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Parametric Studies on Detergent Using Low Cost Sorbent

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Abstract- Water is a valued natural resource for the existence of all living organisms. Indian rivers are polluted due to the discharge of untreated sewage and industrial effluents. Management of the quality of this precious resource is, therefore, of special importance. In these study industrial effluents samples from the various detergent factories were collected and analyzed for physicochemical and bacteriological evaluation of pollution. The use and effectiveness of granular and powder activated carbon made from agricultural waste i.e. coconut husk and that coconut husk is a suitable adsorbent for such an effluent. Maximum adsorption capacity is a derived from Langmuir isotherm. A series of fixed bed experiments was carried out and the results were applied to a bed-depth/service time model for column adsorption. The validity of such a model is discussed. In the removal of organic matter in wastewater effluents from a industry waste water were investigated. The effect of process variables such as carbonization temperature, carbonization duration and activation temperature on the production and quality of activated carbon was studied as well as adsorption capacity was studied.

Index Terms- Coconut husk as activated carbon, carbonization, activation temperature, detergent sample, adsorption.

I. Introduction

The water contamination by toxic metals through the discharge of industrial wastewaters is a worldwide environmental problem. Water is super abundant on the planet as a whole, but fresh potable water is not always available at the right time or the right place for human or ecosystem use. Water quality refers to the physical, chemical and biological characteristics of water.

Wastewater may be purely domestic or may contain some industrial wastewater as well. Residential waste water is a combination of excreta, flush water, and all types of wastewater generated from household. It is more commonly known as sewage and much diluted. There are two types of domestic sewage: black water or wastewater from toilet sand gray water, which is wastewater from all sources except toilets. Industrial wastewater comes from commercial activities (shops, restaurants, fast food shops, hospitals, etc.), industries (e.g., chemical industries, pharmaceutical companies, textile manufacturing, etc.), agriculture (e.g. Slurry), and so forth. Wastewaters from dyeing operations are characterized by color caused by both organic and inorganic compounds .The organic compounds are more problematic in industrial effluent than inorganic materials because, apart from the color, it imparts on the wastewater, biodegradation of organic material in the dye depleting the dissolved oxygen of the water thereby stressing aquatic microbes .Traditional wastewater treatment technologies have shown to be ineffective for handling detergent because of the chemical stability of these pollutants .There is no single or economically attractive method of treatment of Industries wastewater ,although notable achievements were made in the use of biotechnological approaches to solving the problem. In addition to biological treatment, many physical and chemical treatment methods have been employed for detergent removal from wastewaters such as coagulation, flocculation, filtration, oxidation or reduction, complex formation, or neutralization. New adsorption/oxidation, adsorption/reduction, and many combined processes were reviewed while radiation induced degradation process for treatment of wastewater. Solid sorbents have been employed in adsorption techniques to remove certain classes of chemical pollutants from waters; activated carbon is the most successfully used, but the high operating International Journal of Chemical Engineering costs and problems with regeneration of the spent activated carbon discourage its large-scale application. Therefore, a number of nonconventional sorbents have been tried for the treatment of wastewaters, in this class are various industrial wastes, agro waste, or natural materials available in large quantity at low cost and are classified as alternative sorbents for the removal of inorganic and organic pollutants from wastewaters . In this present study, the aim is to determine the efficacy of chemically modified and unmodified biological (portentous and cellulosic) waste sorbents in treatment of detergent wastewater; also the effect of particle sizes, carbonization (activation), and contact time will be established.

What is Adsorption?

Since activated carbon also possesses an affinity for heavy metals, considerable attention has been focused on the use of carbon for the adsorption of hexavalent chromium, complexes cyanides and metals present in various other forms from wastewaters. Watonabe and Ogawa first presented the use of activated carbon for the adsorption of heavy metals in 1929. Adsorption on activated carbon has been found to be superior compared to other chemical and physical methods for wastewater treatment in terms of its capability for efficiently adsorbing a broad range of pollutants, fast adsorption kinetics and its simplicity of design. However, commercially available activated carbons are still expensive due to the use of non-renewable and relatively high-cost starting material such as coal, which is unjustified in pollution control applications. Therefore, in recent years, many researchers have tried to produce activated carbons for removal of various pollutants using renewable and cheaper precursors which were mainly industrial and agricultural byproducts, such as coconut shell , waste apricot, sugar beet bagasse, molasses, rubber wood sawdust , rice straw, bamboo , rattan sawdust , oil palm fiber and coconut husk . Coconut husk is the mesocarp of coconut and a coconut is consists of 33–35% of husk.

Adsorption techniques employing solid sorbents are widely used to remove certain classes of chemical pollutants from waters, especially those that are practically unaffected by conventional biological wastewater treatments. However, amongst all the sorbent materials proposed, activated carbon is the most popular for the removal of pollutants from wastewater. In particular, the effectiveness of adsorption on commercial activated carbons (CAC) for removal of a wide variety of dyes from wastewaters has made it an ideal alternative to other expensive treatment options. Because of their great capacity to adsorb, CAC are the most effective adsorbents. This capacity is mainly due to their structural characteristics and their porous texture, which gives them a large surface area, and their chemical nature which can be easily modified by chemical treatment in order to increase their properties. However, activated carbon presents several disadvantages. It is quite expensive, the higher the quality, the greater the cost, non-selective and ineffective against disperse and vat dyes. The regeneration of saturated carbon is also expensive, not straightforward, and results in loss of the adsorbent. The use of carbons based on relatively expensive starting materials is also unjustified for most pollution control applications. This has led many workers to search for more economic adsorbents.

Role of activated carbon in controlling water pollution

- Water pollution is an important environmental issue which needs immediate attention.
- Prepared carbon from various agricultural wastes can play a valuable role in controlling water pollution.
- Carbon can reduce harmful materials and pollutants from water thereby minimizing water pollution.

II. MATERIALS AND METHODS

A. Collection of Sorbents and Preparation.

Cellulosic waste sorbents (coconut-husk (coir)) were procured from a local market around Navi Mumbai. They were thoroughly washed with soap solution, sun dried for two days before drying in an oven at 105◦C for 2 hours, and then ground. Ground material was carbonized at temperature of 80◦C for 30 mins, cooled and activated with H_2SO_4, and further heated at a temperature of 500◦Cfor complete carbonization. The carbonized materials were again pulverized. Materials were sieved into two particle sizes of 325 μm and 625 μm using mechanical sieve.

B. Column preparation.

2.5 g of each sorbent (both carbonized and uncarbonized and each particle size) were separately packed in glass adsorption column with inner diameter 2.2cm, bed height 3-18cm; the wastewater was eluted into it and allowed a contact time of 60 and 120 minutes. The wastewater was collected after 60 and 120 mins, respectively, and all the previous parameters were again determined to ascertain the Percentage absorption after each batch. The flow rate was varied between 25-75 ml/ min.

Adsorption isotherms are useful in providing information on the effectiveness of the adsorption system. However, the isotherms are obtained under equilibrium conditions. In most industrial treatment applications, the contact time is not sufficiently long for equilibrium to be achieved. In order to establish the suitability of coconut husk in removing detergent on a continuous basis, some flow studies using columns were conducted. For column operation, the husk is in constant contact with a fresh solution and hence equilibrium is unlikely to be attained. The usefulness of a column is related to the length of time before renewal or regeneration is necessary. For this purpose, the determination of breakthrough curve at different bed depths and flow rates is necessary.

C. Wastewater Collection and Analysis.

Detergent wastewater was collected from MIDC Taloja, Navi Mumbai. Physicochemical parameters of the wastewater were analyzed before and after contacting with the adsorbents for each contact time and particle size. Nitrate was determined according to American Public Health method, and chemical oxygen demand (COD) was determined by the dichromate method. Biological oxygen demand (BOD) and dissolved oxygen (DO) were determined electrochemically. The chloride content was determined by colorimetric method; while total suspended solid (TSS) and total dissolved solid (TDS) were determined by their respective standard methods. A standard pH meter was used to determine the pH, and a digital conduct meter (consort K120, Belgium) was used to determine electrical conductivity (EC).Heavy metals (Pb, Mn, Ni, and Cr) were determined at their respective wavelengths (281.5, 278, 231, and 358)nm after digestion using clean filtrates of the samples by means of atomic absorption spectrophotometer 205 A.

D. Analysis:-

Measurements commonly made include temperature, pH, conductivity, Dissolved Oxygen (DO) and turbidity. Apart from the field observations other parameters- Alkalinity, Total solids, Dissolved and Suspended Solids, Total Hardness, Sulphate, Phosphate, Chloride, Fluoride, Nitrate, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD).

The sample was collected from TALOJA MIDC, NaviMumbai. Then these samples were distributed in various fractions & analyzed for various parameters before passing through a activated carbon bed. Then Different activated columns of coconut husk bed by above method were prepared & the collected waste water sample was passed through it from the fixed bed for different contact time period. After that the sample is collected at the different time interval with different contact time & subjected for analysis for different parameters like PH, conductivity, D.O, turbidity, hardness, sulphate, Phosphate chloride, etc. Now these parameters were compared to the parameters analyzed before passing through the bed. From this comparison the amount of the various content adsorbed by the activated carbon bed (coconut Husk) is observed.

E. Adsorption Isotherms:

Adsorption isotherms were obtained by passing the detergent water sample through activated carbon coconut husk. The results from adsorption studies at equilibrium can be used to determine the maximum of detergent adsorbed by the husk by using a modified Langmuir isotherm shown below.

$$Ce/ Ne = 1/(N^*b) + Ce/ N^*$$

Where Ne is the amount of detergent adsorbed per gram of husk at concentration Ce. Despite its lower adsorptive power, coconut husk, a cheap agricultural by product, could still be used to remove phosphate from wastewaters.

F. Activated carbon yield:-

The activated carbon yield was calculated based on Eq.

$$\text{Yield (\%)} = W_c/W_o \times 100$$

Where W_c the dry weight (g) of final activated carbon and W_o is the dry weight (g) of precursor.

2.7. The composition of coconut husk:

Moisture =15.0%
Lignin =43.0%
Ash=8.26%
Alkalinity of ash (as K_2O) =37.5%

G. Environmental hazards

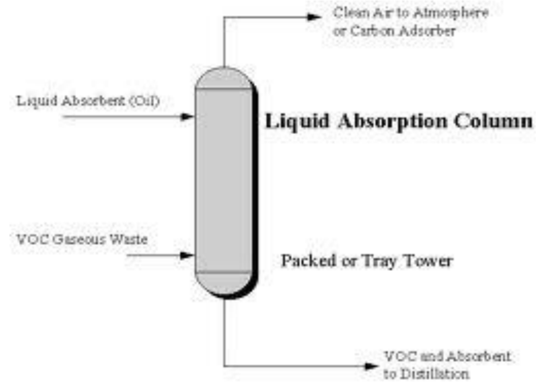
- Water and air pollution amongst major environmental issues.
- Environmental issues need to be addressed in the immediate future in order to maintain ecological balance
- Growing dye industries, pharma industries cause major water pollution.
- In many areas, water is contaminated with toxic materials as well as heavy metals.
- To develop a new, economic and fast acting method to control water pollution is the need of the day.

H. Physical Properties

- Activated carbon has the strongest physical adsorption forces or the highest volume of adsorbing porosity of any material known to man.
- Very high surface area 500 – 1500 m2/g.
- Highly porous structure – Consists of micro-pores and macro-pores

III. METHDOLOGY

The sample i.e. waste water which is highly contained detergent in it. It is collected from TALOJA MIDC CETP CO. SO. LTD, at Raigad District.



COLUMN METHOD BY USING COCONUT HUSK

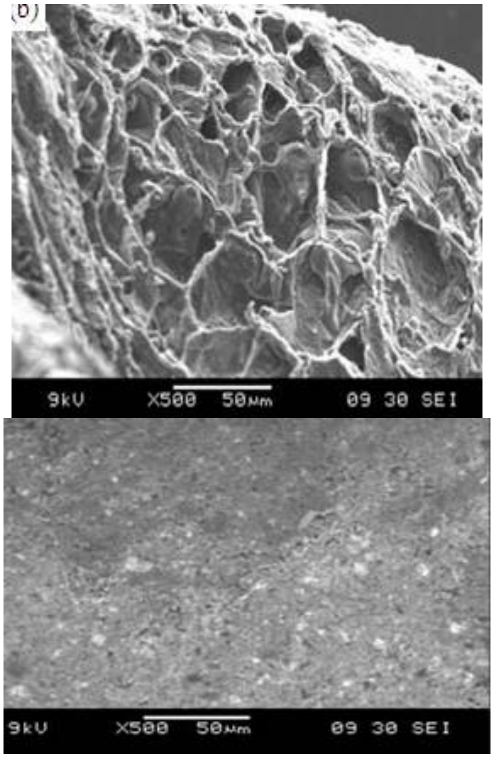
A..Column Study:

Adsorption isotherms are useful in providing information on the effectiveness of the adsorption system. However, the isotherms are obtained under equilibrium conditions. In most industrial treatment applications, the contact time is not sufficiently long for equilibrium to be achieved. In order to establish the suitability of coconut husk in removing detergent on a continuous basis, some flow studies using columns were conducted. For column operation, the husk is in constant contact with a fresh solution and hence equilibrium is unlikely to be attained. The usefulness of a column is related to the length of time before renewal or regeneration is necessary. For this purpose, the determination of breakthrough curve at different bed depths and flow rates is necessary.

B. Activated carbon characterization:-

The raw coconut husk was found to be high in volatile matter and moderate carbon content, indicating the suitability of coconut husk to be used as precursor for activated carbon preparation. After undergoing activation process, the volatile matter content decreased significantly whereas the fixed carbon content increased in activated sample. Similar trend was observed for the elemental analysis where the carbon content increased up to 73.8% for coconut husk activated carbon. This was due to the pyrolytic effect at high temperature where most of the organic substances have been degraded and discharged both as gas and liquid tars leaving a material with high carbon purity

The BET surface area, total pore volume and average pore diameter of the prepared activated carbon were found to be 370.75m2/g, 0.385cm3/g and 2.61 nm, respectively. The average pore diameter of 2.61 nm indicates that the coconut husk activated carbon prepared was in the mesopores region. During the activation, CO2 gas molecules diffuse into the carbon structure thus increases the CO2-carbon reaction, thereby developing more pores on the sample. From the SEM micrograph, the raw coconut husk surface texture was undulating with very little pores as shown in Fig. 3a. After activation process, pores were developed with homogeneous distribution on the coconut husk activated carbon surface (Fig 3b).

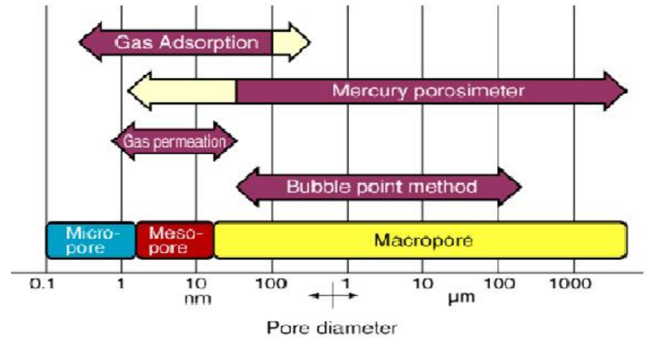


SEM micrographs;
(a) raw coconut husk (magnifications: 500 xs)
(b) Coconut husk activated carbon (magnifications: 500 xs)

C. Method of pore size distribution:

The typical methods to measure the pore size distribution of power and materials are the gas adsorption and mercury porosimetry. The pore size distribution from the gas adsorption method is commonly analyzed from the nitrogen or Ar adsorption isotherm at their boiling temperature, and it is possible to evaluate the pore size from the molecular size to a few hundred nm. The realistic largest detectable pore size is just over 100nm due to the restriction from the pressure sensor accuracy and temperature stability of coolant. Mercury porosimetry calculates the pore size distribution by pressurizing mercury, which is non-wetting, and measure the corresponding intrusion amount. By this method, it is possible to detect the pore size from a few nm to 1000µm within a short period of time. For the pore size measurement below 10nm, it requires over 140MPa of pressure for the intrusion of mercury, so it is necessary to make sure that the material has the strength to withstand the pressure. Also, by this method, it evaluates the pore size of inkbottle neck (the smallest diameter of the pore) from the principle. The realistic measurement range is from a few 10 nm.
Recently, there are bubble point method and gas permeation method to measure the through pore size of filters and separation membranes.

- Determination of pore size distribution



IV. SAMPLING AND FIELD WORK

Measurements commonly made include temperature, pH, conductivity, Dissolved Oxygen (DO) and turbidity. Apart from the field observations other parameters- Alkalinity, Total solids, Dissolved and Suspended Solids, Total Hardness, Sulphate, Phosphate, Chloride, Fluoride, Nitrate, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD). According to the united coconut Association of Philippines (UCAP), the average weight of coconut fruit is 0.4 Kg. It has been established that 30% of the husk can be obtained as commercial coir fiber.

V. CONCLUSION

Acentral composite design was conducted to study the effects of activated carbon preparation variables, which were the activation temperature, activation time and chemical impregnation ratio, activated carbon yield. Quadratic models were developed to correlate the preparation variables to the two responses. Through analysis of the response surfaces derived from the models, whereas activation temperature showed the most significant effect on activated carbon yield. Process optimization was carried out and the experimental values obtained and carbon yield were found to agree satisfactorily with the values predicted by the models. The optimal activated carbon was obtained using 300◦C activation temperature, 2 h activation time and impregnation ratio, resulting in 20.16% of carbon yield and 191.73 mg/g uptake. From the SEM image obtained, large and well-developed pores were clearly found on the s urface of the activated carbon. Various functional groups on the prepared activated carbon were determined from the FTIR results.

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