (biosorption) methods and the effect of pH, contact time, adsorbent dosage, and adsorbent particle size in removal of pollutants present in diary wastewater was evaluated. The studies showed that the orange peels are more effective than the banana peels in the removal of pollutants from the dairy wastewater. The carbonization method is found to be more efficient than the de-hydration method for both, orange and banana peels, the orange peel found to be more efficient in both methods with the highest percentage removal of 50.1% and 14.3% respectively compared to the banana peels where the percentage removal are found to be 44.1% and 8.2% for the carbonization and de-hydration methods respectively. The optimum pH for both methods, orange and banana peels found to be in a range between 6-8. The optimum contact time for de-hydration method of orange peel and carbonization method of banana peel is 120 min and for de-hydration of banana peels and carbonization of orange peel is 150 min. The optimum adsorbent dosage for the dehydration method of orange peel is 0.15 g and for banana peel is 0.25g. The optimum adsorbent dosage for carbonization of orange and banana peel is 0.3g and the optimum particle size for methods, orange and banana peels are 300µm. The results were validated using Langmuir and Freundlich equations.

Keywords: Adsorbent, Orange peel, Banana peel, Dairy waste water, De-hydration method, Carbonization method.

INTRODUCTION

Worldwide water demand is increasing day by day due to rapid population and industrial growth, and on the other hand there is continuous decline in ground and surface water levels due to over exploitation. Efforts are being made to find the alternatives for water supply and one prominent solution is treatment and re-use of industrial wastewater. The dairy industry involve processing of raw milk into products such as milk, yogurt, cheese etc. and generates lot of wastewater which contains very high concentration of organic substances such as proteins, carbohydrates and lipids. Many technologies are in practice to treat the dairy wastewater and in the present study, an attempt was made to investigate the application of low cost adsorbents from orange and banana peels for the treatment by considering the wastewater from local dairy form in Oman. Tones of orange and banana peels were discarded and send to garbage as useless materials and it is very significant and even essential to find applications and uses for these peels, as the management of wastes nowadays is becoming a very serious environmental issue. These waste peels are low cost, non-hazardous and environment friendly bio-materials which can be used as adsorbents in wastewater treatment. Dehydration and carbonization methods were used to prepare the adsorbents from these peels and the effect of contact time, pH, dosage and particle size in removal of pollutants from the dairy wastewater was evaluated.

2.0 Literature Review
These literature reviews outlined gives an idea on the research work chosen and are usually similar or continuing the work done. Nikolaeva, *et al*., (2013) conducted a study on dairy wastewater treated by anearobic fixed bed reactor from laboratory to pilot-scale plant using hybrid material composed of tier rubber and zeolite. The effect of hydraulic retention time was evaluated from 1-5.5 days. It was concluded that, in the laboratory scale, COD (Chemical Oxygen Demand) removal efficiencies varied from 28.3% to 82.1% respectively. Whereas, pilot-scale plant, COD removal efficiency achieved at 63.6% in a hydraulic retention time of three days. Abdur Rahman, *et al*., (2013) studied the removal of dyes from textile waste water using orange peels as adsorbent. The study evaluated the effect of different pH, contact time, and amount of adsorbent. The experiment showed that the percent removal was 60-70% at pH 7, retention time of 120 minutes and amount of adsorbent of 1.5 grams. Kartik, *et al*., (2012) studied the adsorption of Congo red onto carbon prepared from Neem leaf litter and Raw Neem leaf and it was discovered that the adsorption of Neem leaf litter carbon is showed to have higher adsorption capacities of Congo Red compared to Raw Neem leaf litter adsorbents.

Velmurugan. P, *et al*., (2011) conducted a study on dye removal (Methyl blue) from aqueous solution using low cost adsorbent. The adsorbent were prepared from orange, banana, and neem leaves. The effects of pH, contact time, adsorbent dosage were experimented. It was concluded that the orange peel is very effective compared to others, as the maximum removal found to be 99%.It was also concluded that the optimum pH, time and adsorbent dosage was at 6.5 pH, 45 min, and 1 grams respectively. Kanawade and Gaikwad, (2011) studied the removal of dyes (Acid orange–II) from dye effluent by using sugarcane bagasse ash as an adsorbent. The effects of contact time, bed height, column diameter and pH were investigated. For the effect of pH, it was concluded that the rate of removal of acid orange–II is very high at pH 7 because of its in neutral medium. For the effect of time, it was concluded that the removal of acid orange–II decreases due to the minimum time of contact between adsorbent and adsorbate.

Mohapatra, *et al*., (2010) discusses about the usefulness and characteristics of banana peel, and it was concluded that banana peels are strong antioxidant and color absorber.Vieira, *et al*., (2010**)** studied the treatment of wastewater using Moringaoleifera seed as natural adsorbent. The main objective of the study is to use the MO (Moringaoleifera) seeds as natural adsorbent for the treatment of dairy wastewater. He evaluated the effect of time, pH, MO biomass dose and concentration. The MO seed keeps its adsorption power under pH range between 5-8 and has the potential to be used in the dairy wastewater treatment in an efficient way with low cost. Adsorption of heavy metals from water using banana and orange peels was studied by Annadurai, et al., (2002). The effect of pH was experimented for both orange and banana peels on different metals. It was concluded that the maximum adsorption occurs at pH 6-8 for orange and banana peels. Taiuddin, *et al*., studied the removal of carcinogenic substance in waste cooking oil using banana peels. The banana peels was prepared using different methods, de-hydrated banana peel, carbon banana peel, activated carbon banana peel, shallot and commercial activated banana peel. It was concluded that the de-hydrated banana peel is the best compared to other methods, because de-hydrated banana peel have absorbent potentiality and high absorption capacities as a result of absorbing high amount of peroxide from waste cooking oil. Ademiluyi, *et al*., (2009) studied the adsorption of organic contaminates from refinery waste using activated carbon from waste Nigerian bamboo. The effect of various time (1,2,3,4 and 5 hours) on the removal of COD was investigated. It was concluded that as the time is increased the percent removal decreases. The optimum percent removal was in the first hour with percentage of 62.4 %.

Jatto, *et al.*, (2010) studied the treatment of wastewater from food industry using snail shell. The parameters turbidity, COD(Chemical Oxygen Demand), BOD (Biological Oxygen Demand), TSS (Total Suspended Solids) and TDS (Total Dissolved Solids) was studied before and after treatment was studied before and after treatment, turbidity, COD, BOD, TSS and TDS. It was concluded that snail shell is effective in the treatment of wastewater as the turbidity decreases from 332 to 133 NTU, COD decreased from 872 to 215 mg/L and the BOD decreased from 29.27 to 19.77.El Zayat and Smith, (2007) studied the removal of heavy metals contaminates from water and wastewater using activated carbon from cotton stalks. The effect of pH on the removal of heavy metals was investigated. It was concluded that, the high removal of heavy metals at pH values greater than 5.5 is motivated by the electrostatic interaction between the activated carbon with its high negative charge and the heavy metal element with their positive charge (+2). However, in some cases a notable removal has occurred at lower pH values which may be due to surface complexation.

EXPERIMENTAL SECTION

Orange and banana peels wastes were collected from houses and diary wastewater was collected from Sultan Qaboos University dairy form, Sultanate of Oman. The rotatory shaker model Rotaterm (P Selecta make) was used to stir the samples at 100 rpm. The pH of the samples was measured using digital pH meter MK VI model and turbidity was measured by turbidity meter. Chemical Oxygen Demand (COD) was measured using COD digester model Orion COD 125 and photometer model Orion AQ 4000 and Biological Oxygen Demand (BOD) was measured using Dissolved Oxygen meter.

4 sets of conical flasks labelled with respective parameters (pH, contact time, adsorbent dosage and adsorbent particle size) were taken at a time and 20 ml of sample is added to each conical flask. The flasks were kept in a rotary orbital shaker at 100 rpm and then samples were withdrawn from the shaker, filtered using a filter paper and COD was measured at respective time intervals.

3.1 De-hydrated Method:
The collected peels were cut into small pieces, washed with distill water to remove dirt and suspended impurities and then dried for 48 hours in an oven at 100^{o}C to remove the moisture content from the peels. After the drying process, the peels were removed from the oven and kept in the desiccators for 30 minutes. The desiccators contains calcium chloride ($CaCl_2$) which is used to cool and maintain a dry environment and then the peels are ground to fine powder and sieve through 600µm, 425µm, 300µm for different particle size. These dehydrated peels were directly used as biosorbents in the experimental investigations.

3.2 Carbonization Method:
The collected peels were cut into small pieces, washed with distil water to remove dirt and suspended impurities and then dried for 48 hours in an oven at 100^{o}C to remove the moisture content from the peels. After the drying process, the peels were removed from the oven and kept in the desiccators for 30 minutes and then the dried peels kept in the furnace for 3 hours at 200^{o}C to convert it into carbon. After that the peels were removed, cooled and ground to fine powder and sieve through 600µm, 425µm, 300µm for different particle size.

RESULTS AND DISCUSSION

4.1 Effect of pH:
pH was adjusted according to the label value using 0.1N NaOH and 0.05N HCl. 0.1g of 300 µm adsorbent (de-hydrated orange / banana peel or Orange / Banana peel Carbon) was weighed using electronic balance and added to each of the samples. Figure 1 shows that the maximum adsorption occurs between pH 6-8 in both methods for orange and banana peels.

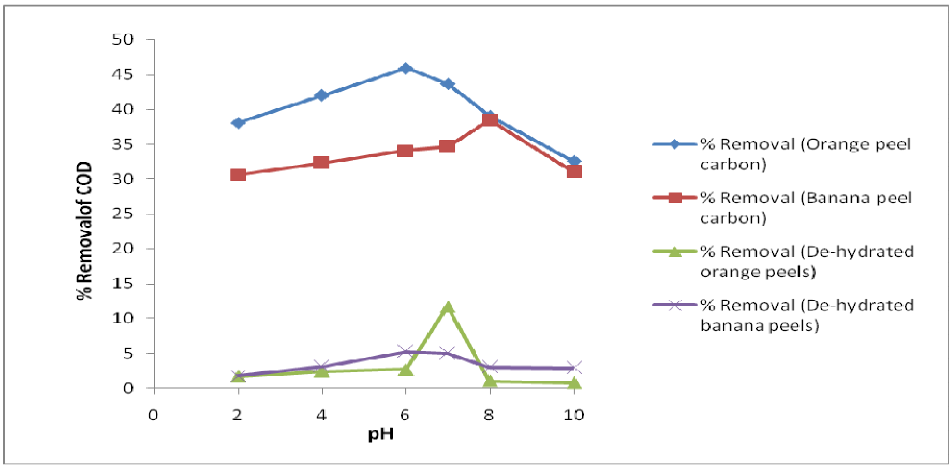

Fig 1 Effect of pH on percentage removal of COD

4.2 Effect of Contact Time
The optimum contact time was studied at optimum pH, 0.1 g of 300 µm of adsorbent (de-hydrated orange / banana peel or Orange / Banana peel Carbon) at different contact times of 30,60,90,120, and 150 minutes respectively. The Figure 2 shows that, the percent removal increases gradually as the time is increased. It can be attributed to the fact that more time becomes available for the organic substances to stick with the adsorbent surface, as well as surface adsorption increases with time. However, a slight decrease on the percent removal at 150 min in de-hydrated orange peel and banana peel carbon, this may be due to desorption of pollutants from the adsorbent surface due to continue stirring process.

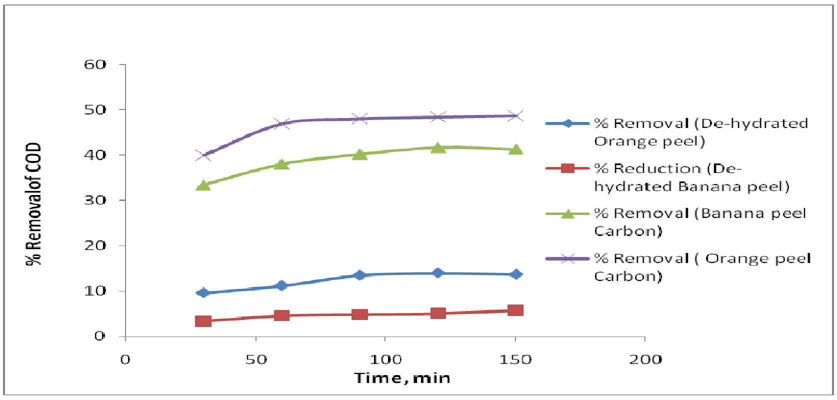

Fig 2 Effect of Time on percentage removal of COD

4.3 Effect of Adsorbent Dosage:

The optimum adsorbent dosage was studied at optimum pH, 0.1 g of 300 µm of adsorbent (de-hydrated orange / banana peel or Orange / Banana peel Carbon) at different dosages of 0.05, 0.1, 0.15, 0.2, 0.25, and 0.3g respectively. Figure 3 shows that the percent removal increased as the mass of adsorbent dosage was increased. This result indicates that more surface area was made due to increased mass of adsorbent. In some cases, the percent removal started to decrease which indicates that the adsorbent reach its optimum adsorption and desorption of the organic substances form the surface of adsorbent occurs.

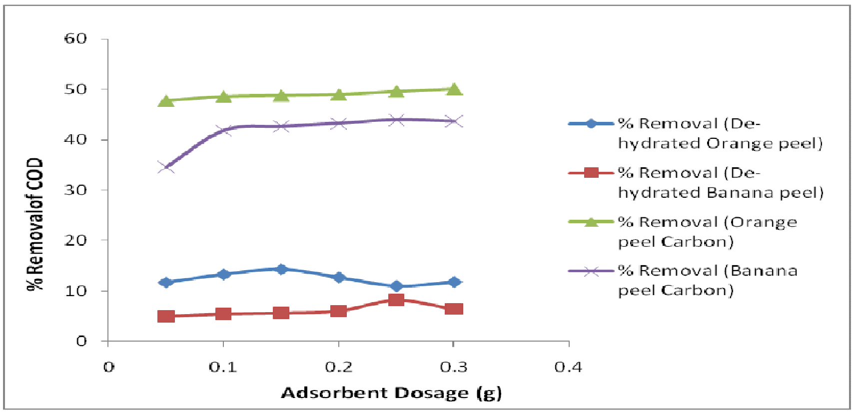

Fig 3 Effect of Adsorbent dosage on percentage removal of COD

4.4 Effect of Particle Size:

The optimum adsorbent particle was studied at optimum pH, 0.1 g of 300 µm of adsorbent (de-hydrated orange / banana peel or Orange / Banana peel Carbon) at different particle size 300, 425, and 600 µm respectively. Figure 4 shows that, decrease in adsorbent particle size results, an increase of percent removal of COD and this may be due to the increase in the available surface area for the adsorption process

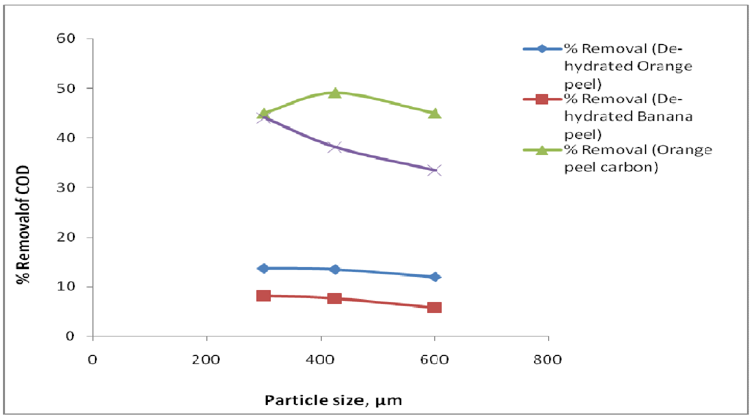

Fig 4 Effect of Particle size on percentage removal of COD

5.0 Adsorption isotherms

The adsorption isotherms, over small concentration gradients, particularly for dilute solutions can be frequently represented by Freundlich equation $q_e=K[C_e]^{1/n}$, where Ce is the equilibrium concentration and K and n are constants and the Langmuir equation is $q_e=(bC_e)/(1+a\ C_e)$, where 'a' and 'b' are the Langmuir constants. The adsorption isotherms of De-hydration and Carbonization methods for orange peel were shown in the figures 5 to 8.On regression analysis, the entire data covered in the present study is represented by the following equations:

1. De-hydration method (orange peel)
Freundlich isotherm $q_e= (6.4565\ x10^{-62})(C_e)^{-1/0.647}$
Langmuir isotherm $q_e= (-1.4183)C_e/(1-2.318C_e)$

2. De-hydration method (banana peel)
Freundlich isotherm $q_e= (1.4454\ x10^{-20})(C_e)^{-1/1.612\ x10\text{-}3}$
Langmuir isotherm $q_e= (0.0212)C_e/(1+1.0843\ C_e)$

3. Carbonization method (orange peel)
Freundlich isotherm $q_e= (0.9885)(C_e)^{-1/8.62}$
Langmuir isotherm $q_e= (5.102)C_e/(1+2.097\ C_e)$

4. Carbonization method (banana peel)
Freundlich isotherm $q_e= (4.027x10^{-3})(C_e)^{1/1.845}$
Langmuir isotherm $q_e= (1.1695)C_e/(1+1.4456\ C_e)$

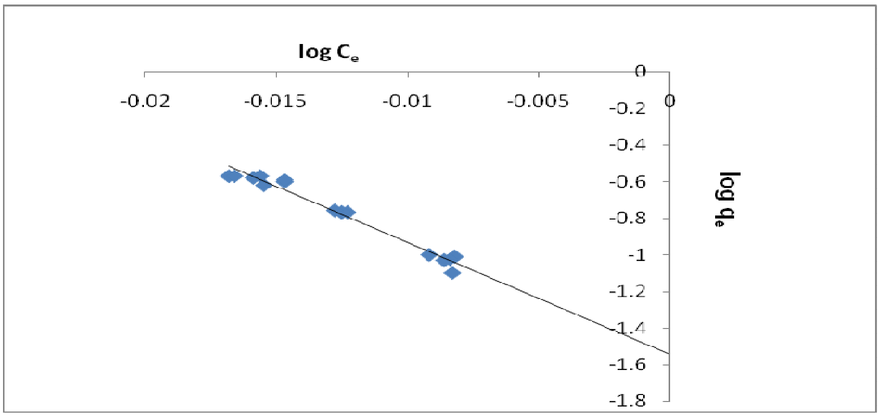

Fig 5 Frendlich isotherms for orange peel by De-hydration method

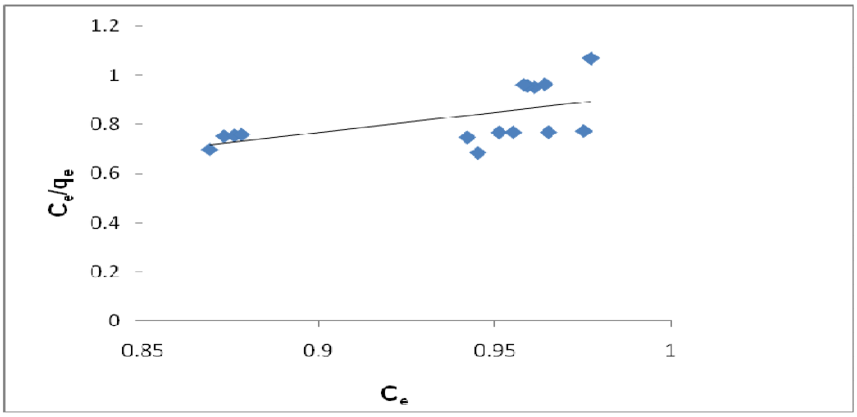

Fig 6 Langmuir isotherms for orange peel by De-hydration method

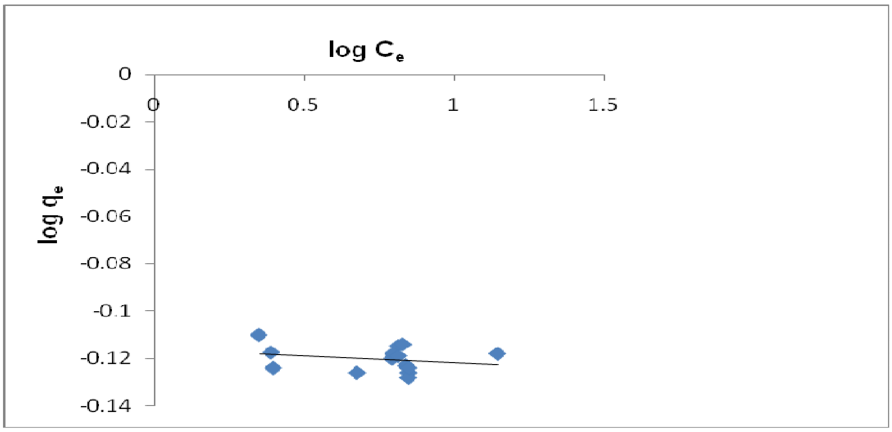

Fig 7 Frendlich isotherms for orange peel by carbanization method

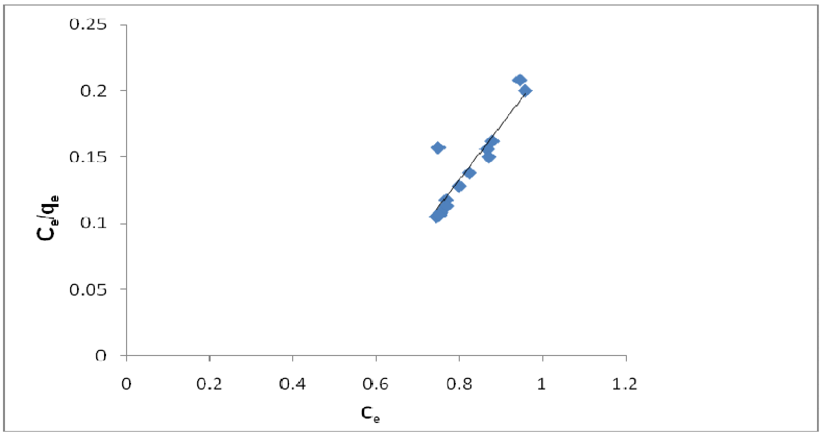

Fig 8 Langmuir isotherms for orange peel by carbanization method

CONCLUSION

The removal of organic substance from dairy waste water using de-hydration and carbonization methods for orange and banana peels was studied by investigating the effect of pH, time, adsorbent dosage and particle size. The carbonization method is found to be more efficient than the de-hydration method for both, orange and banana peels with highest percentage removal of 50.1 % and 44.1% respectively. The carbonization method is considered to be better since carbon is a strong oxidant and has a unique pores structure which adsorbs the organic substances to its surface easily. The orange peel found to be more efficient in both methods with the highest percentage removal of 50.1% and 14.3% respectively compared to the banana peels where the percentage removal is found to be 44.1% and 8.2% respectively for the de-hydration and carbonization methods. This is due to the characteristics of orange peels in its content fiber which contain more hydroxyl radicals, hence more adsorption capacity. The optimum pH for both methods, orange and banana peels are found to be in a range between pH 6-8. The optimum time for de-hydration method of orange peel and carbonization method of banana peel is at 120 min. The optimum time for de-hydration of banana peels and carbonization of orange peel is at 150 min. The optimum adsorbent dosage for the dehydration method of orange peel is at 0.15 g and for banana peel is at 0.25g. The optimum adsorbent dosage for carbonization method of orange and banana peel is at 0.3g. The optimum particle size for both methods, orange and banana peels are at 300µm. Experimental data validated with Freundlich and Langmuir isotherms equations.

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REFERENCES

[1] CS Sharma; RK Nema; SN Meyyanathan. *Academic J. Cancer Res.*, **2009**, 2(1), 19-24.
[2] Abdur Rahman, F., Akter, M. and Abedin, M.Z., *International Journal of Scientific & Technology Research*., **2013**,2(9), 47 – 50.

[3] Ademiluyi, F. T., Amadi, S. A., Amakama, and Jacob, N., *Journal of Application Science and Environmental Management.*,**2009**, 13(3), 39-37.
[4] Annadurai, G., Juang, R.S. and Lee, D.J., *Water Science and Technology*.,**2002**, 47 (1):185 – 190.
[5] Bazarafshan, E., Moein, H., Mostafapour, F.K. and Nakhaie, S., *Journal of Chemistry*, **2013**.
[6] El Zayatans Smith, *Environmental Engineering Programme*: 1-9, **2007**.
[7] FAO Corporate Document Repository, n.d. Management of waste from animal product processing. [Online].Available from: http://www.fao.org/wairdocs/lead/x6114e/x6114e03.htm. [Accessed:31st May **2014**].
[8] Jatto, E.O., Asia, I.O., Egbon, E.E., Otutu, J.O., Chukwuedo, M.E. and Ewansiha, C.J. *Acaedmia Arena*., **2010**,2(1):32–36.
[9] Kanawade, S.M. &Gaikwad, R.W., *International Journal of Chemical Engineering and Applications*.,**2011**, 2(3):202 – 206.
[10] Mane, S.M., Vanjara, A.K. and Sawant, M.R., *Journal of the Chinese Chemical Society*,**2005**, 52:1117 – 1122.
[11] Metcalf and Eddy, Wastewater Engineering Treatment and Reuse. 4th edition. New York: McGraw-Hill, **2004**.
[12] Odebunmi, E. O. and Okeola, O.F., Preparation and Characterization of Activated Carbon from Waste Material. J. Chem. Soc. Nigeria.,**2001**,26(2):149 – 155.
[13] Taqiuddin, R. and Sliah, N.Y., *APEC Youth Scientist Journal*. 4(1), p. 62 – 73.
[14] Taylor, C. and Yahner, J.,Wastewater Treatment Protects small Community Life, Health. [Online]. Available from: https://engineering.purdue.edu/~frankenb/NU-prowd/disease.htm, **1996**.
[15] Velmurugan, P., Rathina Kumar, V. &Dhinakaran, G., *International journal of environmental sciences*.,**2011**, 7(1):1492-1496.
[16] Wikipedia, Freundlich equation[Online],Available from: http://en.wikipedia.org/wiki/Freundlich_equation, **2014**.
[17] Wikipedia,Water. [Online], Available form: http://en.wikipedia.org/wiki/Water, **2014**.
[18] World Health Organization, Environmental management. [Online]. Available from: http://www.who.int/denguecontrol/control_strategies/environmental_management/en/, **2014**.